NREL
Transforming ENERGY

VEHICLE AND MOBILITY TECHNOLOGIES
2024 ANNUAL IMPACT REPORT

October 2024

Table of Contents

EXECUTIVE SUMMARY

Charging Into the Future: Technical Prowess in Transportation Electrification Safeguards a Stronger, Sustainable Nation

By the end of last year, sales of electric vehicles (EVs) in 31 countries around the world had reached a critical tipping point of 5% or more in new car markets—generally considered the start to mass adoption by mainstream car buyers. The data show there's no doubt the future is electrified. Across the spectrum of light-, medium-, and heavy-duty vehicles, electrification offers holistic benefits. There is broad consensus that minimizing transportation-related emissions is vital to limiting global warming and avoiding many of the worst climate impacts. But an electrified transportation sector is not only a boon to public health and the environment. By maintaining our technical leadership in this area, American companies can lead industries poised to dominate the global market—thereby creating good U.S. jobs, driving economic growth, and ensuring our national security, resilience, and energy independence. From increased battery ranges and faster charging to lighter materials, more reliable components, and cleaner fuels, technological advances are largely driving these recent shifts to widespread EV adoption. Now is not the time to falter in our progress; rather, it's an imperative for all that we continue pushing the pedal to advance U.S. leadership in the EV transition.

Onwards,

John Farrell, Ph.D.
Laboratory Program Manager
Vehicle Technologies
National Renewable Energy Laboratory
303-275-4434 | *john.farrell@nrel.gov*

KEY ACTIVITIES SPOTLIGHT

NREL Leads the Way to the Sustainable Airports, Seaports, and Freight Systems of the Future

The seas, the skies, and the American highway system connect us, enabling the United States to compete on a global scale. They are also home to some of the heaviest-emitting vessels and vehicles in the world. As the United States ramps up its clean transportation goals, NREL is rising to meet them with trailblazing research and deployment aimed at decarbonizing each mode within the national freight system—including planes, trains, trucks, and vessels—and the facilities that enable it.

From conducting analysis and developing new solutions for airports and seaports to charting a course for future no- to low- freight systems, NREL's sustainable freight research knows few bounds.

NREL Charts the Course for Its Next Decade of Sustainable Freight Research

- **The Background:** Decarbonization of the nation's freight sector is a formidable challenge, requiring low- and zero-emissions technologies for freight vehicles, new charging and refueling infrastructure, and logistical changes. NREL is poised to serve as a critical accelerator by addressing the barriers to sustainable freight transportation.
- **What Happened:** NREL convened the Sustainable Freight Futures workshop to identify industry, government, and academic perspectives on the common challenges posed by freight decarbonization, and opportunities to share resources and solutions across stakeholder groups.
- **What's Next**: The laboratory is charting out a research roadmap to guide NREL's next decade of sustainable freight research. The roadmap will focus on the energy, economic, environmental, and equity challenges of decarbonization, spanning all freight modes—including aviation, maritime, rail, trucking, and intermodal—as well as freight resilience and facilities. It is informed by and will complement the efforts outlined in The U.S. National Blueprint for Transportation Decarbonization, its associated Action Plans, and the National Zero-Emission Freight Corridor Strategy.

Texas Airport Sets the Stage for Electrifying Rental Fleets by the Thousands

- **What To Know:** The Athena Zero-Emissions Vehicles (Athena ZEV) project has partnered NREL and Dallas-Fort Worth International Airport (DFW) and Oak Ridge National Laboratory to decarbonize thousands of vehicles operating at the airport, with an initial focus on electrifying the airport's extensive rental car fleet.
- **Why It's a Megawatt-Scale Effort:** High-power charging for airports' rapid rental car electrification will require finely tuned optimization of charging strategies integrating advanced hardware and controls, renewable energy sources, behind-the-meter energy storage, and flexible building loads. NREL is uniquely suited to help.
- **How NREL Is Tackling It:** Researchers are leveraging state-of-the-art charging infrastructure analysis tools and an expanded "digital twin" originally created for DFW to develop cost-effective solutions for megawatt-scale charging. The powerful Advanced Research on Integrated Energy Systems (ARIES) platform will conduct MW-scale experiments to validate and de-risk the recommendations before implementation.
- **What's Next:** NREL researchers are supporting a new Vehicle Technologies Office (VTO) effort called Athena Airport Infrastructure Readiness (Athena AIR) to adapt tools developed for Athena ZEV for all 3,000 general and commercial airports in the United States.

The Sky Is No Limit for NREL's Sustainable Aviation Research

- **The Background:** Aviation remains one of the nation's most carbon-intensive modes of transporting people and goods. NREL researchers are working to not only reduce the carbon emissions of flight, but also transition airports, vertiports, and their operations toward low- and zero-emissions technologies.
- **NREL's Efforts** The lab's researchers are advancing national efforts to deploy electric vertical takeoff and landing (eVTOL) aircraft, conducting regional analysis for sustainable aviation fuel (SAF) deployment, and developing plans for airports to become the initial backbone of a charging network for sustainable aircraft.

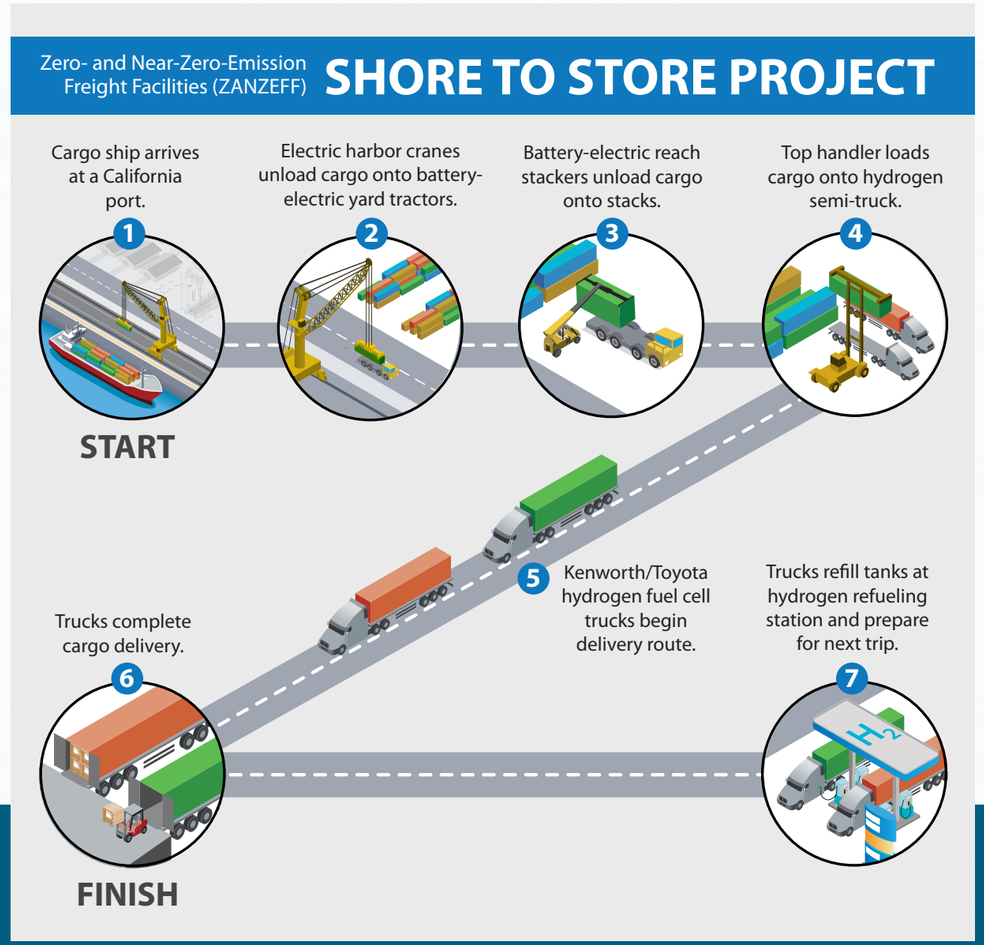
NREL Takes a Snapshot of the Clean Port Supply Chain of the Future

- **What To Know:** The Port of Los Angeles' $82.5 million Zero- and Near-Zero-Emissions Freight Facilities Shore to Store project brought together dozens of partners for a 12-month demonstration of a net-zero-emissions supply chain that stretched across Southern California. NREL researchers quantified each link in the net-zero-emissions supply chain.
- **Digging Deeper:** NREL analysis demonstrated that battery-electric cargo handling equipment, Class 8 hydrogen-powered trucks, and hydrogen refueling stations can enable net-zero-emissions goods movement from ports to storefronts.

NREL ANALYSIS SUPPORTS ZERO- AND NEAR-ZERO-EMISSIONS FREIGHT FACILITIES PROJECT

NREL analysis formed the backbone of the Port of Los Angeles' $82.5 million Zero- and Near-Zero-Emissions Freight Facilities Shore to Store project and final report, which brought together more than a dozen public and private sector partners for a 12-month demonstration of a net-zero-emissions supply chain across Southern California.

The Shore to Store project, which used battery-electric cargo handling equipment, heavy-duty hydrogen-powered trucks, and hydrogen refueling stations to move goods from Southern California's ports to brick-and-mortar storefronts, provided one of the largest real-world demonstrations of clean goods movement to date. The project illustrated that multiple clean technologies can be combined to form a larger clean-energy system.



NREL's Transportation Decarbonization Efforts Cross Highways, Train Tracks, and the Skies

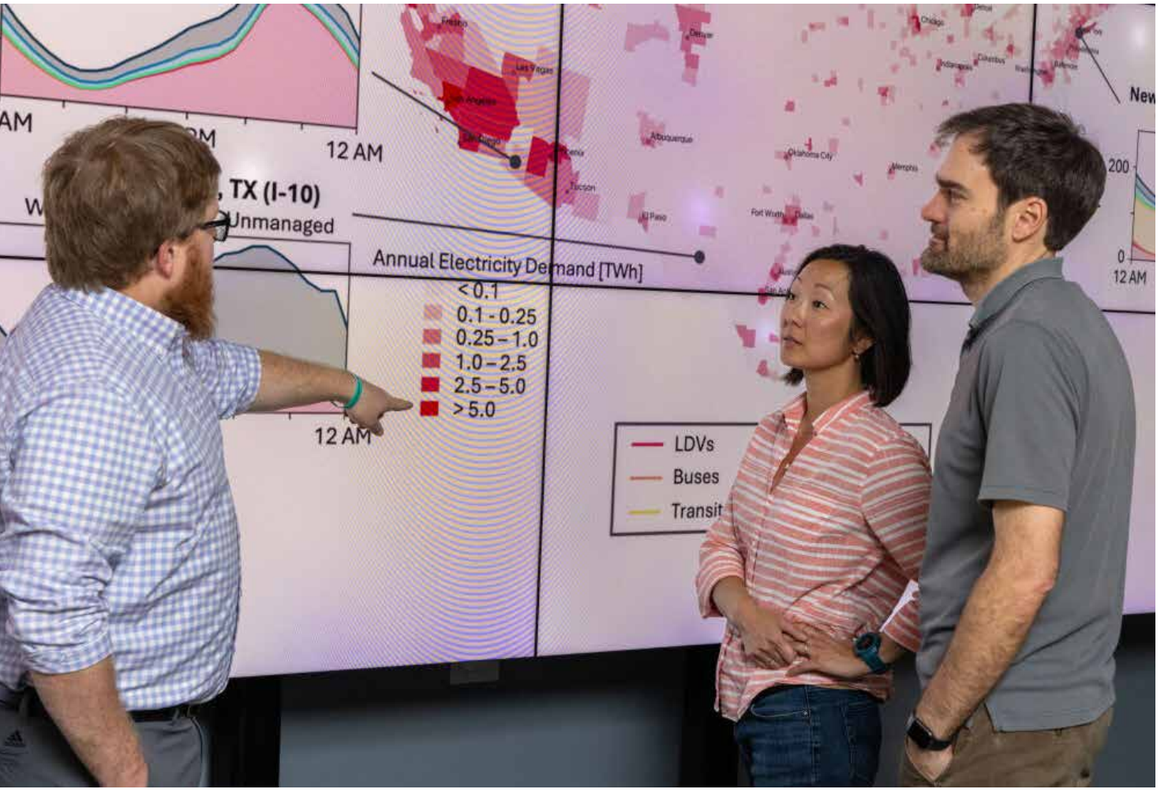
NREL researchers broke new ground in 2024 in pursuit of wide-ranging transportation decarbonization advancements.

Some of these achievements are of nation-spanning scale. NREL researchers co-authored a comprehensive nationwide survey of the state of smart charge management (SCM) and unveiled the expanded EVI-X modeling suite, the most sophisticated and comprehensive set of integrated charging infrastructure analysis tools available today. Researchers are also working to optimize a disruptive new freight rail concept and equip the aviation industry with the information needed to push a sustainable jet fuel across the finish line.

Other achievements are writ on a microscopic scale. This year, NREL researchers advanced a revolutionary strategy to manufacture faster-charging EV batteries and created improved versions of recyclable carbon fiber composites that have the potential to replace heavy, resource-intensive steel parts in vehicles. Together, these efforts are linking NREL research across highways, train tracks, and the skies.

NREL Completes Comprehensive Survey and Gap Analysis of SCM Nationwide

- **What To Know:** Researchers from NREL and Lawrence Berkeley National Laboratory (LBNL) conducted a survey of SCM practices implemented by U.S. utility and EV companies nationwide. The survey was the basis of a gap analysis to determine key barriers to wider deployment of SCM technologies.
- **Why It Matters:** SCM will be critical to supporting accelerating numbers of EVs nationwide, and can help utilities defer costly and time-consuming grid upgrades. When implemented, these strategies can save utilities and consumers money, optimize EV charging so cars can recharge and get back on the road faster, and promote grid resilience.
- **What They Found:** After reviewing more than 100 managed charging programs and interviewing more than 40 utility companies and stakeholders, NREL and LBNL researchers identified four high-priority areas to accelerate SCM at scale: expanding SCM demonstrations; developing dynamic pricing mechanisms for EV charging; creating systems that put SCM scheduling in customers' hands; and further developing SCM standards, communications hardware and networks, and technologies, each powered by renewable energy, to the area of best fit.



EVI-X Modeling Suite Nears $10 Billion Mark for Strategic EV Charging Deployments

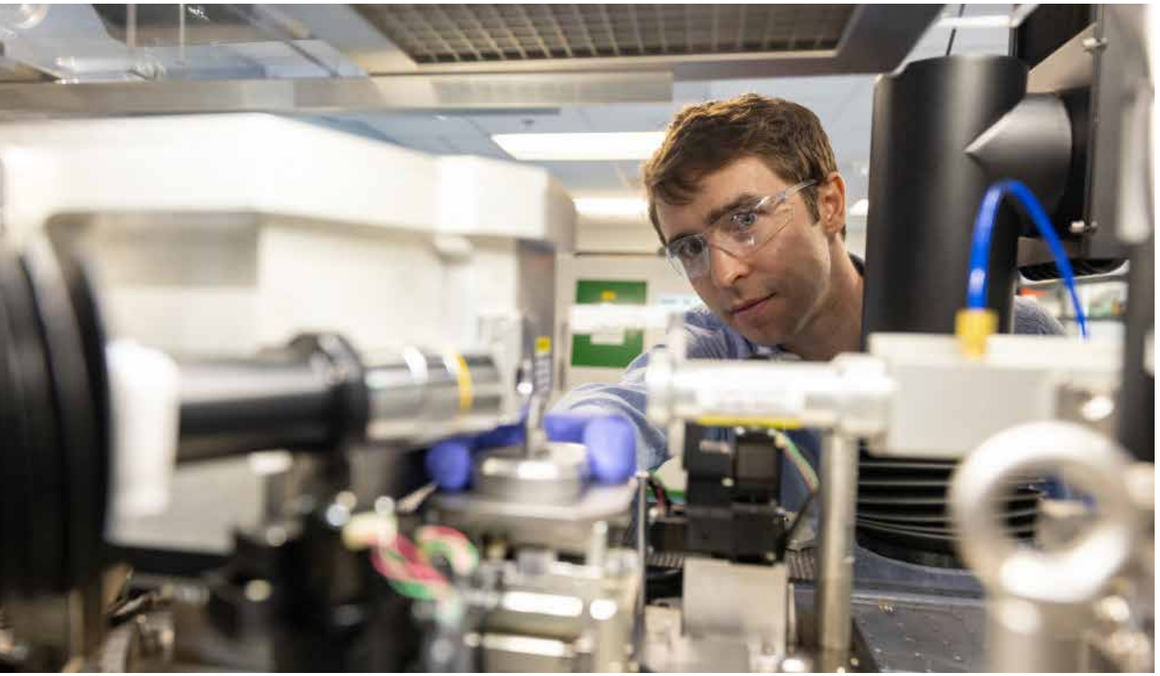
- **The Story Behind the Software:** The EVI-X modeling suite has been in development by NREL researchers for nearly a decade. Now, its 13 software tools form the most sophisticated and comprehensive set of EV charging infrastructure analysis tools available today.
- **What It's Used For:** In the past 5 years alone, EVI-X has informed more than $9 billion in planned EV charging investments and helped generate 10 EV infrastructure plans at the national, state, and city levels.
- **Why It's Newsworthy:** This year, all 13 of EVI-X's innovative software tools became available for commercial license, as open-source applications, or as web tools open to public use. They will be critical tools for stakeholders aiming to achieve aggressive EV charging infrastructure deployment goals.

NREL Partners With Disruptive New Freight Rail Provider

- **The Partnership**: NREL researchers are partnering with Parallel Systems to optimize the operations of their groundbreaking battery-electric railcars, which combine fully electric drivetrains with an ability to seamlessly group and separate themselves while traveling.
- **Why It Matters:** Moving freight on battery-electric rail vehicles can use 75% less energy per mile than moving it on a Class 8 truck. By combining the high freight efficiency of rail with the flexibility and speed normally associated with trucks, Parallel Systems railcars could enable faster, cheaper, and lower-emissions movement of goods.
- **How NREL Is Helping:** NREL researchers are applying the laboratory's new, open-source Advanced Locomotive Technology and Rail Infrastructure Optimization System (ALTRIOS) software to help optimize Parallel's operations. ALTRIOS will quantify how Parallel Systems' railcars reduce energy consumption and greenhouse gas (GHG) emissions relative to existing locomotives.

"Virtual Jet Engine" Pushes SAF Closer to the Finish Line

- **What's Happening:** NREL researchers built a "virtual jet engine" powered by supercomputers and are gathering meticulous fuel chemistry data to equip the industry with an ultra-detailed SAF combustion model.
- **Why Simulations Matter:** Proving a new jet fuel that is ready for use in airplanes can be enormously expensive. NREL's combustion simulations can reduce the quantities of costly candidate fuel needed by predicting how SAF performs during flight and providing insights on how to tune it to maximize its safety and performance.
- **What's Next:** Results from NREL's SAF research platform will be validated with data captured in combustion test cells at GE Aerospace and Georgia Institute of Technology. Once validated, the simulations could be used to help the aviation industry scale up SAF production to meet the federal government's SAF Grand Challenge, which sets a national goal of supplying sufficient SAF to cover 100% of projected aviation fuel demand by 2050.



Better Materials and Manufacturing Accelerate EV Advancements

- **Battery Manufacturing Improvements:** NREL researchers have pioneered a breakthrough battery manufacturing process that could allow EVs to charge 200% faster. The process adds a minimal cost of just 2% to the conventional battery manufacturing process, and debris collected during manufacturing can be reused to make new battery cells.
- **Carbon Fiber Improvements:** NREL researchers are also working to replace the heavy, resource-intensive steel parts in vehicles with recyclable carbon fiber composites. When used in place of steel, they can reduce the weight of a typical passenger car by half and boost fuel efficiency by up to 35%. Carbon fiber composites made with NREL's bio-derivable resin can be recycled via thermoforming at least three times, reducing the cost and GHG emissions of the material's second life by 90% to 95% compared to the first life of the material.
- **Why Better Materials Matter:** Faster recharging times from improved EV batteries can eliminate a critical barrier to widespread EV adoption, and cost-effective, lightweight, and environmentally friendly alternatives to steel can further extend vehicle range. Each of these innovations can help accelerate the pace of national transportation decarbonization.

NREL Experts Support Customized Clean Transportation Deployment To Meet Diverse Needs

With wide-ranging knowledge, cutting-edge tools, and extensive clean transportation deployment experience, NREL's deployment experts continue to lead the way in providing critical technical assistance to solve complex transportation decarbonization challenges. NREL researchers provide unbiased solutions to stakeholders in communities of varying sizes and types, from rural, suburban, urban, and beyond—all with equitable access front of mind. In 2024, NREL led the Clean Energy to Communities (C2C) program, supporting more than 40 participants to further equitable and successful EV infrastructure deployment. NREL implemented a rebranding of Clean Cities and Communities (CC&C) and facilitated training for 17 CC&C coalitions to develop deeper partnerships with underserved communities. Additionally, NREL researchers, through DOE's Technologist in Communities Program, partnered with communities to analyze and develop unique mobility solutions.

City of New Haven employees learn more about electric mobility options.

Lab's C2C Leadership Enables Participants To Build Capacity for EV Charging Infrastructure Deployment

- **Growing From the Ground Up:** Through C2C's Peer-Learning Cohorts and Expert Match offerings, NREL, with support from long-standing CC&C coalition deployment experts and in partnership with other national laboratories, is building the capacity of local governments, utilities, and community-based organizations to successfully and equitably deploy public EV charging infrastructure and creative public mobility options, including transit and micromobility.
- **Training Materials for Public Benefit:** Alongside providing technical assistance in the form of tailored guidance and access to cutting-edge NREL tools, NREL developed extensive training materials to guide participants through important steps needed to navigate key considerations for planning and deploying EV infrastructure. The guidance covered topics including effective community engagement, identifying sites, determining costs, adopting EV-friendly policies, and more. These materials were adapted by the Joint Office of Energy and Transportation (Joint Office) to create an interactive public EV charging infrastructure playbook.
- **National Network Creates Local Impacts:** To date, 44 C2C participants across the United States—including Sedona, Arizona; Washtenaw County, Michigan; and New Haven, Connecticut—have received tailored one-on-one guidance by NREL and other national laboratories to further their EV infrastructure planning. Participants benefit from coalitions' local knowledge and relationships, plus access to national laboratory technical assistance and state-of-the-art tools.

Members of the Clean Cities and Communities Energy and Environmental Justice Initiative CEL Pilot gather for a photo at a Donaldsonville, Louisiana museum during the Baton Rouge in-person workshop in April, 2024.

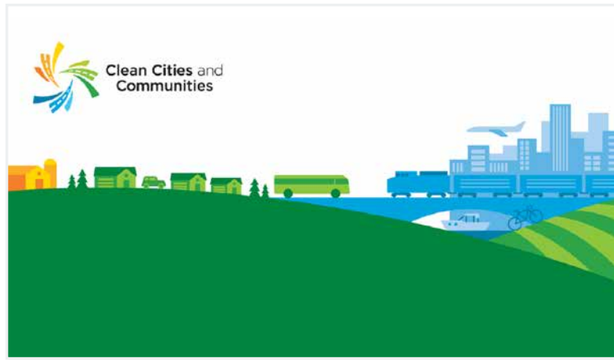
Coalition Community Engagement Liaisons Co-Develop Clean Transportation Action Plans With Underserved Communities

- **The Details:** Seventeen CC&C coalitions hired community engagement liaisons as part of a pilot project led by NREL and Argonne National Laboratory (ANL) to develop partnerships with underserved communities. Coalitions received in-depth training on equitable engagement that prioritizes listening to the community and facilitating bidirectional knowledge sharing with potential energy benefits, increased ridership, increased travel speed, reduced wait time, and reduced costs. This includes facilitating the co-development of clean transportation action plans with communities, which will shape projects that address local priorities.
- **How It Works:** Building on extensive community engagement and iterative feedback efforts, clean transportation action plans include community background and context, stakeholder and resource mapping, an engagement overview, identification of needs, vision and goals, project identification and prioritization, funding identification, and recommended next steps. In the next phase of the pilot, liaisons will support communities in implementing solutions identified in their clean transportation action plan and find opportunities for coalitions to maintain long-term partnerships with these communities.
- **Zooming Out:** Overarching lessons from the pilot include the importance of taking the time to build community relationships, listening to communities before suggesting solutions, and proceeding at the "speed of trust" when working with historically underserved and overburdened communities, only moving forward with projects and initiatives when communities have developed trust and feel comfortable with the community engagement liaison. Pilot results show that liaisons engage communities at higher levels of collaboration and governance compared to other CC&C coalitions by adhering to these key points, ensuring that procedural justice is incorporated into project design and implementation.

Rebrand Better Reflects CC&C Partnership's Focus on Clean Transportation and the Diversity of Areas Coalitions Serve

- **What To Know:** NREL rapidly implemented a rebrand of CC&C that will improve national branding efforts, raise visibility, and bolster the understanding of and support for the partnership's impact and value. This work built on extensive market research and interviews conducted by DOE and the marketing firm LMD Agency. NREL's expertise and deep history with CC&C provided the trust needed to achieve a successful rebrand on an aggressive timeline. NREL developed the visuals, messaging, and communications resources to support the new name and redesign of a brand with a 30-year history, with buy-in from DOE, multiple national labs, and more than 75 CC&C coalitions with nearly 20,000 stakeholders.
- **How It Will Play Out:** NREL developed a national-level branding strategy and promotional campaign that will expand partnership impact by increasing the awareness of coalition impacts and engaging new stakeholders in years to come.

Integrated on-demand transit could connect the first and last miles of a traveler's journey with other modes and be a primary transit option in less dense communities.



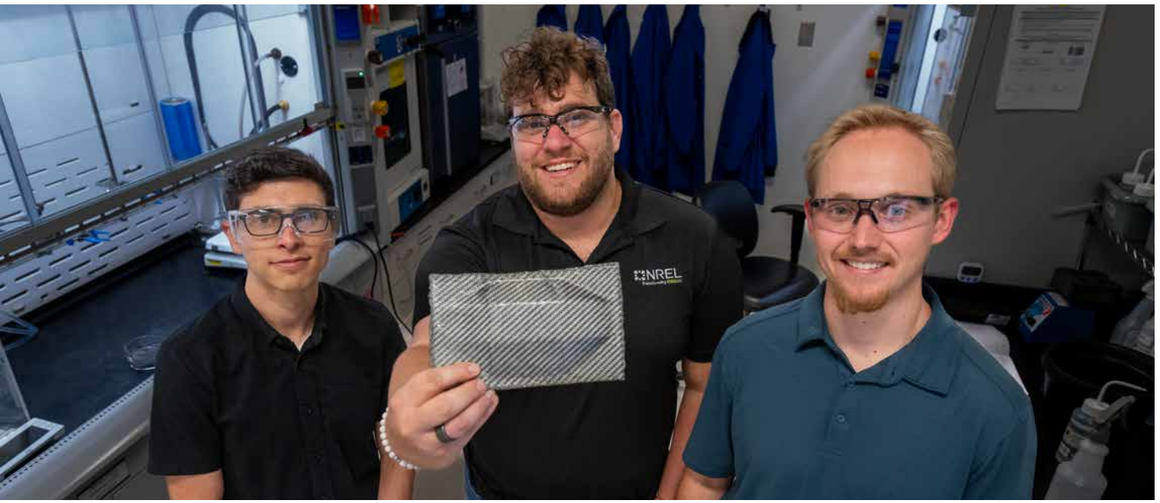
Redesigned CC&C landscape and logo.

Through Technologist in Communities, NREL Advances Equitable, Effective Public Mobility Solutions

- **The Latest:** A series of NREL case studies through 2024 (Innisfil, Ontario; Fort Erie, Ontario; Arlington, Texas; and St. Louis, Missouri) demonstrated that on-demand mobility's ability to quickly recalculate and optimize routes and provide first- and last-mile service makes it adaptable to rural, suburban, and urban communities alike, with potential energy benefits, increased ridership, increased travel speed, reduced wait time, and reduced costs.
- **Expert Analysis To Guide Decision-Making:** Later this year, NREL will release the third edition of its automated mobility district catalog on the principles, data, research, and other aspects of fully automated mobility services (get ready by revisiting the second edition). The catalog provides a system-level framework for city transit operators and planners to prepare for optimally leveraging future automated vehicle technology for equitable and efficient public mobility.
- **What Else To Know:** NREL's Technologist in Communities work prioritizes balancing time, cost, and energy, partnering with communities to maximize equitable and effective mobility and minimize and manage risk associated with new technology.

Piecing Together a Sustainable Future: Impactful Publications Provide Insights From Nanoparticles to the Grid

In the ever-evolving landscape of scientific innovation, NREL's publications reflect the depth and breadth of the day-to-day work to advance the lab's mission: delivering solutions for a clean energy economy. Like pieces of an intricate puzzle, each publication serves as an essential piece of the whole, from developing nanoscale particles that improve batteries to large-scale analyses that guide an equitable, decarbonized energy future. With 69 peer-reviewed articles in high-impact journals like Nature Communications, ACS Energy Letters, Energy Storage Materials, and Matter, as well as 40 NREL-authored reports with more than 21,000 lifetime downloads, NREL's scientific publications address the complex challenges of our time, piecing together a more sustainable future.



"Boron–Silicon Alloy Nanoparticles as a Promising New Material in Lithium-Ion Battery Anodes"

(doi.org/10.1021/acsenergylett.4c00856)

ACS Energy Letters (impact factor: 19.3) | NREL authors: *Gregory Pach, Pashupati Adhikari, Avtar Singh, Ankit Verma, Andrew Colclasure, Jae Ho Kim, Glenn Teeter, Nathan Neale, and Gerard Carroll*

Silicon's potential to replace graphite as a higher-energy-density material for lithium-ion battery anodes is hindered by its reactivity. To address this, NREL partnered with Pacific Northwest National Laboratory and Oak Ridge National Laboratory to introduce an innovative approach by alloying silicon with boron, creating boron/silicon nanoparticles synthesized via plasma-enhanced chemical vapor deposition. These nanoparticles exhibit altered electronic structures that demonstrate outstanding cycle stability with minimal capacity fade or impedance growth when integrated into lithium-ion battery anodes. Detailed electrochemical and microscopic characterization further suggest that electrolyte degradation is virtually nonexistent. This unconventional strategy offers a promising avenue for high-performance lithium-ion battery anodes with the potential for rapid scale-up, marking a significant advancement in silicon anode technology.

"Quantifying the Impact of Operating Temperature on Cracking in Battery Electrodes, Using Super-Resolution of Microscopy Images and Stereology"

(doi.org/10.1016/j.ensm.2023.103036)

Energy Storage Materials (impact factor: 18.9) | NREL authors: *Donal Finegan, Peter Weddle, and Kandler Smith*

A significant factor limiting battery lifetimes is structural degradation of the electrode material, which can be affected by the operating temperature of the battery itself. To further quantify this phenomenon, this study employed scanning electron microscopy of cross-sectioned electrodes to determine structural changes such as global particle porosity, crack size distribution, and porosity and specific surface area distribution of individual particles. The results uncover important insights about battery electrode degradation, setting the stage for future optimized materials that can provide longer lifetimes and fast-charge capabilities.

"Synthesis, Characterization, and Recycling of Bio-Derivable Polyester Covalently Adaptable Networks for Industrial Composite Applications"

(doi.org/10.1016/j.matt.2023.10.033)

Matter (impact factor: 17.3) | NREL authors: *Chen Wang, Avantika Singh, Erik Rognerud, Robynne Murray, Grant Musgrave, Morgan Skala, Paul Murdy, Jason DesVeaux, Scott Nicholson, Kylee Harris, Alison Shapiro, David Barnes, Ryan Beach, Robert Allen, Gregg Beckham, and Nicholas Rorrer*

Fiber-reinforced polymers can advance decarbonization by lightweighting transportation applications and enabling robust wind turbines. However, their current manufacture and inability to be reused contributes to growing material waste and continued GHG emissions. To decarbonize the composite manufacturing sector, NREL is leveraging bio-based epoxies and anhydrides to make polyester covalently adaptable networks (PECANs) that maintain their requisite performance while being depolymerizable using inexpensive reagents, resulting in completely recyclable resins.

"Exploring Decarbonization Pathways for USA Passenger and Freight Mobility"

(doi.org/10.1038/s41467-023-42483-0)

Nature Communications (impact factor: 14.7) | NREL authors: *Christopher Hoehne, Matteo Muratori, Paige Jadun, Arthur Yip, Catherine Ledna, and Laura Vimmerstedt*

Passenger and freight travel are among the largest contributors to GHG emissions, so eliminating their tailpipe emissions is a major step on the road to complete decarbonization. This study performed more than 2,000 simulations in NREL's Transportation Energy and Mobility Pathway Options (TEMPO™) model to determine what pathways can achieve the goal of reducing emissions by 80% or more by 2050. Analyzing 50 such deep decarbonization scenarios in detail, the researchers show that rapid adoption of zero-emission vehicles is essential alongside a simultaneous transition to a clean electric grid. Equally important is managing travel demand growth, which would reduce the amount of clean electricity supply needed. Fundamentally, the researchers demonstrate that the most dynamic variable in reducing total transportation-related emissions are measures to support the transition to zero-emission vehicles, highlighting this as an important focus for policymakers.

LA100 Equity Strategies

(www.nrel.gov/docs/fy24osti/85960.pdf)
NREL technical report | NREL authors: *Kate Anderson, Megan Day, Patricia Romero-Lankao, Sonja Berdahl, Thomas Bowen, Garvin Heath, Bryan Palmintier, Ashreeta Prasanna, Vikram Ravi, Janet Reyna, Dong-Yeon Lee, Nicole Rosner, Noah Sandoval, Ashok Sekar, Christina Simeone, Katelyn Stenger, Bingrong Sun, Alana Wilson, Sherin Ann Abraham, Lis Blanco, Greg Bolla, Paritosh Das, Paul Denholm, Kapil Duwadi, Anthony Fontanini, Ry Horsey, Gayathri Krishnamurthy, Yun Li, Lixi Liu, Jane Lockshin, Jeff Maguire, Isaias Marroquin, Meghan Mooney, Kinshuk Panda, Joe Robertson, Kwami Senam Sedzro, Julien Walzberg, Philip White, and Daniel Zimny-Schmitt*

The Los Angeles 100% Renewable Energy Study (LA100), commissioned by the Los Angeles Department of Water and Power (LADWP) and published by NREL in 2021, charted a roadmap to 100% renewable energy in Los Angeles by 2045. But NREL's work didn't end there. Although all communities will share in the benefits of the clean energy transition, improving equity requires intentionally designed policies and programs. To answer this call, NREL led the LA100 Equity Strategies project to analyze how LADWP programs can be improved or expanded to achieve equity for disadvantaged communities, incorporating what community members themselves feel is needed to achieve more equitable outcomes. Among the many areas of focus, Chapter 10: Household Transportation Electrification details strategies to increase equity in household transportation electrification, including adoption of new and used EVs, access to charging infrastructure, and expanding transportation electrification benefits to households who do not own vehicles or cannot afford to purchase an EV.

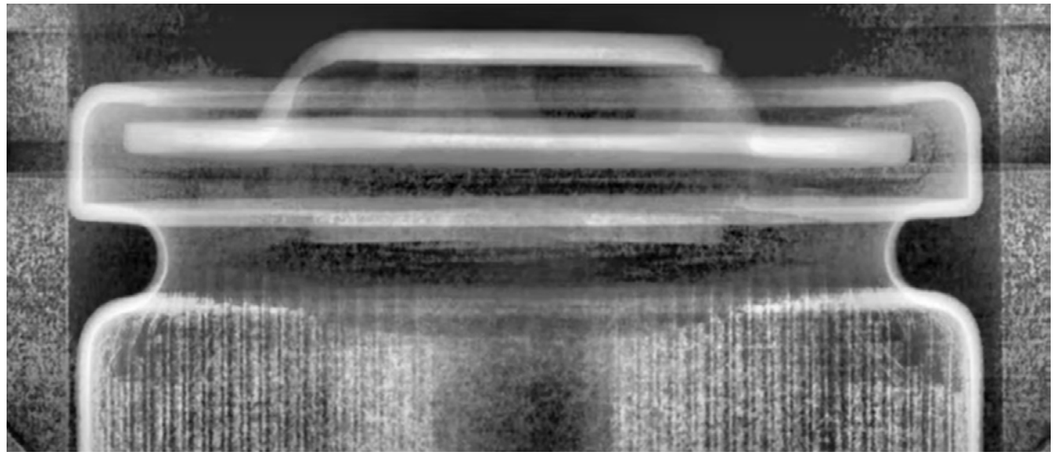
Multi-State Transportation Electrification Impact Study: Preparing the Grid for Light-, Medium-, and Heavy-Duty Electric Vehicles

(doi.org/10.2172/2329422)
DOE technical report | NREL authors: *Eric Wood, Brennan Borlaug, Killian McKenna, Jeremy Keen, Bo Liu, Jiayun Sun, Dave Narang, and Lawryn Kiboma*

Consumer and fleet demand for plug-in EVs is expected to rise—requiring new charging networks and clean electricity infrastructure to power it. To guide utility distribution plans for this new infrastructure, NREL partnered with DOE, LBNL, and Kevala to assess the charging and grid infrastructure needed across five representative U.S. states that illustrate the nation's diverse travel demands and utility infrastructure: California, Illinois, New York, Oklahoma, and Pennsylvania. The study estimates the investments in charging and electrical infrastructure needed to support increased EV adoption and explores strategies to manage load and benefits to the electric system, allowing the conclusions to guide investments at a national scale.

Strategic Research Partnerships Drive Transportation Decarbonization Impacts

NREL's cutting-edge research capabilities and technical expertise make the lab an indispensible partner across many strategic partnerships aiming to solve some of the nation's most complex transportation and mobility challenges. In FY 2024, NREL continued or initiated 104 strategic partnerships with leading industry, government agency, and research entities. These partnerships resulted in numerous sustainable transportation initiatives, including battery lifetime modeling software to simplify transitions to lithium-ion batteries and develop a deeper understanding of the potential impact of electric aircraft at regional airports.



A time-stamped radiograph from a video shows the propagation of thermal runaway inside an 18650 cell. Here you can see the inside of the cell reacting to thermal triggers.

NREL and NASA Partner To Improve the Safety of Lithium-Ion Battery Packs for Aerospace Applications

- **The Details:** NREL is using high-speed X-ray imaging combined with in situ calorimetry to understand how thermal runaway initiates and propagates throughout battery cells. This will inform what thermal management solutions are needed to prevent propagation inside a battery pack for aerospace applications with NASA. As part of this partnership, NREL and NASA developed the Battery Failure Databank to provide open access to a large dataset of thermal behavior of cells during thermal runaway in high detail.
- **Why It Matters:** NREL is contributing its expertise to develop a deep understanding of the ways in which batteries fail and how to engineer solutions to prevent the occurrence of catastrophic thermal runaway propagation.
- **What's Next:** The lab will continue to expand the Battery Failure Databank in the near future. The resource provides engineers and researchers with data to help guide their cell selection decisions, acting as a benchmarking resource for their own internal evaluations and further deep-dive analyses.

Australian Department of Defence Partnership Supports Replacement of Lead Acid With Lithium-Ion Batteries by Predicting Battery Lifetimes

- **What Happened?** Researchers are using NREL's VTO-funded Battery Lifetime Analysis and Simulation Tool (BLAST-Pack) suite to analyze degradation mechanisms and create lifetime aging models for three lithium-ion battery chemistry options for the Australian Department of Defence, replacing lead-acid battery technology.
- **What's Next?** NREL is further customizing the battery life cycle prediction software for the Australian Department of Defence, creating training materials and user-friendly software to allow the department to perform their own analysis of additional battery aging datasets.
- **The Impact:** BLAST-Pack will quickly and easily enable agencies and companies to assess the cost-effectiveness and feasibility of replacing older battery technologies with more energy-efficient options. The software reduces the number of experiments that must be run to prove out the new technology. System design considerations such as cell balancing, thermal management, and operational charge/discharge strategies can all be tested virtually using BLAST-Pack rather than experimentally, saving significant cost and time.

NREL researchers partnered with Xcel Energy to use NREL's EVI-DiST to provide standards development guidance on infrastructure upgrades to prepare for growing EV charging loads.

NREL's Grid-Scale EV Charging Tool Enables Xcel Energy To Pinpoint Strategies for Managing Expected EV Charging Loads at Scale

- **What To Know:** NREL researchers have developed the Electric Vehicle Infrastructure – Distribution System Integration Tool (EVI-DiST) to provide standards development guidance for Xcel Energy on infrastructure upgrades in response to incoming EV charging loads.
- **How?** EVI-DiST can illustrate EV charging grid impacts at the feeder level down to detailed secondary models at the residential and commercial building level. It is informing Xcel Energy's regional grid planning efforts in more than five states.
- **Beyond the Infrastructure:** The project is supporting Xcel Energy in evaluating the effectiveness of possible SCM solutions to mitigate peak loads and be responsive to growing electrical demand.

NREL Partnerships With NASA, Colorado Department of Transportation Assess Electric Aircraft Impacts on Airport Infrastructure

- **What's Happening:** Through several projects in partnership with NASA and the Colorado Department of Transportation, NREL is studying how and where certain airports could deploy electric aircraft, as well as the infrastructure and policy implications of expanded electric aircraft charging needs. This complements multiyear efforts with the Federal Aviation Administration's Office of Airports and the Air Traffic Organization, informing advanced air mobility and hydrogen infrastructure efforts.
- **The Details:** NREL is supporting NASA's Airports as Energy Nodes project through airport and infrastructure modeling, power system modeling, and real-time airport digital twin simulation for both supply and demand. In a separate partnership with the Colorado Department of Transportation, NREL is providing supply and transportation demand modeling tools to evaluate where new aircraft technologies for regional air mobility and flights schools might be deployed in Colorado and identify potential infrastructure, policy, and regulatory implications.
- **Strategic Future Planning:** NREL's analyses and modeling will inform policy, infrastructure development, and funding conversations, with the goal of helping airports prepare for the widespread use of electric aircraft in a variety of airport and community energy scenarios.

NREL researchers took the Infrastructure Perception and Control laboratory trailer on the road to collect real-world mobility data.

City of Colorado Springs Partnership Expands NREL Research Capability To Assess Potential for Advanced Traffic Control, Optimization, and More

- **What Happened:** Researchers took a specialized trailer that transports and deploys NREL's infrastructure perception and control technologies on an inaugural trip to Colorado Springs, Colorado. NREL collected data in partnership with the city, which received a U.S. Department of Transportation "Strengthening Mobility and Revolutionizing Transportation" grant for integrating advanced sensing into the city's traffic control systems to improve transportation efficiency and safety.
- **How It Worked:** The research team used the trailer to deploy lidar and radar sensors and interface with an on-site traffic control cabinet to collect real-world mobility data.
- **The Impact:** NREL researchers refined their data capture framework using this process, furthering NREL's infrastructure perception and control open-source data fusion framework, sensor data schema standardization, and application of advanced 3D trajectory data for traffic, energy, and safety applications.

NREL Research Continues To Bolster Google Maps' Eco-Friendly and EV-Specific Features

- **The Background:** NREL supported the global expansion of Google Map's eco-friendly routes product, modeled after the lab's Route Energy Prediction Model (RouteE) powertrain methodology, using the Future Automotive Systems Technology Simulator (FASTSim™) to model representative passenger vehicles around the world. Google estimates the eco-friendly routing option reduced on-road carbon dioxide (CO_2) emissions in the United States by an estimated 1 million metric tons as of 2022, and that impact has increased significantly in the years since.
- **What's Happening Now:** In the past year, NREL has supported energy modeling for battery-electric vehicles that enhances some of the new EV-specific features in Google Maps, including suggested charging stops based on a vehicle battery's charge level, forecasted energy consumption, impacts of weather on EV range, and more.
- **Why It Matters:** Drivers using Google Maps will be able to plan their EV trips more easily, gain reassurance of charging availability, and overcome knowledge barriers to traveling in EVs such as familiarity with charger power levels and awareness of battery depletion.

A new silicon carbide (SiC)-based inverter design from NREL's power electronics researchers will give U.S. military ground combat vehicles 200% greater range at a fourth of the size of predecessor technology

NREL Selected To Design Next-Generation Power Inverters for U.S. Combat Vehicles

- **What Happened:** NREL will redesign the traction inverter in U.S. ground combat vehicles, a device that controls the flow of electricity between a vehicle's battery and the traction motor and manages bidirectional power to and from the drivetrain. The new silicon carbide (SiC)-based propulsion system will double the length of time Army vehicles can stay in the field before refueling, with a footprint four times smaller than its predecessors. Researchers will capitalize on multiple prior NREL technical innovations to design this high-performance inverter.
- **How:** NREL's power electronics researchers will develop a SiC-based power inverter called PICHOT (pronounced "pea-ko"): a power inverter that is compact in scale and functions at a high operating temperature. The inverter will be designed, fabricated, and characterized in-house at NREL facilities prior to evaluation at the U.S. Army's Ground Vehicle Systems Center.
- **A New Power Electronics Frontier:** PICHOT will not need a separate cooling system as commonly used in conventional inverters, instead linking to the existing engine coolant system to eliminate extra weight, and will remain fully functional at high temperature. The new inverter will be smaller, easier to install, and able to monitor its own state of health to predict failures before they happen. The final design will have the potential to be leveraged in multiple kinds of U.S. military ground combat vehicles.

NREL researchers Francois Usseglio Viretta (left) and Ankit Verma (right), members of the Silicon Consortium Project, examine a 3D data visualization of a battery microstructure in the Visualization Lab at NREL's Energy Systems Integration Facility (ESIF).

Consortia and Technical Leadership Accelerate Zero-Emission Transportation Future

Silicon-Enhanced EV Batteries

Advancements in lithium-ion battery designs are incorporating silicon as an alternative for traditional graphitic carbon in anode materials to enhance the energy density and extend the driving range of EVs. The NREL-led Silicon Consortium Project uses characterization and electrochemical modeling tools to overcome commercialization barriers, including extending calendar life. Funded by the U.S. Department of Energy's Vehicle Technologies Office, the consortium also includes Argonne, Sandia, Oak Ridge, Pacific Northwest, and Lawrence Berkeley national laboratories.

- **Activating Artificial Intelligence (AI):** NREL's modeling team applied machine-learning techniques to investigate the calendar life of silicon batteries, creating early-life prediction tools that identify key indicators that lead to battery lifetime degradation.
- **Piloting a New Production Process:** NREL researchers are developing new approaches to silicon battery designs that demonstrate a 50-fold increase in the amount of material that can be produced, advancing the production of silicon nanoparticles through plasma-enhanced chemical vapor deposition.
- **Stabilizing Silicon:** Boron-silicon alloy nanoparticles synthesized with plasma-enhanced chemical vapor deposition demonstrated outstanding cycle stability with minimal capacity fade or impedance growth.

Inside the battery energy storage system at the Golden Valley Electric Association's (GVEA's) facility in Fairbanks, Alaska. Behind-the-Meter-Storage systems such as this one can help manage demand charges, provide continuous energy supply during power outages, enable EV fast charging, and more.

Behind-the-Meter Systems Offer Energy Storage Synergy

To minimize costs and reduce grid impacts associated with nationwide electrification initiatives, NREL researchers are combining the benefits of fast charging for EVs, photovoltaic (PV) energy generation, and flexible building loads as part of DOE's Behind-the-Meter Storage (BTMS) Consortium. Along with new state-of-health monitoring techniques, these breakthroughs will help ensure that BTMS battery systems are safe, reliable, and affordable energy storage options. NREL leads BTMS Consortium research, which involves scientists and engineers from across NREL as well as from other U.S. Department of Energy laboratories, including Idaho National Laboratory, Sandia National Laboratories, and Argonne National Laboratories. The consortium's research is funded by the Department of Energy Vehicle Technologies Office.

- **Safety First:** While NREL experts are exploring all facets of BTMS systems, from materials and complete system design to controls, battery researchers are focusing on identifying the safest possible designs for stationary systems.
- **Limiting the Impacts of Thermal Events:** In one recent approach, researchers isolated cells to prevent propagation, isolating adjacent cells to prevent thermal runaway and catastrophic failure.
- **Flame-Resistant Battery Designs:** In addition, NREL researchers found that several nonflammable electrolytes, including organophosphorus and hydrofluorocarbon formations, promote anode passivation and deliver similar cycling stability to conventional electrolytes over 500 cycles.

Matt Bruchon, EVs@Scale Lab Consortium member, presents data findings from consortium SCM and grid integration research pillar project Flexible charging to Unify the grid and transportation Sectors for EVs at scale (FUSE).

VTO Electric Vehicles at Scale (EVs@Scale) Lab Consortium

The NREL-led EVs@Scale Lab Consortium brings together seven national laboratories—ANL, INL, NREL, LBNL, ORNL, Pacific Northwest National Laboratory, and Sandia National Laboratory—and key stakeholders to conduct EV charging and grid integration R&D that will support the creation of a secure and scalable U.S. charging network for light-, medium-, and heavy-duty EVs.

NREL Leads EVs@Scale Consortium Outreach

- **Events:** NREL hosted the consortium's fourth semiannual stakeholder meeting to identify R&D opportunities alongside thought leaders from industry, academia, and more.
- **Publications:** The consortium's third year of R&D is documented through several publications and presentations, including a series of reports on all high-level findings from the Next-Generation Profiles (NextGen Profiles) project.

EVs@Scale Technical Achievements

- **High-Power Charging:** NREL's consortium team produced a report that details the design and development process of a kilowatt-scale, direct-current (DC) charging hub platform that can integrate various DC-DC converters connected to a common DC distribution system. This will prove vital for designing and validating efficient, low-cost, and interoperable hardware for next-gen, heavy-duty EVs.
- **SCM:** To forecast the value potential of SCM, the NREL consortium team developed multiple SCM controls that address these challenges as identified in past analysis simulations and updated the controls to demonstrate the performance capabilities of SCM in a laboratory environment.
- **Characterization and Modeling:** The NREL consortium team also completed two nominal-temperature and two off-nominal-temperature electric vehicle supply equipment (EVSE) performance characterization tests. The team is also leveraging prior work with the EVI-X modeling team to actively develop new capabilities, numerical algorithms, and computational tools as part of a toolkit that will be publicly released

Entrepreneurs Identify Breakthrough Battery Recovery Solutions

Now in its sixth year, the DOE Lithium-Ion Battery Recycling Prize aims to develop and demonstrate processes that, when scaled, have the potential to capture 90% of all discarded or spent lithium-ion batteries in the United States for eventual recovery of key materials for reintroduction into the supply chain.

- **Incentivizing New Submissions:** The two-track Breakthrough contest design helped bolster participation from new competitors while providing an additional $100,000 in voucher support to Phase III winning teams.
- **Getting the Word Out:** NREL prize administrators provided ongoing outreach to prize stakeholders, including new competitors, verified competitors, and industry organizations at numerous industry events, including the NAATBatt International Annual Meeting and the International Battery Seminar.
- **Verifying Solution Impacts:** A critical component of the upcoming Phase IV of the prize required teams to partner with pre-approved Evaluation Entities to verify the impact of their proposed solution.

NREL Propels Transportation & Mobility Priorities

A future, large-scale multimodal charging hub for zero-emission vehicles like this one may one day become reality, thanks to research efforts funded through the Joint Office of Energy and Transportation.

Joint Office of Energy and Transportation

NREL continued to support the Joint Office's efforts throughout 2024 to make zero-emission transportation available to all Americans. Namely, NREL researchers helped advance the Joint Office's mission by providing technical assistance to states, communities, Tribal nations, school districts, and transit agencies, and supported the National Charging Experience (ChargeX) Consortium's work to improve the customer charging experience.

Technical Assistance Advances the Planning and Deployment of Zero-Emission Transportation Infrastructure

- **Concierge Service**: NREL, along with subcontractor ICF, has managed the Joint Office's Technical Assistance Concierge, providing stakeholders with unbiased, free, and customizable technical assistance to help accelerate the advancement of zero-emission vehicles and infrastructure. As of June 30, 2024, the concierge had processed 1,763 requests from states, communities, Tribal governments, transit agencies, and school districts.
- **New Technical Assistance Resources**: NREL led the development of 13 technical assistance help sheets that cover a wide range of topics from operating transit and school buses in extreme weather conditions to leveraging battery energy storage in grid-constrained regions and a high-level technical assistance overview.
- **In-Depth Support and Analysis for States**: NREL has played a vital role in providing technical assistance to states planning and building out infrastructure funded by the Joint Office's National Electric Vehicle Infrastructure (NEVI) Formula Program. NREL researchers completed a deep-dive technical assistance request with the Utah Department of Transportation to develop strategies that can assist states with evaluating battery-buffered options for remote EV charging infrastructure.
- **School Bus Electrification Efforts**: NREL technical assistance experts launched several resources and initiatives to help school districts transition to electric fleets in support of the EPA. These include the Electric School Bus Forum, Clean Bus Planning Awards, Electric School Bus Data Logging, and the launch of the Electric School Bus Familiarization Webinar Series.

NREL Senior Researcher Abby Brown spoke with attendees about school bus electrification technical assistance capabilities on behalf of the Joint Office of Energy and Transportation at the 2024 STN Expo held in Reno, Nevada.

Support for ChargeX Consortium Identifies Best Practices To Improve the Charging Experience

- **The Background**: NREL leads the ChargeX Consortium's working group focused on triage charging reliability and usability.
- **What Happened?** Key outputs from the past year include a report on best practices for payment systems, an adapter safety report, and the successful seamless retry demonstration at the CharIN Testival that identified a method to retry failed charging sessions without requiring the user to unplug and re-plug their vehicle.
- **On the Horizon**: NREL researchers will be publishing two reports on recommendations for seamless retry and charging timeouts. These reports aim to address time-consuming charging processes to improve reliability and enhance the charging experience.

EVSE Soft Costs and Visualization Effort

- **What to Know:** In 2024, NREL completed the first phase of a multi laboratory EVSE soft costs project for the Joint Office. The project is identifying pathways to reduce soft costs through a data-driven approach in collaboration with industry stakeholders.
- **The Details:** Leveraging learnings from the novel NREL-led soft cost analysis project that helped achieve cost reductions for solar technologies over the past decade, the team developed a comprehensive framework for benchmarking, tracking, and reducing EVSE soft costs that will be refined in the coming years.
- **Why It Matters:** The team analyzed more than 4,000 station build-out invoices to benchmark EVSE soft costs for light-duty vehicles and identify avenues to reduce these costs for the efficient deployment of a nationwide charging network. As the project moves forward, the research team continues to develop a visualization for an initial cost model that can incorporate various uncertainties of key inputs from stakeholder interviews.
- **Related News:** Additionally, the research team is developing a website, reports and publications, and a series of infographics based on the data collected for public use to provide insight into variations and dependencies in project cost categories for benchmarking and identifying EVSE soft costs baselines not only for light-duty vehicles, but also medium- and heavy-duty vehicles in the near future.

NREL is helping the EV charging industry streamline installation to reduce barriers to mass adoption.

Participation in National Climate Assessment Highlights NREL's Broad Sustainability Expertise

- **What To Know:** Three NREL researchers, including NREL distinguished researcher and group manager Matteo Muratori, contributed to the Fifth National Climate Assessment. The landmark publication, released approximately every 4 years, evaluates the state of the science and current impacts of climate change in the United States.
- **Why It Matters:** The National Climate Assessment serves as a mechanism for experts to provide insights for decision makers working on climate policies around the country and globally. NREL's cross-cutting research addresses many of the concerns highlighted in the report—from climate impacts on power systems and the energy transition to sustainable transportation and resilience.
- **The Bigger Picture:** NREL's expert contributions to the assessment provide pioneering science, techniques, and analysis to enable leaders to make informed decisions on a most urgent problem.

NREL Expertise Supports Data-Driven Decisions in Federal Fleet's Transition to Zero-Emission Vehicles

- **The Backstory:** An NREL transportation deployment team, including Ted Sears, senior project leader on assignment to the White House Council on Environmental Quality, continues to provide federal agencies with hands-on support to help transition their fleets to zero-emission vehicles.
- **The Latest:** Key to this support is NREL's development of two new online resources—the ZEV Ready Center, which features a 15-step guide to help fleet and facility managers select and acquire EV and charging infrastructure options that best fit their needs; and the Electric Vehicle Infrastructure-Locally Optimized Charging Assessment Tool and Estimator (EVI-LOCATE), which offers insight into identifying suitable charging station locations, as well as installation design, deployment, and cost.
- **A Step Beyond:** Sears is also providing technical expertise to the U.S. Department of the Treasury as it develops regulations and guidance associated with the clean energy tax credits authorized by the Inflation Reduction Act.

NREL Experts Accelerate Electrification of Department of Defense (DOD) Vehicle Fleets

- **What's Happening:** NREL fleet electrification experts are helping federal agencies like DOD transition their nontactical vehicle fleets to EVs. The NREL team's cross-cutting expertise, advanced tools, and longtime experience have made them the go-to resource for strategies for vehicle electrification and efficient selection and siting of EV charging stations.
- **The Impact:** NREL is helping DOD fleet managers and working particularly closely with the U.S. Army to sustainably grow and manage their EV fleets. In a single year from 2021 to 2022, NREL researchers helped increase EV acquisitions in federal fleets by 500%. In the Army alone, 27% of the new or replacement light-duty vehicles like sedans, minivans, and pickup trucks ordered in 2022 were EVs, up from just 1% the year before.
- **Benefits for Everyone:** NREL developed the Zero-Emission Vehicle Planning and Charging tool, NREL's marquee EVI-X modeling suite of EV charging infrastructure analysis tools, and EVI-LOCATE with funding at least in part from DOD. In future iterations, these tools will allow all stakeholders to plan for commercial charging stations.

NREL fleet electrification experts are partnering with the U.S. Army and other agencies within the DOD to accelerate transitioning their nontactical vehicle fleet to electric, like this vehicle plugged into a solar-powered charging station at Joint Base Pearl Harbor-Hickam.

Capability Investments in Support of Clean Transportation

Equipment and Facility Investments Expand Transportation and Mobility Research Capabilities

NREL is enhancing its world-class facilities from the bench scale to the utility scale in support of new transportation advances from the road to the skies.

Energy Storage

- **The Latest:** Work in the Research and Innovation Laboratory (RAIL) has focused on the development of two cell fabrication lines—one for lithium-sulfur batteries and one for lithium-ion batteries—replete with gloveboxes to put the cells together. Battery cyclers and environmental chambers are also being added to the space to help with cell performance evaluations.
- **All About RAIL:** The laboratory houses multipurpose and "wet" lab space for research in next-generation batteries, advanced energy materials, and other technologies. The 15,000-square-foot building also provides space for cross-disciplinary collaboration.
- **In the Works:** Meanwhile, redesign plans are well underway for transforming NREL's Thermal Test Facility to accommodate equipment currently housed in various locations across campus.
- **What's Next:** The consolidation of equipment will form the backbone of a new coin cell and pouch cell testing lab. The new lab will enable long-term cell cycling to improve understanding of battery lifetimes across chemistries and formats.

Power Electronics and Electric Machines

- **Powering Capabilities:** Several pieces of new equipment have enhanced NREL's research capabilities in the advanced power electronics and electric machines arena.
- **Up First:** The SIGNATONE PowerPro probe station is a high-power semiconductor device measurement system capable of characterizing bare semiconductor devices at voltages up to 10 kV and currents up to 4 kA. NREL researchers can use the probe station to characterize both existing and novel power semiconductor devices.
- **Next:** The Ultimaker Factor 4 is an industrial-grade 3D printer capable of printing a unique range of composite plastics, including carbon-fiber-based plastics. The printer will increase the speed at which researchers can fabricate and assess prototype designs by allowing them to print metal-equivalent parts on demand.
- **And Finally:** The Tekscan Pressure Mapping System provides real-time pressure feedback to quickly validate experiments requiring uniform pressure distribution, such as those employing the NREL-developed sintering hot press. The Glowforge Plus Laser Cutter enables researchers to rapidly make solder masks, customized printed circuit board templates, and other items requiring a high level of cutout precision.

Sreekant Narumanchi (left) and Joshua Major (right) are pictured next to a newly installed Signatone PowerPro probe station.

Rendering of the EMAPS facility.

Groundbreaking for New Research Facility

- **What's Happening?** A groundbreaking ceremony in September 2024 marked the start of construction for NREL's new Energy Materials and Processing at Scale (EMAPS) facility. Construction is slated for completion in 2027.
- **The Details:** Research at the facility will accelerate materials and process innovations in energy storage, advanced manufacturing, technologies for grid modernization, and net-zero chemicals and fuels for transportation and industrial decarbonization.
- **Zooming Out:** The 127,000-square-foot building will enable collaboration with industry partners, universities, and other national laboratories to accelerate innovations in energy materials to market-ready products and processes.

Electric Vehicle Research Infrastructure (EVRI) Evaluation Platform Evolves To Address Critical Needs

The White House set a target for EVs to comprise 50% of all new vehicle sales by 2030 with the EV Charging Action Plan. To provide a continuum of critical capabilities that will enable EVs at scale, NREL continues to enhance its world-class facilities through a combination of internal and VTO investments from the bench scale to the utility scale. The laboratory's leading EVRI evaluation platform within the Energy Systems Integration Facility (ESIF) enables researchers and industry stakeholders to develop a new generation of electrified transportation technologies that integrate with buildings, energy storage, renewable power technologies, and others within the larger energy ecosystem.

NREL's Keith Davidson, a senior EV research engineer, works within the lab's state-of-the-art Electric Vehicle Research Infrastructure (EVRI) platorm. EVRI capabilities support NREL's Advanced Research on Integrated Energy Systems (ARIES) research platform one of several field research sites and facilities that work together to demonstrate the potential for renewable energy to power a large fraction of the country's transportation needs with high-power EV charging in concert with electrified buildings and a healthy, resilient grid.

World-Class Facilities

NREL continued to add advanced equipment within the EVRI evaluation oplatform in 2024, enabling continued growth of its innovative, systems-integrated research.

- **The Vehicles:** A Hummer EV was added to the EVRI's vehicle lineup, which interfaces with the chargers installed at the ESIF and represents a 350-kW charging vehicle that researchers expect to see more of on roads in the future.
- **The Software:** NREL continued to refine its in-house emulation system, which enables enhanced power-hardware-in-the-loop studies as well as the emulation of EV batteries and battery management systems. The innovative emulation system allows researchers to perform dynamic evaluations of charging systems for any battery chemistry and charging protocol.
- **The Hardware:** NREL procured customized DC-DC charging systems to support the development of next-generation, ultra efficient, high-power charging solutions.
- **Better Performance and Control:** NREL's megawatt-scale DC charging hub platform integrates various DC-DC converters connected to a common DC distribution system, employing a DC-fed high-power charging unit in EVRI that enables broader system performance and control studies for DC-integrated charging systems.
- **Bigger Picture:** This type of charging equipment is vital for designing and validating efficient, low-cost, and interoperable hardware for the next generation of heavy-duty EVs to operate and will accelerate the adoption of these EVs and their infrastructure. In FY25, NREL will continue investments in state-of-the-art capabilities through an expansion of the medium-voltage outdoor test area at ESIF.

Empowering Partners

Various partnerships and stakeholder events leveraged NREL's capabilities throughout the year to help accelerate the creation of a comprehensive national charging network.

- **Standards Research:** NREL supported the Joint Office's ChargeX Consortium and UL2251, UL2252, and SAE J3400 standards development by conducting thermal and mechanical evaluations of Combined Charging System (CCS) and North American Charging Standard (NACS) connectors, inlets, and adapters, with evaluation scope expanding to include prototype and production CCS/NACS components from more than 12 manufacturers. The shift to these standards is expected to enhance charging infrastructure, providing a better customer experience by making it easier for all EV drivers to access a wider network of DC fast chargers.
- **Interoperability Research:** Manufacturers evaluated interoperable designs for vehicle inlets and charger connectors with the EVRI's thermal evaluation benches for characterizing air- and liquid-cooled charging connectors for 350–3,000 A. NREL's evaluation events provided a platform for researchers and industry participants to evaluate, discuss, and improve the technical merits of different equipment parameters and standards.
- **Multi-Vehicle-Class Research:** NREL validated safety and durability within the Megawatt Charging System (MCS) standard for medium- and heavy-duty EVs. These activities enable researchers and industry stakeholders to study and develop a new generation of electrified transportation technologies within the context of the larger energy ecosystem.

An aerial view of the BTMS infrastructure build-out at NREL's Flatirons Campus.

Why It Matters

NREL's expanded research efforts to enable high-power charging research at scale and in real-world conditions.

- **The Platform:** The lab's advanced ARIES research platform continues to expand its world-class megawatt charging and grid integration capabilities for enabling the electrification of commercial vehicles and beyond.
- **The Progress:** This year, NREL started construction of a megawatt-scale charging site that will include DC emulation of multimegawatt battery systems at up to 10 MW at the lab's Flatirons Campus in Arvada, Colorado, leveraging ARIES investments in the 20-MW controllable grid interface.
- **In Related News:** A recent SuperLab 2.0 demonstration showed that, using DOE's ESnet, NREL researchers can create "virtual proximity" with its ARIES platform and fellow DOE national laboratories' research capabilities, experimental sites, and user facilities. SuperLab 2.0 set the stage for 2025, when tens of thousands of devices across multiple laboratories could link together for highly complex, large-scale grid emulations that bring improved connectivity across NREL campuses and beyond.
- **What Makes It Unique:** NREL's leading-edge system has both DC and alternating-current (AC) emulation. Features include a sophisticated megawatt-scale BTMS system which includes megawatt-scale solar and storage, a megawatt-scale battery emulator, a DC-as-a-service microgrid and fast chargers, and megawatt-level charging evaluation and vehicle emulation capabilities. These features help evaluate systems at the megawatt scale.

Jesse Bennett (left) and Isaac Tolbert (right), NREL researchers, discuss prototype MCS connectors and inlets in the ESIF. The consortium's interoperability evaluations support the development of a "reference" inlet, which provides a known device against which connectors can be evaluated.

New Chief Transportation Strategist Aligns Mobility Research With Emerging Trends, Industry Needs

As mobility systems move toward a clean energy future, the transportation industry faces the critical challenge of turning innovative concepts into actionable solutions. As a result, thoughtful leadership, creative problem-solving, and united partnerships dedicated to navigating this challenge are essential to meet the demands of this evolving future.

In support of this transition, NREL's Center for Integrated Mobility Sciences tapped Wes Maurer in March 2024 to serve as its chief transportation strategist. In this role, Wes leads the development and implementation of the center's strategic plan, aligning research and deployment efforts with emerging trends and key industry needs. Furthermore, Maurer's depth of experience will support next-generation energy and transportation advancements through strategic collaboration, industry partnerships, and management of key initiatives. Prior to joining NREL, Maurer played pivotal strategy roles at the Colorado Energy Office, Colorado Department of Transportation, and National Science Foundation, where he pioneered programs and policies to advance energy, technology, and transportation systems. His most recent experience as a corporate vice president and national director in the architecture and engineering sectors further honed his expertise in public policy, emerging markets, public-private partnerships, and technical project delivery.

Wes Maurer

Award Recognition

Shashank Yellapantula Recognized as 2024 American Institute of Aeronautics and Astronautics Associate Fellow

Shashank Yellapantula, an NREL computational scientist, was recognized as a 2024 American Institute of Aeronautics and Astronautics associate fellow. The recognition is for contributions to the art, science, or technology of aeronautics or astronautics. Yellapantula leads projects in wind energy, solar energy, and biofuel combustion. He is also actively involved in reducing costs and risks associated with qualifying newer SAF candidates.

Shashank Yellapantula

Eric Wood Recognized With Energy Efficiency and Renewable Energy Assistant Secretary Award, VTO Distinguished Achievement Award

Eric Wood, a senior NREL EV charging infrastructure researcher, was part of the greater interagency team recognized with an Office of Energy Efficiency and Renewable Energy Assistant Secretary Award for outstanding efforts and technical contributions toward the successful release of nationwide light-, medium-, and heavy-duty emissions standards—the largest emissions rule ever issued to date by the Environmental Protection Agency. He also received a Distinguished Achievement Award at VTO's 2024 Annual Merit Review in recognition of his outstanding leadership and technical excellence in leading the DOE's Multi-State Transportation Electrification Impact Study to an "unmitigated success." The first-of-its-kind report directly supported not only DOE research goals, but also EPA and National Highway Traffic Safety Administration regulations for vehicle efficiency and emissions.

Eric Wood

Three NREL Researchers Honored With Secretary of Energy Achievement Award

NREL researchers Ted Sears, a senior project manager; Emily Kotz, a project manager; and Lissa Myers, a project leader, were recognized with Secretary of Energy Achievement Awards, the highest form of recognition for federal and contractor employees within DOE. Sears was awarded for his work as part of the Inflation Reduction Act Energy Tax Credit Tiger Team. Kotz and Myers were praised by Deputy Secretary of Energy David Turk for their "dedication to pursue an ambitious strategy to meet an executive order requiring federal agencies to reach 100% zero-emission vehicle acquisitions by 2030."

Ted Sears

Emily Kotz

Lissa Myers

Gilbert Moreno Elevated to American Society of Mechanical Engineers (ASME) Fellow

Gilbert Moreno, an NREL power electronics and electric machines researcher, was elevated to an ASME fellow. The honor, granted to just 3% of ASME members, recognizes Moreno as an international authority in heat transfer who specializes in developing advanced thermal management technologies and packaging for power electronics and electric machines. Along with other NREL researchers, Moreno was also awarded a patent this year for methods and devices for cooling automotive power electronics modules.

Gilbert Moreno

Doug DeVoto Awarded 2023 ASME Excellence in Mechanics Award

In recognition of his body of work in accelerated testing, failure evaluation, and system reliability modeling for electric-drive vehicles, including electric cars and aircraft, NREL's Doug DeVoto has been awarded the 2023 Excellence in Mechanics Award by the Electronic and Photonic Packaging Division of ASME. DeVoto leads reliability and prognostics research for automotive power electronics within NREL's advanced power electronics and electric machines group and has collaborated with more than 50 universities, research institutions, and national laboratories on projects totaling more than $30 million in funding.

Doug DeVoto

Ahmad Pesaran Recognized With VTO Distinguished Achievement Award

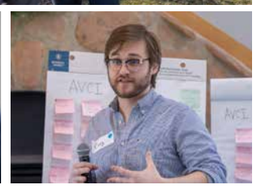
NREL's Ahmad Pesaran, chief energy storage engineer, received a Distinguished Achievement Award at VTO's 2024 Annual Merit Review in recognition of his more than 25 years of cutting-edge research in battery thermal management systems, battery calorimetry, and battery safety models and tools. Pesaran supports VTO with battery recycling projects, U.S. Advanced Battery Consortium battery processing and manufacturing projects, NAATBatt's Lithium-Ion Battery Supply Chain Database, and National Highway Traffic Safety Administration EV battery fires and safety investigations. He also serves on the electrochemical energy storage technical team and workgroups of the Driving Research and Innovation for Vehicle efficiency and Energy sustainability (U.S. DRIVE) program.

Ahmad Pesaran

Livewire Data Platform Team Recognized With VTO Team Award

NREL researchers Lauren Spath Luhring, a researcher and software developer; Joe Fish, a transportation research engineer; Andrew Kotz, commercial vehicle technologies team lead; Phillip Stewart, a software developer; and Jeffrey Gonder, mobility, behavior, and advanced powertrains group manager were among a multilaboratory team that received awards recognizing outstanding teamwork and technical expertise for their work on the Livewire Data Platform in support of VTO and its Energy Efficient Mobility Systems Program. The award highlighted how the team increased engagement and registered users.

PACCAR SuperTruck II Team Recognized With VTO Team Award



NREL researchers Ken Kelly, Chief Engineer for Commercial Vehicle Electrification; Mike Lammert, a commercial vehicle technologies researcher; Jason Lustbader, Advanced Vehicles and Charging Infrastructure group manager; Andrew Kotz, Commercial vehicle Technologies Team Lead; and Cory Sigler, a commercial vehicle technologies researcher—were recognized alongside partner organizations making up the PACCAR SuperTruck II team for their unique achievements in the field of heavy-duty engine and vehicle efficiency contributing to a more than doubling of freight truck ton-miles per gallon. The award recognized the team's achievements in identifying a representative highway test route for realistic on-road evaluation of SuperTruck II improvements and analyzing energy-saving cabin thermal management designs.

Margo Melendez Honored With NREL Van Morriss Award

Margo Melendez, recently named NREL's chief transportation technology deployment and integration engineer, was honored with the FY 2023 Van Morris Award at NREL's annual staff awards event. Melendez was previously the group manager for NREL's sociotechnical transportation engagement projects group. She led the group to new levels while also finding time to volunteer as the leader of the Hispanic and Latinx Alliance Employee Resource Group.

Margo Melendez

Sreekant Narumanchi Named NREL Distinguished Researcher

Sreekant Narumanchi, a senior researcher and a power electronics and electric machines group manager at the laboratory, has been named an NREL distinguished member of research staff. The honor recognizes Narumanchi's technical contributions and leadership in advanced packaging, thermal management, and reliability for power electronics and electric machines for electric-drive vehicles, as well as numerous energy efficiency and renewable energy applications. This year, Narumanchi was also named chair of the ASME Electronic and Photonic Packaging Division Executive Committee (July 2024–June 2025). In addition, he is serving as the chair of the IEEE Electronic Packaging Society Thermal Mechanical Technical Committee (2023–2025), associate editor of the ASME Journal of Electronic Packaging, and associate editor of the IEEE Transactions on Components, Packaging, and Manufacturing Technologies.

Sreekant Narumanchi

Shafquat Khan Elevated to Institute of Electrical and Electronics Engineers (IEEE) Senior Member

Shafquat Khan

In recognition of his significant contributions in the field of power electronics and renewable energy, NREL's Shafquat Khan, a researcher on the charging hardware for advanced research and grid impact evaluations team, has been elevated to a senior member of IEEE. Khan was recognized for his research contributions in EV-grid integration, control of power converters in wind turbine systems, and high-power DC charging infrastructure. His contributions are substantiated by numerous publications and patents, reflecting his technical leadership and innovation in the field.

Paul Paret Honored With IEEE Certificate of Distinguished Achievement

Paul Paret

Paul Paret, an NREL power electronics researcher, has been recognized by IEEE's Electronic Packaging Society with a distinguished achievement certificate. The certificate recognizes Paret's technical leadership, sustained contributions, and innovation in reliability, lifetime prediction, and thermal management of electronics packaging. Paret will have an opportunity to accept the award at the 2025 Electronic Components and Technology Conference.

Saad Akhtar Awarded Natural Sciences and Engineering Research Council of Canada Fellowship

Saad Akhtar

NREL commercial vehicle technologies researcher Saad Akhtar has been awarded a 2-year postdoctoral fellowship by the Natural Sciences and Engineering Research Council of Canada. The program provides support to a core of the most promising researchers at a pivotal time in their careers. Akhtar will hold his fellowship with NREL's advanced vehicles and charging infrastructure group in the Center for Integrated Mobility Sciences.

Venu Garikapati Appointed Chair of a National Academies Transportation Research Board Standing Committee

Venu Garikapati

Venu Garikapati, who leads NREL's transportation and modeling metrics research team, has been designated as chair of the Transportation Research Board's Technical Committee on the Effects of Information and Communication Technologies on Travel Choices. Committee members pursue studies addressing a range of information and communication technologies topics—such as telecommuting, online shopping, ride-hailing, real-time information, social media, mobile phone apps, and the use of virtual/augmented reality and gamification—to better understand travel behavior. In his role as chair, Venu intends to expand the committee's research horizons to study the energy implications of information and communication technologies.

John Kisacikoglu Tapped To Lead IEEE's Transportation Systems Committee

John Kisacikoglu

Mithat John Kisacikoglu, who leads NREL's EV-grid integration team, has been named chair of the IEEE Transportation Systems Committee, which focuses on electrification of the entire transportation sector from vehicle traction and energy storage system improvements to sweeping electrical grid infrastructure upgrades. Kisacikoglu will serve as chairman of the IEEE Industry Applications Society's Transportation Systems Committee from January 2024 to December 2025.

Nick Thornburg Elected to International Symposia on Chemical Reaction Engineering (ISCRE) Board of Directors

Nick Thornburg

NREL's Nick Thornburg, a senior reaction engineer, has been elected to the ISCRE board of directors. ISCRE is the premier professional society for chemical reaction engineers around the world, and the board organizes international conferences every 2 years for students and professionals in the discipline. Thornburg is the first and currently only national laboratory engineer to serve in an ISCRE leadership role and is accompanied on the board by world-renowned reaction engineering leaders in industry and academia.

Patents

Emily Cousineau and Gilbert Moreno Awarded U.S. Patent Related to SiC Inverters

Emily Cousineau and Gilbert Moreno, NREL power electronics researchers, were awarded a third patent related to a novel two-phase-cooled SiC inverter for heavy-duty applications in John Deere commercial vehicles. The inverter is so unique that each component has been patented or is in the process of receiving a patent. This latest patent recognized the condenser component of the inverter's cooling system.

Emily Cousineau

Gilbert Moreno

R&D HIGHLIGHTS

Battery Technologies

Leveraging Advanced Capabilities To Improve Battery Recycling

As batteries proliferate in EVs and stationary energy storage, NREL is exploring ways to increase the lifetime value of battery materials through reuse and recycling. As part of DOE's ReCell Center, NREL is working with ANL and ORNL to enable direct recycling of lithium-ion batteries that uses less energy and captures more of the critical materials. In support of this effort, NREL researchers are evaluating new approaches to anode upcycling, cathode relithiation, black mass purification, and ensuring the safety of recycled materials. NREL expertise spans technology development, optimizing processes to repair end-of-life materials while minimizing costs. This collaboration is part of a massive ongoing effort to accelerate the growth of profitable recycling and strengthen the battery supply chain.

Collaboration Concludes a Legacy of World-Class Thermal Characterization, Enters New Phase

Over the past 20 years, NREL has pioneered advanced techniques for the thermal characterization of batteries, from lead acid to lithium ion. NREL researchers developed an R&D 100 Award-winning calorimeter technology to evaluate the thermal efficiency of new battery technologies, offering critical insights to inform thermal management strategies and cooling systems that extend the life and safety of batteries. In the past year, NREL researchers worked alongside the U.S. Advanced Battery Consortium (USABC) to better understand thermal characteristics of new advanced technologies, including lithium-metal, silicon, and high-nickel cathodes. As the collaboration with the consortium enters a new phase, the comprehensive data provided by NREL will continue to shape the design of future advanced battery systems.

Real-World Driving Data Inform Battery Requirements for Heavy-Duty Truck Electrification

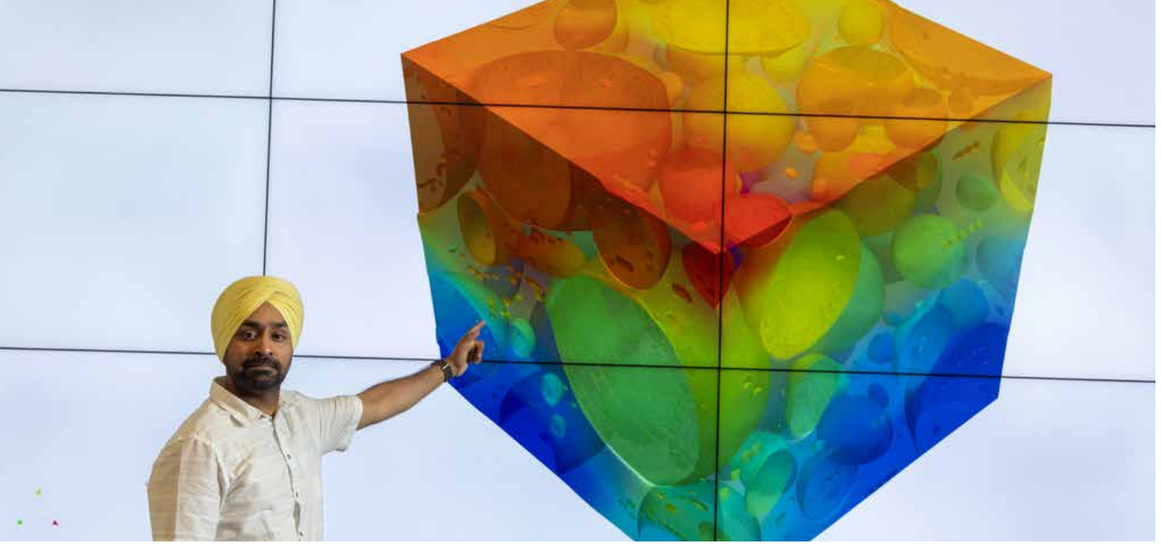
Heavy-duty vehicles are difficult to electrify due to large energy demands per mile, reliability requirements, and diverse vocations. More research is needed to better understand their unique battery requirements and establish standard test protocols to quickly assess how new battery designs will perform. Using NREL's Fleet DNA database, researchers identified real-world heavy-duty drive cycles for regional and long-haul truck routes with the most challenging requirements. NREL's FASTSim vehicle simulator predicted the dynamic power for a hypothetical battery-electric truck to follow the same drive cycle. Idaho National Laboratory then developed a dynamic stress test protocol for accelerated performance/aging tests based on those dynamic power profiles. The team will present these results to the 21st Century Truck Partnership for feedback before applying physics and AI models to map how emerging chemistries and designs can be applied to meet the needs of heavy-duty trucks. NREL's preexisting battery life models of lithium-ion cells will set baseline expectations of how long today's batteries might last in trucks under different charging and use scenarios and provide targeted insights into how to develop battery systems optimized for use with HD vehicles.

Identifying Degradation Mechanisms in Cobalt-Free Battery Cathodes

NREL and ANL are investigating earth-abundant active materials, such as lithium- and manganese-rich cathodes, to eliminate the use of cobalt in batteries. Despite promising initial electrochemical performance evaluations, lithium- and manganese-rich cathodes currently fall short of capacity retention targets (<80% at 1,000 cycles). Researchers are using cutting-edge molecular- to macroscale techniques—including cryo-scanning transmission electron microscopy plus electron energy loss spectroscopy and X-ray nano-computed tomography—to map nanoscale interfacial heterogeneity and structural changes after cycling. In addition, the team developed a custom Fourier-transform infrared spectroscopy spectro-electrochemical cell to measure harmful manganese ion dissolution and formation in the electrolyte. This multiscale characterization approach identifies key degradation mechanisms of lithium- and manganese-rich batteries, offering crucial feedback to develop sustainable, high-performance cathodes. Future studies will investigate electrolyte additives to mitigate manganese dissolution and further optimize these cobalt-free materials.

New NREL Diagnostic Method Reveals Complexities of Lithium-Ion Battery Degradation

Lithium-ion battery failure processes remain poorly understood. A key process contributing to reduced performance is oxidation of electrolytes at high voltage. Multiple electrochemical methods can detect the presence of electrolyte degradation products, but they are unable to identify their origins. NREL has developed a new method based on generation/collection scanning electrochemical microscopy that has shown that oxidation of varied lithium-ion battery electrolytes occurs in a multistep process. The results link the formation of key degradation processes to certain steps in the oxidation process and identify others that may lead to novel failure processes. Mechanistic insight into the chemistry of lithium-ion battery degradation and failure can inform strategies for rational design of more durable cell chemistries. This new method will now be applied to more complex lithium-ion battery systems, including commercially available materials, to discover novel failure modes.



Pioneering Low-Pressure, All-Solid-State Batteries

NREL researchers have developed a novel all-solid-state battery system that makes significant progress toward developing a high-energy-density, all solid-state battery. By integrating a high-loading, cobalt-free lithium nickel manganese aluminum oxide cathode with a thin-film silicon anode and argyrodite solid electrolyte (Li_6PS_5Cl), researchers demonstrated a new battery configuration with impressive room temperature discharge capacities of more than 210 mAh/g-cathode at low cycling rates. Advanced characterization was used to explore the primary degradation mechanisms of this design. Electrochemical impedance spectroscopy revealed early electrolyte degradation and changes in charge transfer kinetics, while advanced spectroscopy techniques identified lithium carbonate as a key degradation product. Additionally, high cell pressures, often used during fabrication, were found to fracture cathode particles, suggesting a need for optimized manufacturing conditions. Continued research aims to improve upon the battery design to further reduce inactive component weight/volume and required stack pressure, which provides a promising pathway toward commercial viability for sustainable, high-energy, all-solid-state batteries.

Enabling Extreme Fast Charging for Energy-Dense Battery Technologies

Extreme fast charging is key to advancing the public adoption of EVs, which must be able to charge in 15 minutes or less to compete with the refuel times of combustion engines. Enabling extreme fast charging in energy-dense batteries (mAh/cm_2) requires a deep understanding of internal resistances and rate-limiting mechanisms within battery systems. As part of DOE's eXtreme Fast Charge and Cell Evaluation for Li-ion Batteries (XCEL) program, NREL led research to develop benchmark designs to show how emerging technologies can achieve extreme fast charging. Alongside partners from LBNL, ANL, and Idaho National Laboratory, the XCEL team achieved significant advancements in fast-charging battery technologies by incorporating single-walled carbon nanotubes into battery electrodes, applying model-informed laser-ablation designs to mitigate harmful lithium plating, and developing novel electrolytes with enhanced lithium-ion transport properties. Although the XCEL program is drawing to a close, this work will be published in several manuscripts early in FY 2025. Advancing Battery Stability With Continuum-Level Solid-Electrolyte Interphase (SEI) Modeling

Advancing Battery Stability With Continuum-Level Solid-Electrolyte Interphase (SEI) Modeling

Stabilizing the SEI is critical to improving next-generation lithium-ion battery performance. NREL researchers have developed a chemically complex continuum-level SEI model that integrates atomistic insights of reaction mechanisms from first-principle calculations. This hybrid approach to computational modeling allows for a more accurate understanding of SEI formation, capturing the degradation of key electrolyte components like ethylene carbonate, ethyl methyl carbonate, and fluoroethylene carbonate. By bridging atomistic and continuum-level modeling, this work provides a comprehensive view of SEI dynamics across relevant length and time scales, making it one of the most advanced models of its kind. Calibrated against experimental data, the model shows qualitative agreement with SEI growth trends and irreversible leakage currents. This framework will accelerate fundamental understanding of SEI behavior and guide future improvements in battery stability, enabling the development of energy-dense lithium-ion batteries for EVs and grid-scale energy storage.

Improved Mechanistic Understanding of Calendar Life Fade in Silicon Anodes

Silicon is a promising next-generation anode material with the potential to increase the driving range of EVs, but it is hindered by a limited calendar lifetime. Over the past year, the NREL-led Silicon Consortium Project has narrowed in on two critical factors contributing to this issue. First, the SEI, formed by conventional electrolyte decomposition, is unstable on silicon surfaces. Second, SEIs in silicon anodes often have electronic and ionic barriers, aggravating the state-of-charge inhomogeneities and accelerating degradation. These findings provide crucial insights into why silicon behaves differently from traditional graphite anodes, highlighting the root causes of calendar life fade. By understanding these mechanistic details, researchers can now devise strategies to stabilize silicon anodes and extend battery lifetimes. The next steps involve testing these hypotheses and developing methods to mitigate the identified fade mechanisms, moving closer to realizing the potential of silicon-based batteries for long-lasting energy storage.

Artificial-Intelligence-Powered Lifetime Predictions Guide Design of Longer-Lasting Silicon Batteries

Silicon anodes are a promising technology for lithium-ion batteries due to their high energy density, but batteries with silicon anodes typically demonstrate shorter calendar lifetimes. The ability to accurately predict calendar life aging early in testing is critical to reduce the time and iteration cost of developing novel silicon electrodes. In response, the NREL-led Silicon Consortium Project has designed an innovative machine-learning pipeline to predict capacity fade 10 months in advance with 5% accuracy across different silicon types (micro-silicon and nano-silicon in a carbonaceous matrix), cathodes (NMC811 and LFP), and electrolytes. This early prediction capability is crucial for streamlining the development of silicon anodes, allowing researchers to remove underperforming cells from testing and optimize battery designs more efficiently. Ongoing improvements aim to further refine the model, incorporate metadata for even more accurate predictions, and publish the methodology.

High-Purity Graphite Upcycling Supports Sustainable Battery Innovations

In a collaborative effort through a cooperative research and development agreement supported by VTO and the Advanced Materials & Manufacturing Technologies Office, NREL and Orbia are identifying processing requirements to upgrade the morphology of spent first-generation graphite and/or natural graphite via mechanochemical treatment to meet modern battery performance demands. This fiscal year, the team developed optimized purification and binder removal strategie to achieve >99.95% purity graphite from end-of-life anodes recovered from industrial cells. The team has employed an experimental design framework to comprehensively evaluate a series of industrially relevant operating parameters associated with graphite mechanical processing, and has demonstrated tunable morphology control using a natural graphite analog. NREL and Orbia are utilizing advanced characterization techniques to evaluate the morphology and physicochemical properties of the mechanically processed graphite, and these data are being concurrently evaluated through a machine-learning model framework to predictively inform optimal combinations of operating conditions. Finally, the team has completed techno-economic analysis, which predicts a substantial profit margin for the morphologically upcycled graphite product, presuming final optimization and validation of electrochemical performance.

Electrification Technologies

New Electrically Insulting Substrate May Offer Enhanced Power Electronics Performance at Lower Cost

Ceramic substrates are an integral part of the overall thermal management system for power electronics, but NREL researchers have found that an organic electrically insulating substrate material called Temprion can result in superior thermal performance and greater reliability under thermal cycling, thermal aging, vibration, power cycling, and electrical high-potential evaluation—all key components of NREL's extensive reliability testing for power electronics. Under VTO's Electric Drive Technologies Consortium, researchers developed a novel co-design workflow to balance key parameters, such as electrical, thermal, and mechanical constraints, based on the engineer's preference. Using this new workflow, the team developed two power modules: one focused on optimization for electrical parameters, and the other for thermal metrics. The Temprion power modules eliminate design constraints associated with traditional ceramic substrates, enable simplified package design and more flexibility at reduced manufacturing costs, and may demonstrate better reliability at high temperatures. Next, the team will fabricate a prototype to demonstrate a full, optimized power module design.

NREL's Aging Detector for Semiconductor Devices Is Poised To Boost EV Reliability

WBG power semiconductor devices, especially SiC MOSFETs, are widely used in EV drivetrains to achieve higher power density—but they have limited technical maturity and reliability compared to silicon-based technologies or devices. In response, NREL researchers developed a cost-effective,

gate-driver-integrated in situ detection system for aging and degradation of power modules. To evaluate the system's effectiveness, the team created an accelerated lifetime cycler and used it to age SiC power module samples with different types and levels of degradation. Next, they will fully validate the newest version of the detector hardware to maximize its precision. This novel aging detector will provide a valuable resource to achieve better safety and reliability for EVs.

Thermal Characterization of Electric Motor Materials Shapes Caterpillar's Heavy Mining Motor Design

The mining industry relies heavily on hybrid and electric propulsion systems, as diesel emissions can create air quality concerns in underground environments. In addition to contributing to emissions reductions, innovations in these propulsion systems can create significant improvements in their reliability and cost. Through a partnership with Caterpillar, one of the leading global manufacturers of mining equipment, NREL researchers conducted experimental thermal characterization of novel materials for Caterpillar's custom electric motors. Characterization of these materials, which had not previously been described in power electronics literature, has helped guide Caterpillar's thermal models for future motor designs. It also sparked a new working relationship with the manufacturer, which has potential to broaden NREL's impact in the heavy mining industry.

Development of EV Tool Inventory Informs DOE Selection of Tools for Stakeholder Toolkit

To fill a gap in the availability of tools for transportation stakeholders to robustly plan for the transition to an electrified fleet, the EVs@Scale Lab Consortium FUSE (Flexible charging to Unify the grid and transportation Sectors for EVs at scale) project team at NREL developed an inventory of existing laboratory vehicle-grid integration capabilities, such as models, tools, and datasets, to create a stakeholder toolkit. The inventory includes details on spatial and temporal detail, alignment with key vehicle-grid integration deployment topics, and perceived user-friendliness and scalability. The team identified 20 tools with high user-friendliness and usability that are ready for inclusion into the toolkit, and 75 tools that require modest to significant funding to become user-friendly and/or usable by stakeholders. The team subsequently led a discussion with DOE to select tools for enhancement and will use the feedback received to proceed with tool refinements and enhancements and creation of the EV stakeholder toolkit.

New Utility Partnership Accelerates Adoption of SCM Solutions With Field Demonstration, Hardware Improvement

Managing charging loads to mitigate grid impacts with SCM is critical to mass adoption of EVs. To accelerate the market adoption of SCM solutions, SCM must also be successfully demonstrated in a utility environment in the field. The EVs@Scale Lab Consortium FUSE team at NREL partnered with Holy Cross Energy (HCE) in Colorado to demonstrate multiple SCM solutions architectures and objective functions to perform within and expand the capabilities of their current distributed energy resource management systems (DERMS) and SCM programs. These demonstrations will accelerate the adoption of SCM solutions and mitigate grid impacts from electrification, as well as the adoption of EVs. The team learned that there is a preference from DERMS providers to leverage OpenADR where possible, but that OCPP integration will be necessary to implement direct controls of the EVSE given minimum required information such as if there is a vehicle plugged at an EVSE. The team also learned that there is generally more flexibility in deploying SCM at workplace or free charging sites as opposed to residential sites given vehicle SOC may be unknown and customers will require a minimum SOC to leave their residence in an emergency. The team is planning multiple SCM field demonstrations for both residential charging at customer homes and workplace charging at HCE headquarters. Alongside ANL, the FUSE team will also improve the EVSE hardware at HCE headquarters EV charging stations to support an Open Charge Point Protocol (OCPP)-centric SCM architecture. The next steps include possible integration of NREL SCM into DERMS platforms, adaptability of DERMS platforms communication to expand control capabilities, and EVSE installation plans for HCE headquarters charging and integration with NREL's OCPP controls. The team plans to share results with HCE industry peers.

Development of SCM for Site-Level Depot Controls Account for Wind Energy in Key Region of Study

To mitigate equipment overloads potentially caused by peak grid demand from at-scale EV adoption, the introduction of depot controls that can increase the limit of charging ports without overloading site capacity is key. The EVs@Scale Lab Consortium FUSE team at NREL developed depot controls that focus on transformer overloading, which can be tailored to large fleet charging sites, workplace charging, destination charging, and residential charging with secondary banks serving multiple customers. Additional controls developed respond optimally to market rates and emissions profiles to prevent distribution system overloads, while meeting transportation energy needs and responding to rates and emissions where there is additional flexibility. More complex controls, including optimization-based market response and emission response controls, were implemented and tested on IEEE-13 bus feeders and real feeders with Caldera and OpenDSS that included forecasted EV adoption and simulated EV charge schedules. Analysis of these results during the beginning of FY25 will quantify the benefits of the controls and compare benefits of simple versus complex SCM implementations. Preliminary analysis during FY24 shows high EV peak loads when there are sharp drops in emissions or marginal pricing, so controls with grid feedback or for minimizing peak loads may be more beneficial for utilities. Next steps include scaling the demonstration, conducting in-depth analysis of co-simulation results, and extending control adaptations for laboratory demonstration. The transformer-based controls will be adapted and evaluated for their impacts on large feeder networks. The demonstrations will also include other loads that reduce the charging limits under the transformer controls and adapt the optimization-based controls for laboratory testing.

Demonstration of SCM With OCPP Testbed Verifies Real-World Performance, Identifies Ongoing Challenges to Address

Although SCM solutions have proven their potential value in energy and cost management in the theoretical field, laboratory and field demonstrations are essential to verify their real-world performance and identify challenges, especially for communication bandwidth and interoperability. Building upon NREL's developed SCM solutions and OCPP testbed, the EVs@Scale Lab Consortium FUSE team began building a communication gateway that enables NREL's SCM solution to factor in available information from the real-world. The team developed a gateway logic to translate OCPP messages into the SCM data format, which collects vehicle state of charge, EVSE power, and session status and transmits power setpoints. The team demonstrated SCM's effectiveness under different EV and EVSE combinations, plug-in timing, and different SoCs. The communication bandwidth was found to be critical for stable operation and for practical use in the field, and to address the utility-preferred protocol, the team will tackle integrating the SCM into a DERMS and expand the demonstration as the next step.

Development of Smart Charging and Vehicle-to-Edge Strategy Report Roadmaps Use Case Demonstrations

The High-Power Electric Vehicle Charging Hub Integration Platform (eCHIP) project, as part of the EVs@Scale Laboratory Consortium, is developing hardware and software solutions for a DC distribution-based charging hub platform. The eCHIP team at NREL and ANL completed a report that provides a comprehensive overview of the core elements and structure of the site energy management system within the DC hub concept. The report serves as a roadmap for future use-case demonstration objectives and outlines the key functions that can be performed by site energy management systems for operating the DC hub in an efficient, cost-effective, resilient, robust, and stable manner—as well as for seamless integration with and support of the power grid. The report also provides an overview of possible control architectures and functions that the site can provide, establishes a consistent terminology for possible services, and clarifies the manners in which a DC hub can integrate with the grid. Moving forward, the team will leverage the report as a reference guide to implement and demonstrate energy management solutions under the eCHIP project. The team's near-term goal is to deploy a hybrid site energy management system on NREL's hardware-in-the-loop platforms and demonstrate core functions across various use cases, which will enable realistic demonstration of site energy management system deployment for the hardware platform. The project team will further investigate utility DERMS integration to realize some of the functions described in the report.

Industry Collaboration Improves High-Power EV Charging Profiles, Expands Available Charging Datasets

Characterizing and quantifying the charging profiles of high-power charging systems is critical to intelligently integrate them within the grid and among co-located loads and sources. The EVs@Scale Lab Consortium NextGen Profiles team at NREL solicited industry feedback on the project's findings, which include numerous high-power charging profiles, and incorporated the input to improve the project's test plans and procedures document. The team completed EV Profile Capture and EVSE Characterization tests for all four vehicles and two charging assets forecasted at the beginning of the project. In FY24, 16 EVSE characterization tests and 22 EV charging profiles were captured to expand the dataset of charging data available to inform and educate the public about the current status of transportation electrification. Work is ongoing to distill captured vehicle charging profiles and EVSE performance characterization in grid modeling tools to reduce uncertainty and assumptions made about impacts of scaling up EV charging on the electric grid. Next steps for this team are to continue integrating captured EV profiles into grid modeling tools and gaining access to additional EVs and EVSE to expand the set of equipment for testing and reporting.

Securing EV Charging Protocols Advances Public Key Infrastructure (PKI) Interoperability

Rapid deployment of NEVI-mandated protocols relies on the implementation of interoperable PKI. Deployment of the PKI is rapidly accelerating, and cybersecurity is critical to the safe operation of these protocols with the PKI.The EVs@Scale Lab Consortium cyber-physical security team at NREL developed an emulation platform that enables analysis of the NEVI implementation of PKI. The team deployed emulated protocols in the ARIES Cyber Range, analyzing the threat model of the PKI and documenting the resulting environment and threat model in a technical report. The next steps for this research are to expand analysis capabilities by incorporating open-source EV charging station management systems and Open Charge Point Interface into the environment.

EVSE Cyber Risk Assessment Controls Catalog Refines Deployment With Distributed Energy Resource Cybersecurity Framework

Grid cybersecurity is paramount to the safe and efficient deployment of a reliable EV charging network. The EVs@Scale Lab Consortium cyber-physical security team at NREL studied EVSE-specific cyber assessment question sets that align with the Distributed Energy Resource Cybersecurity Framework, developed and maintained through the Federal Energy Management Program, for conducting cybersecurity self-assessments for EVSE. The team finalized EVSE-specific cyber controls that were incorporated into the framework, including action items, mitigations, metrics, and maturity levels, to aid in assessing the cyber maturity of EVSE. Assessing EVSE cybersecurity maturity is critical to understand where to apply and prioritize cybersecurity in the deployment of EVSE in the effort to advance cybersecurity of the grid. Next steps include leveraging the tools to conduct in-person assessments with industry partners.

Investigation of EV Ecosystem Apps Security Identifies Security Risks, Guideline Solution

The EVs@Scale Lab Consortium cyber-physical security team at NREL studied the security attributes and vulnerabilities of a sample of mobile apps that support key user functions in the EV ecosystem. The team found that all analyzed apps have security risks, categorized as high, medium, or both, and a comprehensive cybersecurity guideline for developing EV ecosystem mobile apps is necessary to mitigate the security risks. Continued investigation is essential to foster a safer and more secure environment for all EV users by ensuring their data and interactions remain protected. Next, the team will continue conducting advanced analysis with hardware-in-the-loop in the mobile applications.

Autonomous Response Function Implementation Demonstrates Path to Support EV Grid Integration

To support the at-scale integration of EVs and EVSE for charging, the EVs@Scale Lab Consortium codes and standards team at NREL investigated autonomous response functions of EVs and EVSE for AC charging using real power (V/W and Hz/W) and potentially other reactive power (V/Var) control. Leveraging an approach developed for building loads, the team implemented an autonomous function into EVSE that senses grid frequency locally, responds to the frequency change, and evaluates the EV and EVSE responses to the grid frequency change. The EV and EVSE responses obtained from this evaluation were modeled to integrate into grid stability analysis. The result demonstrated the capability to support the grid with a localized, simple approach that does not use high-level digital communication, which provides a path for supporting increased EV and EVSE integration. Furthermore, this functionality could reduce the need for grid stability services, benefiting the grid beyond charging integration. Next, the team will publish their results and work with SAE International and manufacturers to help incorporate the autonomous function into a standard and/or a commercial program.

Modeling High-Resolution Electricity Demand for Vocational EVs Enables Proactive Grid Planning

An NREL research team has developed high-resolution estimates of EV charging loads for multiple vocational vehicle segments. These vehicles are historically challenging to model due to limited data on their stock, operating patterns, energy use, and charging behaviors. This research addresses a gap by forecasting their future electricity demands for proactive planning. The team has developed high-resolution load forecasts for electric transit buses, government fleets, port cargo handling equipment, and airport ground support equipment throughout the United States. Annual forecasts are provided for 2025 through 2035, along with a full electrification scenario, and will be made publicly available and incorporated in a forthcoming update to the Electric Power Research Institute's eRoadMap tool. Next, the EV load data and accompanying documentation will be made publicly available via the NREL Data Catalog. These data provide unique insights, such as the amount of energy required to move a shipping container from the vessel to drayage trucks or rail—an easily scalable model that estimates equipment energy demand at a wide range of port sizes, facilitating energy storage and grid planning at ports across the nation. Similarly, the energy required to operate electric ground support equipment at the largest 73 airports in the nation was identified (also scalable for all other airports when hourly flight schedules are available) as was the energy required for electric transit bus operations at 2,393 transit agencies across the nation.

Prioritizing Safety in High-Energy Lithium-Ion Batteries With Nonflammable Electrolytes

For behind-the-meter storage systems, where safety, longevity, and efficiency are essential, LTO/NMC battery designs are an attractive option for storing energy, stabilizing the grid, and reducing peak energy costs. However, addressing safety concerns through innovations such as nonflammable electrolytes is critical to ensure their safe deployment. The team downselected several promising nonflammable electrolytes for further testing using the NREL-designed self-extinguishing time test apparatus. The design enables robust quantification and reproducibility of ignition and extinguishing times, which is notoriously challenging. Electrodes used in downselection studies and several of the electrolyte solvents were prepared by ANL partners. The results of the evaluation will guide the selection of electrolytes for the development of large-scale (18650) cells for further safety evaluations at Sandia National Laboratories.

Two National Labs Chart a Path to Wider SCM Adoption

SCM strategies can have incredible benefits for EV drivers, utilities, governments, and fleets. So why aren't they more widely utilized? To understand the barriers that are hindering wider adoption, researchers from NREL and LBNL surveyed the national state of SCM. After reviewing more than 100 managed charging programs nationwide and interviewing 40 utility companies and stakeholders, researchers identified key three takeaways: Site-level SCM is underutilized; utilities lack the economic data needed to make the business case for SCM investments; and fragmented vehicle-grid integration standards are preventing new deployments. In response, researchers recommend expanding SCM field demonstrations, developing dynamic pricing mechanisms, creating systems that put the power to automate SCM scheduling in customers' hands, and further developing the interoperability of—and standards for—SCM technologies. Each of these strategies can improve confidence in SCM, which can in turn accelerate SCM adoption at scale.

NREL Writes the Roadmap to Next-Generation Power Electronics

NREL researchers contributed deep subject matter expertise to the Advanced Materials & Manufacturing Technologies Office's Power Electronics Roadmap, a comprehensive report outlining the state of the art of power electronics converters and the innovations needed to fully unlock the performance, power density, and reliability of next-generation power electronics systems. The decarbonized transportation systems of the future will heavily rely on these systems, which include WBG and ultra-wide-bandgap semiconductor devices, components such as capacitors and inductors, and the packages that are essential to their peak performance. Having outlined present trends in power electronics manufacturing, urgent research gaps, and future technology directions, NREL researchers plan to engage the research community to begin closing the identified research and technology gaps. Through innovative new processes and next-generation technologies, they will work toward more compact, low-cost, power-dense, and reliable power electronics components that can power the vehicles of the future.

Revolutionary Aircraft Motor Design Leverages 3D Printing

The electric components used in aviation applications are exceptionally sensitive to high temperatures, making powerful thermal management systems critical to their performance, durability, and reliability. Now, as part of the Advanced Research Projects Agency – Energy's (ARPA-E's) ASCEND project, researchers from NREL and Marquette University are developing a groundbreaking aircraft motor built using additive manufacturing—also known as 3D printing—and advanced cooling using heat pipes. This revolutionary design integrates the high-performance heat pipes with additively manufactured hollow coils to form a highly integrated system where oil-based condensers can quickly dissipate heat. The design significantly reduces the size of the motor while enhancing its power density, and ensures optimal motor temperatures. Next, the team will develop an oil-based "cooling jacket" for additional thermal management of the motor's stator core.

NREL Analysis Pinpoints Two Failure Mechanisms in Power Modules for Zero-Emissions Aircraft

SiC power modules designed by GE Aerospace will be critical components of the ARPA-E ASCEND project's integrated traction drive system for electric aviation. But researchers must fully understand why and how these power modules might fail to improve their design. As part of ARPA-E's eFLITES project, NREL researchers performed extensive thermal finite element modeling for GE Aerospace's 2-MW all-electric aircraft powertrain and 660-kW demonstrator machine, helping to achieve record-breaking power density. They also leveraged the laboratory's world-class thermal cycling capabilities to observe two independent failure points: cracks in the substrate attach layer and a breakdown failure of the SiC dies used in the power module. NREL researchers will quantify the extent of the cracking, and then provide the data to GE Aerospace, where it will form the basis of improvements to the SiC power module. These insights will accelerate efforts to develop the 2-MW all-electric aircraft powertrain and a prototype for a zero-emissions narrow-body commercial aircraft.

Powerful Cooling Solutions for Data Centers Emerge Through ARPA-E Collaboration

The United States faces increasing demands for energy from two major sources: EV adoption and the build-out of data centers, which store and process the vast amounts of data modern societies create. Cooling data centers is energy-intensive and can account for 40% of their energy use. Now, NREL researchers are supporting the ARPA-E COOLERCHIPS project with the University of Missouri to identify thermal interface materials that can enable more powerful cooling solutions while avoiding cracking a data center's CPU or GPU die. NREL is also collaborating with the University of Florida on a separate COOLERCHIPS project to develop a two-phase cooling strategy for data center applications. The laboratory's power electronics researchers have identified a packaging structure to enable direct contact between the cold plate and the processor. Next, NREL researchers will demonstrate thermal management systems at the 3- and 10-kW levels.

Decarbonization of Off-Road, Rail, Marine, and Aviation Technologies

New Method Enables Accurate Measurement of SAF Cetane Number With Less Fuel

New SAF formulations offer a promising solution to mitigate aviation GHG emissions. However, measuring fuel properties and combustion testing to ensure safety can require high amounts of fuel that are costly to produce in low-technology-readiness-level SAF development research. Currently, measuring the derived cetane number, which is a predictor of engine failure through lean blowout, requires 100 mL of fuel. NREL researchers developed a new "indicated cetane number" method that allows researchers to measure the indicated cetane number with as little as 15 mL of fuel. The team compared their indicated cetane number measurements with derived cetane number and lean blowout measurements by the National Jet Fuel Combustion Program on a set of the program's test fuels. The NREL team demonstrated that indicated cetane number is equivalent to derived cetane number in predicting lean blowout. The ability to measure key jet fuel properties with just small volumes of SAF can accelerate SAF development and ASTM approval, enhancing success in achieving SAF Grand Challenge goals. NREL researchers will share these results with the SAF production research community via conference presentations and an upcoming journal article.

NREL Designs Bench-Scale Experiment To Improve Understanding of Jet Engine Soot and Better Characterize Fuel Emissions Impacts

Persistent cirrus clouds derived from contrails created by jet engine emissions entrap heat in the atmosphere, contributing to climate warming. Characterizing the surface chemistry and properties of soot formed in jet engines from different fuels, including SAF, is critical to understanding the formation of these clouds. To study these characteristics, NREL researchers designed a laboratory bench-scale reactor that mimics soot-forming conditions in an aircraft engine combustor. This reactor employs flame spray pyrolysis to produce macroscopic quantities (10–30 mg) of soot particles that are very similar to those produced by actual aircraft engine combustors. The reactor allows researchers to evaluate multiple samples of conventional jet fuel and SAF by directly measuring agglomerate average particle diameter and size distribution. The soot produced can be characterized ex situ for primary particle size (using transmission electron microscopy), organic carbon content, water chemisorption, and other surface properties relevant to contrail and cloud formation. This reactor will enable faster, lower-risk, and accessible characterization of jet fuel in the laboratory setting toward the goal of developing cleaner fuels. Construction is targeted to begin in FY25.

NREL Simulations De-Risk Qualification of 100% Drop-In SAF

The costs and risks of qualifying SAF solely based on experimental characterization in commercial aircraft engine combustors are prohibitive for smaller, innovative organizations. NREL researchers developed simulation models that can provide initial screening, reducing development costs by dramatically reducing the fuel volume and number of experiments needed. In simulations, the NREL team showed that HEFA-SPK (today's commercial SAF) formed smaller fuel droplets compared to Jet A (conventional jet fuel), leading to richer fuel-air mixtures, higher temperatures, and more efficient combustion. In collaboration with teams at Georgia Institute of Technology and GE Aerospace funded by the Federal Aviation Administration and NASA, the NREL team experimentally confirmed the findings in the newest lean pre-vaporized premixed combustor. This research will accelerate

NREL ESTIMATES OF ALL-ELECTRIC PORT'S ENERGY REQUIREMENTS INFORM INVESTMENTS

Electrifying maritime ports is a pathway to reduce emissions of freight transportation and improve local air quality. To invest in electric port equipment, port operators and decision makers need to understand the energy use, cost, and grid impact of such an investment. Using the premier Fleet Research, Energy Data, and Insights (FleetREDI) commercial vehicle data collection and analysis platform, and in partnership with the Electric Power Research Institute, NREL estimated the energy demand per container imported (kWh/TEU) at a fully electrified maritime port. NREL also produced a FleetREDI Insight describing the project's methodology and results. Stakeholders can use the estimates to calculate the projected energy use of electric port equipment based on the number of containers moved at their port.

the characterization and qualification of new SAF options, helping the United States achieve the SAF Grand Challenge of manufacturing 3 billion gallons of SAF per year by 2030—a step toward making commercial aviation carbon neutral. Next steps include conducting research on newer fuels produced by innovative pathways from novel feedstocks and validating and updating fuel property predictions in simulation models.

Materials Technology

Composites Combined With PECAN and Polyethylene Increase Viability of Carbon Fiber Vehicle Design

Lighter vehicles use less energy to get around, and carbon fiber composites are an attractive material for vehicle design because they offer superior strength to steel at a fraction of the weight. However, carbon fiber materials are currently too brittle—or have too low ductility—to be employed in automotive design. Researchers at NREL combined NREL-developed PECAN resin with carbon fiber and varying amounts of ductile polyethylene fibers to yield hybrid composites. The team subjected these composites to a flexural analysis, which showed a positive correlation between ductility and polyethylene quantity. Importantly, composites made with 10% polyethylene exhibited a more than 50% increase in ductility while preserving 75% of the strength of an all-carbon-fiber control. The research showed that carbon fiber composites, when combined with polyethylene and bound together with the PECAN resin, can be augmented to increase their ductility. These results provide a path to overcoming a key hurdle for carbon fiber composites in vehicles. Future research will include a techno-economic analysis to determine the economic viability of PECAN carbon/polyethylene composites in vehicles.

Technology Integration

Streamlined Process for Utility-Provided Alternative Fuel Incentives Facilitates Creation of More Comprehensive Database

NREL created a more comprehensive database of utility-provided incentives for alternative fuels by streamlining the process for collecting and presenting incentives. Tracking, summarizing, and publishing utility incentives on the Alternative Fuels Data Center (AFDC) requires a significant level of effort, and the increase in available utility incentives necessitated a more efficient approach. The new streamlined process allows NREL to expand its database of alternative fuel incentives and tailor presentation of the data by target audience, including consumers, fleets, businesses, and policymakers. The new structure organizes incentives by utility, as well as audience and topic, includes pages for each featured utility, and allows users to navigate to the utility's webpage for more details. NREL will continue to expand the AFDC's laws and incentives database by identifying efficient mechanisms to collect and present data from a wider scope of utilities.

Redesigned Tool Facilitates Improved Access to Alternative Fuel Case Studies

NREL's redesign of the search tool behind the case study database on the AFDC enables users to efficiently access resources on alternative fuel deployment successes, lessons learned, and strategies for overcoming barriers. The number of case studies in the database continues to grow as alternative fuel deployment expands across the country. And demand for these case studies is also increasing as fleet managers seek to learn from others' experiences. To accommodate this growth, NREL enhanced the case study search tool to allow users to search by keyword, title, or author, while also employing filters to further refine their search. Search results include images, when possible, and the landing page displays featured case studies. NREL will continue incorporating enhancements in FY 2025, including the ability to select multiple filters while auto-populating results without the page refreshing.

Automated Mobility District Implementation Catalog Spotlights EV Integration and Opportunity Charging

The third edition of the automated mobility district implementation catalog addresses the convergence of vehicle electrification and automation within public mobility fleets to enable sustainable automated mobility district networks. Such networks provide both traditional, fixed-route, scheduled services and on-demand, flexible services—all integrated and optimized into a fully automated system of systems. This year, the research team focused on defining the implications of EVs on automated mobility district networks, along with the operational impacts of ridership surge flows. This involved comparing and contrasting challenges associated with integrating traditional fixed-route services with those of on-demand transit and drawing on lessons learned from automated transit network system modeling. The team also addressed the configuration and management of station boarding and alighting zones (also called pickup and drop-off curb zones) and the need for complementary infrastructure intelligence at intersections and curbs. The transportation industry is entering a new frontier with three major simultaneous transformations: electrification, automation, and on-demand services. The third edition of the catalog addresses EV integration into the design and operations of automated mobility district fleets, as well as the design of stations to address both surge demand and opportunity charging. Next, the team will investigate battery charging parameter impacts on fleet operations and infrastructure, developing a systems

engineering methodology to analyze deployment strategy impacts on fleet size, infrastructure, and service levels; and take a deep dive into the role of robo-taxis in public mobility.

New Online Guide Provides Accessible, Centralized Information for School Bus Fleet Electrification

NREL published an online School Bus Electrification Center to provide school districts with user-friendly, accessible resources for electrifying their bus fleets. Substantial federal funding is currently available for districts to purchase electric school buses and charging infrastructure, but information on how to implement these changes is often scattered and too complex for a nontechnical audience. NREL's guide is available on the AFDC and uses a modular, step-by-step format, allowing the user to follow the full process or quickly jump to the spot where they need additional support. NREL promoted the material at the Joint Office's booth at the School Transportation News conference and presented a webinar as part of the EPA's clean school bus technical assistance webinar series. The first three modules on learning, scoping, and planning are published, and modules on implementation and operation will be published in FY 2025.

Recommendations for the Next Vehicle Charging Opportunities at Airports

Airports are electrifying vehicles to meet their decarbonization goals, but large-scale and uncoordinated charging will create negative grid conditions and high costs. Athena ZEV researchers are investigating the potential impact of rental cars, ground support equipment, transportation network companies, and airport parking charging to understand the potential for large grid impacts. The additional grid capacity needed to meet airport operations is unknown and difficult to determine because of the nonlinear nature of charging, the potential impacts of managed charging, the capacity each of the thousands of batteries will need, and uncertainty around when the adoption will occur. The complexity of computing loads and the optimization involved in finding cost-effective solutions means that compute-intensive modeling is required to provide airports in the United States a first-order approximation to the loads they will face soon and the most cost-effective technology to mitigate the harmful and expensive consequences of ignoring this. In FY 2025, researchers will review the rental car, ground support equipment, transportation network companies, and parking load results with key stakeholders, refine the analysis, and make final recommendations for future applications of Athena ZEV tools.

Sharing Lessons Learned From Past Rural Transportation Projects Can Increase Impact of Future VTO Investments

NREL identified and shared lessons learned through past VTO-funded projects in rural areas to provide the groundwork so others pursuing similar efforts can build on these experiences and future clean transportation investments can generate greater impacts. These project lessons provide best practices for engaging stakeholders, strategies for improving the equitable distribution of project benefits, site selection factors, and permitting/policy elements that could impact projects. Capturing and sharing key considerations from VTO-funded projects is especially critical for rural areas, where people face unique transportation challenges and need resources tailored to the rural context. NREL published the rural lessons learned on the CC&C website and will promote them through the coalition network and key industry partners.

Implementation Funding Extends Technical Assistance Program Into Clean Transportation Deployment

Clean transportation deployment funding is extending the impacts of the NREL-managed integration between CC&C and C2C. Entities participating in technical assistance offerings like C2C build strong partnerships and plans for clean transportation deployment but often lack funding to take the next step of project implementation. In response, NREL worked with VTO's Technology Integration Program to fund 11 follow-on projects for participants in the C2C peer-learning cohort Integrating Community Priorities in EV Plans and Projects. CC&C coalitions will continue to work with the local entities they supported during the cohort, and their clean transportation expertise will increase their partners' capacity to build strong deployment projects. Coalitions will lead project activities in FY 2025 with support from NREL as needed.

Alaska Tour Highlights Key Opportunities and Challenges for Clean Transportation Deployment In Harsh Environments

NREL curated a series of visits with key stakeholders in Alaska to identify how VTO's Technology Integration Program could strategically advance clean transportation deployment by taking into account the local cultural, demographic, geographic, and climate context. The NREL team applied its experience and knowledge of community-based deployment strategies to develop a tour of Fairbanks and Anchorage on behalf of the VTO program team. The visits connected the program with VTO funding awardees, explored opportunities and challenges associated with sustainable transportation in Alaska—including unique equity considerations for working with very remote communities and tribes—and

built connections with potential new partners, and deepened relationships with a prospective host organization for an Alaska CC&C coalition. In FY 2025, NREL will provide the program with a report of meeting summaries, key takeaways, and opportunities, as well as facilitate a second tour.

Analysis Highlights Importance of Charging Station Reliability on EV Adoption

NREL analyzed the relationship between EV charging station reliability and EV adoption to better understand how infrastructure uptime and convenience decrease range anxiety and influence vehicle sales. Understanding these relationships highlights the importance of stations being operational when needed and emphasizes the need for decision makers to allocate resources for maintenance, not just installation. NREL's report documented the impacts of multiple parameters on charger reliability and deployment, including extreme weather, codes and standards, region (urban vs. rural), and grid network type. Next steps include expanding the analysis to control for temperature-related mechanisms such as battery degradation and desire to limit human exposure to extreme temperatures.

New Fleet Research, Energy Data, and Insights (FleetREDI) API Delivers Secure Access to Powerful Decarbonization Data

To accelerate commercial vehicle decarbonization, three critical elements are needed: high-resolution operational data; sophisticated analysis; and distilled, actionable insights. To address each of these needs, NREL's FleetREDI team has launched a new Insights feature. Each time the team uses FleetREDI to analyze, optimize, demonstrate, and deploy clean commercial vehicle technologies, researchers distill key takeaways from their research into one-page Insights. These Insights provide actionable, ready-to-use information that can guide low- and zero-emissions technology deployments. This year, the team also created a new API that enables secure access to NREL's FleetREDI web portal, so partners can view reports, insights, and data products generated from their operational data and download cleansed and augmented data. The API will also assist public users and other tools with accessing aggregate and anonymized statistics from the full Fleet DNA database within FleetREDI.

Multi-State Transportation Electrification Impact Study Estimates Grid Upgrades Needed To Support Increased Demand

A DOE research study is addressing the challenge of preparing the electric grid for increased demand from the widespread adoption of EVs. It focuses on modeling the charging demands for all on-road vehicles—light-, medium-, and heavy-duty—and estimates the associated infrastructure and grid upgrades required to support this growth. In collaboration with LBNL, Kevala, and DOE, NREL has developed high-resolution estimates of EV charging infrastructure needs and distribution grid upgrades across five U.S. states. The study assesses the impacts of proposed EPA regulations on vehicle electrification and demonstrates that managed charging can reduce incremental grid costs by 30%. While the new regulations will accelerate EV adoption, the study shows that grid impacts may be modest, with only a 3% increase in annual utility investments. This finding shows that the transition to EVs is feasible and a promising pathway for achieving long-term decarbonization and climate goals without significant cost burdens. Future research could include modeling more advanced load management strategies and expanding the distribution impact analysis beyond the five states to better guide utility planning for widespread EV adoption.

Analysis

TEMPO Model and Documentation Enhancements Support Advancements in Transportation Modeling

The transportation landscape is rapidly changing, with technology and policy shifts requiring continuous model

improvements and related documentation updates. For example, passage of both the Inflation Reduction Act and EPA GHG regulations for vehicles will alter the future U.S. transportation system. NREL has updated the TEMPO model to establish a new baseline scenario, including representation of key provisions in the Inflation Reduction Act and a preliminary implementation of EPA GHG regulations. Additionally, the modeling team drafted an updated version of TEMPO's documentation to highlight these and other recent extensive enhancements to the model, with a focus on improved methods to represent charging infrastructure, charging load profiles, and vehicle technology adoption. These enhancements enable NREL to model the impact of new policies on U.S. transportation, including identifying gaps and barriers to decarbonization. They also provide a robust baseline against which to evaluate alternative future transportation scenarios. Next, the TEMPO team will finalize analysis of Inflation Reduction Act vehicle tax credit impacts and publish the updated model documentation—making it available via the NREL publications database and TEMPO webpage—and continue to support ongoing TEMPO scenario development and related analysis.

National Framework Enables Modeling of High-Resolution EV Electricity Demands and Flexibility

Electricity demand growth from EV charging, especially for medium- and heavy-duty EVs, is uncertain yet critical for power system planning. Existing projections are limited and often overlook managed charging, which can enhance the sustainability, economics, and reliability of power systems. NREL has developed a framework for producing high-resolution annual hourly EV demand datasets and EV demand flexibility representations compatible with grid models—such as the Regional Energy Deployment System (ReEDS), NREL's flagship capacity expansion model. The framework, which integrates two of NREL's best-in-class EV demand models—TEMPO and the Electric Vehicle Infrastructure – Projection (EVI-Pro) tool—generates hourly EV load projections at the ReEDS balancing-authority level through 2050, covering all on-road vehicles across multiple scenarios of EV adoption, infrastructure deployment, managed charging, and grid decarbonization. These projections offer crucial insights for power system planners, enabling optimized infrastructure investments and ensuring grid reliability while supporting the transition to a decarbonized grid. Next, NREL will integrate the EV load datasets into ReEDS to assess the impacts of increased EV charging and demand flexibility on system build-out, operations, costs, and emissions.

TEMPO Model Enhancements Focus on Non-Driving Modes and Initial County-Level Demand Validation

To support more robust modeling of convenience-focused decarbonization strategies, NREL has updated the TEMPO model with enhanced representation of non-driving modes. NREL has also conducted preliminary validation to ensure the model's accuracy in predicting total travel demand. Non-driving modes in TEMPO were improved by updating the mode calibration to account for walk and bicycle as separate modes, adding a new mode for personal e-bike, and updating transit service availability by time of day based on transit feed data. Preliminary TEMPO county-level validation shows that the model aptly represents total travel demand across counties, especially for shorter trip distances. This ensures the accurate representation of strategies that may cause mode shift away from personal cars such as land use change, transit enhancement, and congestion pricing. Next steps involve assessing convenience-focused strategies and comparing trends to POLARIS model results. Additional validation of TEMPO county-level results will leverage POLARIS outcomes and other travel datasets.

Smart Mobility Systems

Stakeholder Engagement Ensures Livewire Remains Responsive to Mobility Researcher Needs

The Livewire Data Platform team conducted outreach and engagement activities to help ensure the platform evolves in line with researcher needs as it continues to grow and expand its data catalog. The Livewire team sought input from stakeholders to gain insights on the types of projects and datasets they need to advance their research, invited data owners and users to attend a data working group meeting, and sought feedback at the CC&C annual training workshop. The team also released a new interactive, metadata-driven dataset map that visualizes the location of data while users search and continued publishing a quarterly newsletter. In FY 2025, the Livewire team will evaluate and target new data priorities informed by the data working group.

Partnership Explores Energy Advantages of Cargo E-Bikes

Movement and delivery of cargo and passengers in large vehicles contribute to traffic congestion, harmful emissions, and wasted energy. Cargo e-bikes can serve many of these mobility needs for commercial and household use with lower energy intensity. However, the capacity for cargo e-bikes to save energy has not been well studied. As part of the Micromobility Integrated Transit and Infrastructure for Efficiency project and in partnership with ANL and the city of Columbus, Ohio, NREL has conducted analyses to determine cargo e-bike benefits for representative use cases and plans to build on that understanding in future work. The use cases for cargo e-bikes span a wide range, including enabling parents to transport their children to school and replacing car use for movement of goods. One such example is the efficient delivering of Supplemental Nutrition Assistance Program food to underserved groups,

improving equity of access to healthy food. Understanding how cargo e-bikes can replace larger vehicles is critical to supporting shifts toward right-sized mobility options, which is essential to meeting energy and emissions reduction goals. This work is helping to quantify potential energy savings—from city and regional scales to the national scale. Next steps involve continued use-case analysis, including energy and cost evaluations for household use, commercial use, and mobility behavior.

Updated Version of FASTSim With Conventional and Hybrid Electric Powertrains Has Been Publicly Released on GitHub

Version 3 of NREL's FASTSim provides many improvements over FASTSim 2. Among its key enhancements are faster runtime, better user input validation, easier-to-maintain code, customization of which results get saved and how frequently, reduced memory usage, and an intuitive vehicle, system, subsystem, and component hierarchy. As the transition proceeds, developers of tools and projects that use FASTSim 3 are finding it faster, better documented, easier to configure, and easier to troubleshoot. Tools and projects leveraging FASTSim—for example, NREL's RouteE model and Transportation Technology Total Cost of Ownership (T3CO) tool, along with Google and numerous other projects and users—will benefit from lower costs due to more efficient use of developer time and compute time. FASTSim 3 also provides a foundation that could be used for FASTSim interfaces other than the widely used Python API. Next steps will focus on continuing to implement more powertrain types, develop accuracy benchmarks against FASTSim 2, and support the rollout of FASTSim 3 as it replaces the previous version.

Integrating Demographic Evolution Into Public Agency Travel Demand Models Improves Forecasting Capabilities

Many metropolitan planning organizations use static synthetic population data for travel demand modeling, which limits their ability to capture the impact of population dynamics—such as marriage, birth of a child, divorce, and loss of employment—on housing and transportation choices. To address this shortcoming, researchers at NREL and LBNL collaboratively developed the Demographic Microsimulator (DEMOS). The DEMOS software simulates the "continuum of life" in synthetic populations by capturing a wide range of life cycle events at both household and individual levels. Originally developed for DOE research, DEMOS is gaining interest from metropolitan planning organizations such as the Southern California Association of Governments for use in its travel demand model. Integrating DEMOS with this model will provide a richer, more dynamic socioeconomic profile for each person and household, significantly enhancing the model's capacity to predict and analyze the impacts of future transportation policies. The next step is to work with staff from the Southern California Association of Governments to deliver a stand-alone version of the DEMOS software that can take inputs from and provide outputs to their travel forecasting process.

RouteE Refinements Address Needs of Transit and Commercial Fleet Segments

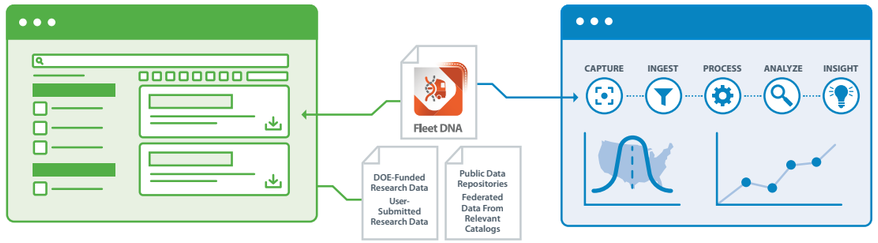
NREL's RouteE suite has been successfully applied in the light-duty passenger vehicle segment to reduce energy consumption. To expand its reach, the research team has refined and customized RouteE to better address the needs of fleets operating heavy-duty vehicles. The RouteE suite now includes models for transit buses and Class 8 freight vehicles to accurately predict the energy consumption of current and hypothetical future vehicles in normal fleet operations. Additional capabilities have been added, in collaboration with EquiCharge, to ingest

Unique, Complementary Tools for Transportation Research and Decision-Making

The **Livewire Data Platform**—co-maintained by the National Renewable Energy Laboratory (NREL)—and NREL's **Fleet Research, Energy Data, and Insights (FleetREDI) platform** serve different users at different points in the transportation research, development, and deployment space to enhance collective knowledge and bolster informed transportation decision-making to achieve decarbonization goals.

Livewire's extensive repository of downloadable data supports users crafting energy efficiency policies and conducting research on a variety of transportation projects. FleetREDI's data analyses and insights target research surrounding fleet needs, guiding users to explore requirements for designing, deploying, and adopting efficient and zero-carbon commercial vehicle technologies and infrastructure.

Livewire	&	FleetREDI
Provides access to data of all types on mobility and transportation projects across all modes.		Provides targeted data collection, processing, curation, analysis, and insights on commercial vehicles and supporting infrastructure.
Range of datasets including behavioral, experimental, modeled, analytical, and **raw** data at the **vehicle, traveler, and system levels.**		**Cleansed**, research-quality, expertly collected and curated **commercial vehicle operations and market data.**
Data are available to download and **analyze off-platform only.**		Data visualizations and insights **generated and accessible within the platform.**
Includes data across a **wide array of transportation modes and transportation- and mobility-related projects.**		Data are specific to **aggregated fleet, vehicle, and duty cycle data** collected through real-world sources and augmented with geospatial data.



- Livewire allows registered data stewards to catalog, document, and share project datasets via file-based sharing, API, or linking to an existing website or repository.
- Anyone can create a Livewire account, and once logged in, users seeking transportation data can securely search, discover, and access shared datasets, their metadata, and available APIs.
- Livewire does not generate, format, manipulate, or process data.

- FleetREDI collects, curates, processes, and analyzes data, combining multiple sources—including NREL's Fleet DNA repository—to create a single, larger, anonymized database and actionable data products.
- Any user can access FleetREDI's data products including visualizations, interactive dashboards, and bite-sized analysis results conducted by NREL researchers with FleetREDI.
- Users can access the FleetREDI portal directly on the web without a login, and data owners can log in via a secure webpage to view their own data dashboards.

LIVEWIRE DATA PLATFORM

Livewire is maintained by NREL, Idaho National Laboratory, and Pacific Northwest National Laboratory and funded by the U.S. Department of Energy's Vehicle Technologies Office.

FleetREDI

FleetREDI is maintained by NREL and funded by the U.S. Department of Energy s Vehicle Technologies Office.

General Transit Feed Specification data and predict transit bus energy consumption on scheduled routes. EquiCharge is now evaluating the new transit-specific RouteE features. Fleets are an important stakeholder in the vehicle electrification transition because they often operate energy-intensive, high-mileage vehicles. This work gives fleets the tools and confidence necessary to transition to electrified powertrains, resulting in significant energy reductions from replacing even a relatively small number of vehicles. Looking ahead, the research team will make similar capability additions in collaboration with commercial fleets, and at least one partner will assess the fleet-specific RouteE features in Class 8 freight vehicles.

RouteE Web API Updates Expose Latest Powertrain and Compass Capabilities

Some RouteE users have limited technical or computational resources, restricting their ability to use the open-source code bases. Enter the RouteE web API, which aims to provide functionality to enable exploration and light integration of RouteE Powertrain and Compass. Key capability improvements made this year include additional vehicle models and improved accuracy in Powertrain and multi-objective optimization in Compass. The updated API makes these improvements accessible with minimal technical requirements. RouteE Powertrain's accurate prediction of vehicle energy consumption can inform a range of energy and emissions reduction strategies from new vehicle adoption to smarter deployment and utilization. RouteE Compass builds on this with energy-aware routing to reduce energy use. Exposing capabilities through simple means like an API amplifies impact. NREL will continue to update the RouteE web API with the latest capabilities while being responsive to user feedback as more specific use cases emerge.

Increasing Access to Transit Can Support Equitable Mobility and Decarbonization

As shown in The U.S. National Blueprint for Transportation Decarbonization and literature review findings, there is a need to manage travel demand and related strategies at a national scale. Low-income and no-driver households see the greatest impacts from reducing or increasing access to transit. By increasing transit access to an additional 4–12 million urban households, researchers used the lab's Transportation Energy & Mobility Pathway Options (TEMPO) Model to determine that transit mode share could rise 1%–5% for low-income households and up to 10% for no-driver households. These results demonstrate the equitable impacts of transportation decarbonization strategies and highlight opportunities for increasing equitable mobility. Next steps are to finalize the results of the analysis and draft a journal publication highlighting its findings.

Cooperative Driving Automation Leads to Improved Mobility and Energy Savings

Researchers addressed the challenge of integrating vehicle and highway automation to optimize energy consumption, emissions, and mobility through cooperative driving automation, focusing on how connected and automated vehicles interact with traffic control systems and with each other. The project refined communication packets for cooperative driving automation applications, developed active traffic management strategies, and implemented a real-time simulation system with connected automated vehicles for optimal traffic signal control and vehicle-to-everything communication. Collaborators include the American Center for Mobility, LBNL, and ANL. This research is vital for reducing energy consumption and emissions while improving traffic flow and safety, contributing to sustainable transportation solutions. Future work includes expanding cooperative driving automation applications to larger network traffic management scenarios and testing the new communication protocols in the field.

SUCCESS METRICS

Patents & Records of Invention

Records of Invention

- High Performing Silicon Nanoparticle Anodes via Secondary Particle Formation
- Sodium-Ion Battery Anodes Based on Phosphorus-Doped Silicon Nanoparticles
- Carbon Nanostructures to Tune Electronic and Ionic Conducting Networks in Silicon Nanoparticle Anodes
- In situ Spectro-Electrochemical Battery Testing Cell with Coupled Multi-Modal ATR-FTIR and Gas Characterization
- Electrolyte Formulations to Improve Electrochemical Stability and Calendar Aging Behavior of Silicon Containing Li-Ion Battery Anodes
- Method for Upcycling Spent Graphite via Selective Surface Species Removal
- Solution Processable Covalent Organic Framework Solid Electrolyte
- Lithium Carborate Direct Solvent Mixing and Deposition for Battery Applications
- Lithium Carborate Interfacial Layer or Layered Electrolyte at Anode in Battery Applications
- Rapid Dry Microwave Synthesis of Argyrodite Solid Electrolytes
- Hybrid Solid State Silicon Anodes
- Direct Attach Thermocouple Using Ultrasonic Wire Bonding
- Continuous Microwave Assisted Leaching of Lithium-Ion Battery Materials
- Functionalization of Separator for Enhanced Battery Performance
- Compact Spring Jig for Applying High Pressures to Solid State Batteries During Electrochemical Testing
- Substrate-Immobilized Ion-Selective Moieties for Metal Recovery from Alkaline Solution

Patent Provisional Applications

- Heatsink Design with Variable Effective Heat Transfer Coefficient
- Ultra-Thin Current Collectors for Lithium-Ion Batteries
- Recyclable Composites of Varying and Hybrid Reinforcement Materials
- Polyester Covalently Adaptable Networks with Amines for Enhanced Recyclability and Cure
- Silicon Nanoparticle Electrode Compositions and Methods of Making the Same
- Methods For Increasing Porosity in Carbon-Silicon Electrodes
- Carbon Nanostructures for Electrodes
- Methods Of Upcycling Spent Graphite from Used Lithium-Ion Batteries
- Rapid Dry Microwave Synthesis of Argyrodite Solid Electrolytes

Patent Applications

- Methods And Devices for Electrochemical Relithiation of Lithium-Ion Batteries
- Recyclable Composites of Varying and Hybrid Reinforcement Materials

Patent Awards

- Condensers And Electronic Assemblies
- Methods And Devices for Electrochemical Relithiation Of Lithium-Ion Batteries
- Ternary Nitride Negative Electrode Based Lithium-Ion Battery

Publications & Communications

Vehicle Technologies Publication Metrics

Publication Type	Q1	Q2	Q3	Q4	Total
Journal Articles	23	13	21	12	**69**
Technical Reports, Conference Papers, Book Chapters, and Subcontractor Reports	26	20	13	17	**76**
Patents	1	1	2	0	**4**
Presentations and Posters	42	39	29	47	**157**
Brochures, Fact Sheets, and Other Outreach Materials	8	9	15	19	**51**
Management Reports	1	0	0	0	**1**
Total Publications	**101**	**82**	**61**	**59**	**358**

Publications

Brochures

1. 2024. "Advance Local Mobility Through Energy Efficient Mobility Systems Technologies." *https://www.nrel.gov/docs/fy24osti/81813.pdf.*
2. 2024. "Become EV Friendly With Planning Resources for Charging Infrastructure." *https://www.nrel.gov/docs/fy24osti/90008.pdf.*
3. Narumanchi, Sreekant; Khan, Faisal. 2024. "Advanced Power Electronics and Electric Machines." *https://www.nrel.gov/docs/fy24osti/89436.pdf.*

Conference Papers

4. Azam, Md Khalid Mahmud Bin; Ahmed, Aquib; Islam, Mohammad Muntasir; Dristy, Afsana Hossain; Siddiquee, Ashraf; Sozer, Yilmaz; Kisacikoglu, Mithat John. 2024. "On-Board AC Charging Topology Integrated with Electric Vehicle Motor Drive System." 2024 IEEE Applied Power Electronics Conference and Exposition (APEC), 25–29 Feb. 2024, Long Beach, CA. *https://dx.doi.org/10.1109/APEC48139.2024.10509402.*
5. Boshkovski, Filip; Nicholas, Carl; Zhang, Zichen; Paret, Paul; Ngo, Khai D. T.; Lu, Guo-Quan. 2023. "Effects of Encapsulant Properties on the Thermo-Mechanical Reliability of Double-Side Cooled Power Modules for Traction Inverters." Proceedings of the IEEE Energy Conversion Congress and Exposition (ECCE), 29 Oct.–2 Nov. 2023, Nashville, TN. *https://dx.doi.org/10.1109/ECCE53617.2023.10362816.*
6. Cairnie, Mark; Kamalapur, Aakash; Nassar, Rajaie; Knoll, Jack; Yuchi, Qingrui; Bae, Jung-Soo; DiMarino, Christina; Ngo, Khai; Lu, Guo-Quan; Li, Qiang; Boroyevich, Dushan; Zhou, Jierui; Cao, Yang; DeVoto, Douglas; Kekelia, Bidzina. 2024. "Modular Coaxial Power Converter for High-Density Integration into Medium-Voltage Cables." Proceedings of the International Exhibition and Conference for Power Electronics, Intelligent Motion, Renewable Energy and Energy Management (PCIM Europe 2024), 11–13 June 2024, Nurnberg, Germany. *https://ieeexplore.ieee.org/abstract/document/10653903.*
7. Chowdhury, Towhid; Koushan, Salar; Vahid, Sina; El-Refaie, Ayman; Feng, Xuhui; Cousineau, Emily; Kekelia, Bidzina. 2023. "Cooling Strategies for an Electric Motor with Additively Manufactured Hollow Conductors and Distributed Power Electronics Integrated with Heat Pipes." Proceedings of the IEEE Energy Conversion Congress and Exposition (ECCE), 29 Oct.–2 Nov. 2023, Nashville, TN. *https://dx.doi.org/10.1109/ECCE53617.2023.10362948.*
8. Chowdhury, Towhid; Koushan, Salar; Vahid, Sina; El-Refaie, Ayman; Feng, Xuhui; Cousineau, Emily; Kekelia, Bidzina. 2023. "Motorette Thermal Performance Testing and Modeling for an Electric Motor with Additively Manufactured Hollow Conductors with Integrated Heat Pipes." Proceedings of the IEEE Energy Conversion Congress and Exposition (ECCE), 29 Oct.–2 Nov. 2023, Nashville, TN. *https://dx.doi.org/10.1109/ECCE53617.2023.10361959.*
9. Dobzhanskyi, Oleksandr; Narumanchi, Sreekant; Tomerlin, Jeff; Kekelia, Bidzina; Gouws, Rupert; Cousineau, Emily. 2024. "Modelling a Motor Cooling System with Stator Lamination Fins." Proceedings of the 2023 IEEE 64th International Scientific Conference on Power and Electrical Engineering of Riga Technical University (RTUCON), 9–11 Oct. 2023, Riga, Latvia. *https://dx.doi.org/10.1109/RTUCON60080.2023.10412969.*
10. Feng, Xuhui; Moreno, Gilbert; Narumanchi, Sreekant. 2024. "Multiphysics Co-Optimization Design and Analysis of Double-Side Cooled Silicon Carbide-Based Power Module: Preprint." Presented at the ASME 2022 International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems, 25–27 Oct. 2022, Garden Grove, CA. *https://www.nrel.gov/docs/fy24osti/82890.pdf.*
11. Hasan, Syed Imam; Uzum, Alper; Haque, Md Ehsanul; Rahman, Mohammad Arifur; Siddiquee, Ashraf; Kisacikoglu, Mithat John; Sozer, Yilmaz. 2023. "Design, Optimization, and Validation of GaN-Based DAB Converter for Active Cell Balancing in BTMS Applications." Proceedings of the IEEE Energy Conversion Congress and Exposition (ECCE), 29 Oct.–2 Nov. 2023, Nashville, TN. *https://dx.doi.org/10.1109/ECCE53617.2023.10362340.*
12. Hasan, Syed Imam; Uzum, Alper; Haque, Md Ehsanul; Rahman, Mohammad Arifur; Siddiquee, Ashraf; Kisacikoglu, Mithat John; Sozer, Yilmaz. 2023. "Design, Optimization, and Validation of GaN-Based DAB Converter for Active Cell Balancing in BTMS Applications: Preprint." Presented at IEEE Energy Conversion Congress and Exposition (ECCE), Nashville, TN, 29 Oct–2 Nov. 2023. *https://www.nrel.gov/docs/fy24osti/87899.pdf.*
13. Hittinger, Eric; Desai, Ranjit; Bouscayrol, Alain. 2024. "Trends and Heterogeneity in Electric Vehicle Economics: A French Case Study." Proceedings of the 2023 IEEE Vehicle Power and Propulsion Conference (VPPC), 24–27 Oct. 2023, Milan, Italy. *https://dx.doi.org/10.1109/VPPC60535.2023.10403275.*
14. Jiang, Kaiying; Kong, Daeyoung; Kim, Kiwan; Narumanchi, Sreekant; Palko, James; Dede, Ercan M.; Ahn, Chulmin; Lee, Hyoungsoon; Asheghi, Mehdi; Goodson, Kenneth. 2024. "Pool Boiling Reliability Tests and Degradation Mechanisms of Microporous Copper Inverse Opal (CuIOs) Structures: Preprint." Presented at the IEEE ITherm Conference, 28–31 May 2024, Denver, CO. *https://www.nrel.gov/docs/fy24osti/88663.pdf.*
15. Kekelia, Bidzina; Wu, Qianying; Narumanchi, Sreekant; Major, Joshua; Moreno, Gilbert; Asheghi, Mehdi; Dede, Ercan M.; Palko, James; Goodson, Kenneth. 2023. "Reliability of Copper Inverse Opal Surfaces for Extreme-Heat-Flux Micro-Coolers in Low-Global-Warming-Potential Refrigerant R-1233zd Pool Boiling Experiments." Proceedings of the ASME 2023 International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems, 24–26 Oct. 2023, San Diego, CA. *https://dx.doi.org/10.1115/IPACK2023-113781.*
16. Khan, Md Shafquat Ullah; Watt, Edward; Thurlbeck, Alastair; Ucer, Emin; Mahmud, Rasel; Kisacikoglu, Mithat John; Meintz, Andrew. 2023. "Development of a DC Distribution Testbed for High-Power EV Charging." Proceedings of the IEEE Energy Conversion Congress and Exposition (ECCE), 29 Oct.–2 Nov. 2023, Nashville, TN. *https://dx.doi.org/10.1109/ECCE53617.2023.10362103.*
17. Kwon, Heungdong; Wu, Qianying; Kong, Daeuyong; Hazra, Sougata; Jiang, Katherine; Ahn, Chulmin; Narumanchi, Sreekant; Lee, Hyoungsoon; Palko, James; Dede, Ercan M.; Asheghi, Mehdi; Goodson, Kenneth E. 2024. "Development of a Hybrid Single/Two-Phase Capillary-Based Micro-Cooler Using Copper Inverse Opals Wick with Silicon 3D Manifold for High-Heat-Flux Cooling Application: Preprint." Presented at the IEEE ITherm Conference, 28–31 May 2024, Denver, CO. *https://www.nrel.gov/docs/fy24osti/88661.pdf.*
18. Le, Nhat; Borlaug, Brennan; Bruchon, Matthew; Jonas, Tim; Nguyen, Hieu T. 2024. "Electrifying Education: Insights into Charging Electric School Buses in the United States." Proceedings of the 2024 IEEE Power & Energy Society Innovative Smart Grid Technologies Conference (ISGT), 19–22 Feb. 2024, Washington, D.C. *https://doi.org/10.1109/ISGT59692.2024.10454200.*
19. Le, Nhat; Bruchon, Matthew; Jonas, Tim; Borlaug, Brennan; Nguyen, Hieu T. 2023. "Electrifying Education: Insights into Charging Electric School Buses in the United States (Citation Only)." Presenting at the IEEE Power & Energy Society (PES), Washington, D.C., 19–22 Feb. 2024.
20. Liu, Zhaocai; Alexeenko, Polina; Bruchon, Matthew; Zhang, Mingzhi; Kisacikoglu, Mithat John. 2024. "Analyzing Residential Charging Demand for Light-Duty Electric Vehicles in Colorado" Presented at the 2024 IEEE Transportation Electrification Conference & Expo, 19–21 June 2024, Rosemont, IL. *https://dx.doi.org/10.1109/ITEC60657.2024.10598922.*
21. Liu, Zhaocai; Alexeenko, Polina; Bruchon, Matthew; Zhang, Mingzhi; Kisacikoglu, Mithat John. 2024. "Analyzing Residential Charging Demand for Light-Duty Electric Vehicles in Colorado: Preprint." Presented at the 2024 IEEE Transportation Electrification Conference & Expo, 19–21 June 2024, Rosemont, IL. *https://www.nrel.gov/docs/fy24osti/89286.pdf.*
22. Lott, J. Sam; Young, Stanley E. 2023. "The Convergence of Vehicle Electrification and Automation - Enabling Sustainable Automated Mobility Districts." Proceedings of ASCE Inspire 2023, 16–18 Nov. 2023, Arlington, VA. *https://dx.doi.org/10.1061/9780784485163.025.*
23. Lott, J. Sam; Young, Stanley E. 2024. "Analysis of Automated Transit Network Systems with Battery-Electric Vehicles in Automated Mobility Districts: Preprint." Presented at the International Conference on Transportation and Development (ICTD 2024), 15–18 June 2024, Atlanta, GA. *https://www.nrel.gov/docs/fy24osti/88848.pdf.*
24. Lustbader, Jason; Baker, Chad; Payne, Grant; Reinicke, Nicholas; Smith, Kandler; Bruchon, Matt; Birky, Alicia; et al. 2023. "ALTRIOS – Advanced Locomotive Technology and Rail Infrastructure Optimization System, Exploring Pathways to Freight Rail Decarbonization (Citation Only)." Presented at the American Railway Engineering and Maintenance-of-Way Association, Indianapolis, IN, 1–4 Oct. 2023.

25. Mir, Faizan; Young, Stanley; Sandhu, Rimple; Wang, Qichao. 2024. "Spatiotemporal Automatic Calibration of Infrastructure Lidar, Radar, and Camera with a Global Navigation Satellite System: Preprint." Presented at the 27th IEEE International Conference on Intelligent Transportation Systems, 24–27 Sept. 2024, Edmonton, Canada. *https://www.nrel.gov/docs/fy24osti/89785.pdf*.

26. Paret, Paul; Bhogaraju, Sri Krishna; Busse, Dirk; Dahlbudding, Alexander; Elger, Gordon; Narumanchi, Sreekant. 2024. "Thermomechanical Degradation of Sintered Copper Under High-Temperature Thermal Shock." Proceedings of the 2024 IEEE 74th Electronic Components and Technology Conference (ECTC), 28–31 May 2024, Denver, CO. *https://dx.doi.org/10.1109/ECTC51529.2024.00196*.

27. Park, Jiho; Liu, Tong; Wang, Chieh; Wang, Hong; Wang, Qichao; Jiang, Zhong-Ping. 2024. "Traffic Signal Control for Large-Scale Urban Traffic Networks: Real-World Experiments using Vision-Based Sensors." Proceedings of the 2024 IEEE 18th International Conference on Control & Automation (ICCA), 18–21 June 2024, Reykjavik, Iceland. *https://dx.doi.org/10.1109/ICCA62789.2024.10591878*.

28. Pereira, Drew J.; Fink, Kae; Harrison, Katharine L. 2024. "Investigation of Nonflammable Electrolytes for Behind-the-Meter Storage Batteries (Citation Only)."

29. Prabakar, Kumaraguru; Velaga, Yaswanth Nag; Meadows, Rebecca; McGilton, Ben; Greco, Tessa; Salmon, Jonathan; Hill, Karl; Tinney, Levi. 2024. "Understanding Line Losses and Transformer Losses in Rural Isolated Distribution Systems." Proceedings of the 2024 IEEE Rural Electric Power Conference, 30 April–2 May 2024, Tulsa, OK. *https://dx.doi.org/10.1109/REPC57617.2024.00019*.

30. Pritchard, Ewan; Borlaug, Brennan; Yang, Fan; Gonder, Jeff. 2023. "Evaluating Electric Vehicle Public Charging Utilization in the United States Using the EV WATTS Dataset: Preprint." Presented at the 36th Electric Vehicle Symposium and Exposition (EVS36), Sacramento, CA, 11–14 June 2023. *https://www.nrel.gov/docs/fy24osti/85902.pdf*.

31. Rallabandi, Vandana; Mohammad, Mostak; Barua, Himel; Chowdhury, Shajjad; Ozpineci, Burak; Wilkins, Jon; Lin, Lainshan; Kekelia, Bidzina; Cousineau, Emily. 2023. "An Integrated Traction Drive with a High Speed Surface Permanent Magnet External Rotor Motor for Electric Vehicles." Proceedings of the IEEE Energy Conversion Congress and Exposition (ECCE), 29 Oct.–2 Nov. 2023, Nashville, TN. *https://dx.doi.org/10.1109/ECCE53617.2023.10362087*.

32. Soriano, Bruno S.; Owen, Landon; Esclapez, Lucas; Chen, Jacqueline. 2024. "DNS of Flame Stabilization Dynamics of a Swirl-Stabilized Spray Burner Using Sustainable Aviation Fuels." Proceedings of the AIAA SCITECH 2024 Forum, 8–12 Jan. 2024, Orlando, FL. *https://dx.doi.org/10.2514/6.2024-1999*.

33. Steuteville, Robin; Baker, Chad. 2024. "Implementing Ordinary Differential Equation Solvers in Rust Programming Language for Modeling Vehicle Powertrain Systems." WCX SAE World Congress Experience. *https://dx.doi.org/10.4271/2024-01-2148*.

34. Thurlbeck, Alastair P.; Siddiquee, Ashraf; Kisacikoglu, Mithat John; Sozer, Yilmaz. 2023. "Thurlbeck, Alastair P.; Siddiquee, Ashraf; Kisacikoglu, Mithat John; Sozer, Yilmaz." Proceedings of the IEEE Energy Conversion Congress and Exposition (ECCE), 29 Oct.–2 Nov. 2023, Nashville, TN. *https://dx.doi.org/10.1109/ECCE53617.2023.10361983*.

35. Thurlbeck, Alastair P.; Siddiquee, Ashraf; Kisacikoglu, Mithat John; Sozer, Yilmaz. 2023. "Active SOC Balancing for a Multi-Chemistry Battery Pack with Reduced Number of Converters: Preprint." Presented at IEEE Energy Conversion Congress and Exposition (ECCE), Nashville, TN, 29 Oct–2 Nov. 2023. *https://www.nrel.gov/docs/fy24osti/86749.pdf*.

36. Ucer, Emin; Thurlbeck, Alastair; Watt, Ed; Khan, Md Shafquat Ullah; Kisacikoglu, Mithat John; Meintz, Andrew. 2023. "Controller Hardware-in-the-Loop Modeling and Operation of a High-Power DC Charging Hub." Proceedings of the IEEE Energy Conversion Congress and Exposition (ECCE), 29 Oct.–2 Nov. 2023, Nashville, TN. *https://dx.doi.org/10.1109/ECCE53617.2023.10362951*.

37. Usman, Adil; Singh Rajpurohit, Bharat. 2024. "Rotor Magnet Fault Analysis in Permanent Magnet AC Machines Under Load Conditions - All Electric Transportation Systems." Proceedings of the 2023 IEEE Industry Applications Society Annual Meeting (IAS), 29 Oct.–2 Nov. 2023, Nashville, TN. *https://dx.doi.org/10.1109/IAS54024.2023.10406969*.

38. Vinoth, Sangeeta P.; Feng, Xuhui; Galea, Christopher; Moreno, Gilbert; Paluszek, Michael; Narumanchi, Sreekant. 2024. "Thermal Management of Wide-Bandgap Semiconductor Amplifiers Used for Plasma Heating and Control." 2024 40th Semiconductor Thermal Measurement, Modeling & Management Symposium (SEMI-THERM), 25–28 March 2024, San Jose, CA. *https://ieeexplore.ieee.org/document/10535011*.

39. Young, Stanley E.; Lott, J. Sam. 2024. "Automated Mobility Districts - A Conceptual Definition: Preprint." Presented at the Infrastructure Intelligence Conference, 6–7 June 2023, Austin, TX. *https://www.nrel.gov/docs/fy24osti/86453.pdf*.

40. Zhao, Shuofeng; Khan, Faisal. 2024. "A Multi-Metrics In Situ Aging Detector for SiC Power MOSFET Modules with Full Driver-Integration Capability." 2024 IEEE Applied Power Electronics Conference and Exposition (APEC), 25–29 Feb. 2024, Long Beach, CA. *https://dx.doi.org/10.1109/APEC48139.2024.10509184*.

Fact Sheets

41. 2023. "Clean Cities Coalitions: Advancing Affordable, Efficient, and Clean Transportation Fuels and Technologies." *https://www.nrel.gov/docs/fy24osti/87034.pdf*.

42. 2023. "Cold Weather Impacts on Electric School Buses." *https://www.nrel.gov/docs/fy24osti/87940.pdf*.

43. 2023. "Conceptos Basicos Sobre los Vehiculos Electricos." *https://www.nrel.gov/docs/fy24osti/87859.pdf*.

44. 2023. "Public EV Charging Station Site Selection Checklist." *https://www.nrel.gov/docs/fy24osti/86706.pdf*.

45. 2023. "Quick Start to Electrifying Your School Bus Fleet." *https://www.nrel.gov/docs/fy24osti/88260.pdf*.

46. 2023. "Technical Assistance 101 – How Can the Joint Office Support You?" *https://www.nrel.gov/docs/fy24osti/87330.pdf*.

47. 2024. "Alternative Fuels Data Center Fuel Properties Comparison." *https://www.nrel.gov/docs/fy24osti/89227.pdf*.

48. 2024. "At a Glance: Electric Vehicles (French Translation)." *https://www.nrel.gov/docs/fy24osti/90667.pdf*.

49. 2024. "Battery Energy Storage for Electric Vehicle Charging Stations." *https://www.nrel.gov/docs/fy24osti/89493.pdf*.

50. 2024. "Building Electrification Pathways for Airports: Envisioning the Future of Zero-Emissions Transportation." *https://www.nrel.gov/docs/fy24osti/88716.pdf*.

51. 2024. "Clean Cities and Communities: Advancing Affordable, Efficient, and Clean Transportation." *https://www.nrel.gov/docs/fy24osti/89087.pdf*.

52. 2024. "Clean Cities and Communities: Connect With Your Coalition (Citation Only)."

53. 2024. "Cold Weather Impacts on Battery-Electric Transit Buses." *https://www.nrel.gov/docs/fy24osti/89888.pdf*.

54. 2024. "Disruptive Silicon Anode Technology for Next-Generation Lithium-Ion Batteries." *https://www.nrel.gov/docs/fy24osti/88587.pdf*.

55. 2024. "Electric Vehicle Fire Primer for Fleet Managers." *https://www.nrel.gov/docs/fy24osti/88225.pdf*.

56. 2024. "Embedding Equity into Community EV Readiness Planning." *https://www.nrel.gov/docs/fy24osti/90148.pdf*.

57. 2024. "Embedding Equity into Electric Vehicle Charging Station Design." *https://www.nrel.gov/docs/fy24osti/90147.pdf*.

58. 2024. "Grid-Constrained Electric Vehicle Fast Charging Sites: Battery-Buffered Options." *https://www.nrel.gov/docs/fy24osti/89492.pdf*.

59. 2024. "Hot Weather Impacts on Battery-Electric Transit Buses." *https://www.nrel.gov/docs/fy24osti/89889.pdf*.

60. 2024. "Hot Weather Impacts on Electric School Buses." *https://www.nrel.gov/docs/fy24osti/90505.pdf*.

61. 2024. "Lessons Learned from the Clean Energy to Communities (C2C) Peer-Learning Cohort on Planning and Funding for Electric Vehicle Charging Infrastructure Deployment." *https://www.nrel.gov/docs/fy24osti/89491.pdf*.

62. 2024. "MUTCD 11th Edition - What's New in Signage for Electric Vehicle Charging and Parking." *https://www.nrel.gov/docs/fy24osti/90387.pdf*.

63. 2024. "Pathways to a Sustainable Aviation Ecosystem: Aviation Energy Research and Operation Simulator (AEROSim)." *https://www.nrel.gov/docs/fy24osti/89450.pdf*.

64. 2024. "Pathways Toward Electric Mobility in Hennepin County, Minnesota." *https://www.nrel.gov/docs/fy24osti/89200.pdf*.

65. 2024. "Physical Safety and Security at Electric Vehicle Charging Sites." *https://www.nrel.gov/docs/fy24osti/90150.pdf*.

66. 2024. "State and Alternative Fuel Provider Fleets: Fleet Compliance Annual Report - Model Year 2022, Fiscal Year 2023." *https://www.nrel.gov/docs/fy24osti/88452.pdf*.

67. 2024. "The Clean Bus Planning Awards Program." *https://www.nrel.gov/docs/fy24osti/88631.pdf*.

68. 2024. "The Clean Bus Planning Awards Program." *https://www.nrel.gov/docs/fy24osti/88669.pdf*.

69. Alexeenko, Polina; Sigler, Cory; Birky, Alicia; Kotz, Andrew; Lustbader, Jason. 2024. "Electrification Analysis: Manhattan Beer." *https://www.nrel.gov/docs/fy24osti/90704.pdf*.

70. Polemis, Katerina; Kotz, Andrew. 2024. "Electrification Analysis: Container Ports' Cargo Handling Equipment." *https://www.nrel.gov/docs/fy24osti/91423.pdf*.

Journal Articles

71. Ahmed, Sheikh; Lockwood, Katherine; Miller, Jacob H.; Huq, Nabila; Luecke, Jon; Labbe, Nicole; Foust, Thomas. 2023. "Understanding Fundamental Effects of Biofuel Structure on Ignition and Physical Fuel Properties." Fuel 358 (B): 129999. *https://doi.org/10.1016/j.fuel.2023.129999*.

72. Arellano Trevino, Martha A.; Baddour, Frederick G.; To, Anh T.; Alleman, Teresa L.; Hays, Cameron; Luecke, Jon; et al. 2023. "Diesel Fuel Properties of Renewable Polyoxymethylene Ethers with Structural Diversity." Fuel 358 (B): 130353. *https://doi.org/10.1016/j.fuel.2023.130353*.

73. Bassett, Kimberly L.; Small, Kathryn A.; Long, Daniel M.; Merrill, Laura C.; Warren, Benjamin; Harrison, Katherine L. 2023. "Interfacial Pressure Improves Calendar Aging of Lithium Metal Anodes." Frontiers in Batteries and Electrochemistry 2. *https://doi.org/10.3389/fbael.2023.1292639*.

74. Berres, Andy; Moriano, Pablo; Xu, Haowen; Tennille, Sarah; Smith, Lee; Storey, Jonathan; Sanyal, Jibonananda. 2024. "A Traffic Accident Dataset for Chattanooga, Tennessee." Data in Brief 55: 110675. *https://doi.org/10.1016/j.dib.2024.110675*.

75. Brow, Ryan; Berquist, Zachary; Lee, Steven; Martin, Trevor; Meyer, Lydia; Schulze, Maxwell; Singh, Avtar; Tancin, Ryan; Teeter, Glenn; Veith, Gabriel; Tremolet de Villers, Bertrand J.; Colclasure, Andrew; Manthiram, Arumugam. 2024. "Cobalt-Free Cathodes and Silicon Thin-Film Anodes Towards High-Capacity Solid-State Batteries." Journal of Energy Storage 99 (A): 113329. *https://doi.org/10.1016/j.est.2024.113329*.

76. Cai, Jiyu; Zhou, Xinwei; Nguyen, Hoai T.; Veith, Gabriel M.; Qin, Yan; Lu, Wenquan; Trask, Stephen E.; et al. 2023. "Critical Contribution of Imbalanced Charge Loss to Performance Deterioration of Si-Based Lithium-Ion Cells During Calendar Aging." ACS Applied Materials & Interfaces 15 (41): 48085–48095. *https://doi.org/10.1021/acsami.3c08015*.

77. Chen, Wan-Xin; Allen, Jeffery M.; Rezaei, Shahed; Furat, Orkun; Schmidt, Volker; Singh, Avtar; Weddle, Peter J.; Smith, Kandler; Xu, Bai-Xiang. 2024. "Cohesive Phase-Field Chemo-Mechanical Simulations of Inter- and Trans- Granular Fractures in Polycrystalline NMC Cathodes via Image-Based 3D Reconstruction." Journal of Power Sources 596: 234054. *https://www.nrel.gov/docs/fy24osti/88494.pdf*.

78. Chowdhury, Towhid; Koushan, Salar; Al-Qarni, Ali; Vahid, Sina; El-Refaie, Ayman; Bennion, Kevin; Cousineau, Emily; Feng, Xuhui; Kekelia, Bidzina. 2024. "Thermal Management System for an Electric Machine With Additively Manufactured Hollow Conductors With Integrated Heat Pipes." IEEE Transactions on Industry Applications. *https://dx.doi.org/10.1109/TIA.2024.3353720*.

79. Cochran, Jaquelin; Denholm, Paul; Mooney, Meghan; Steinberg, Daniel; Hale, Elaine; Heath, Garvin; Palmintier, Bryan; Keyser, David; Oleson, Devonie; Arent, Doug; Horsey, Henry; Fontanini, Anthony; Muratori, Matteo; Jorgenson, Jennie; Ravi, Vikram; Cowiestoll, Brady; Sigrin, Ben; Horowitz, Kelsey; Jain, Himanshu; Irish, Matt; Nicholson, Scott; Ban-Weiss, George; Cutler, Harvey. 2024. "Integrated Multimodel Analysis Reveals Achievable Pathways Toward Reliable, 100% Renewable Electricity for Los Angeles." Cell Reports Sustainability 1 (4): 100078. *https://doi.org/10.1016/j.crsus.2024.100078*.

80. Cooper, Sean P.; Naser, Nimal; Chatterjee, Tanusree; Kim, Yeonjoon; Kukkadapu, Goutham; Fioroni, Gina M.; Kim, Seonah; Mathieu, Olivier; Petersen, Eric L.; Pitz, William J.; McCormick, Robert. 2024. "An Experimental and Chemical Kinetic Modeling Study of 4-Butoxyheptane Combustion." Combustion and Flame 267: 113568. *https://doi.org/10.1016/j.combustflame.2024.113568*.

81. Esteban, Johnny; Grahn, Rick; Powell, Bonnie; Young, Stanley E. 2024. "Community Public Mobility Using On-Demand, Low-Speed Electric Vehicles: A Case Study in Downtown St. Louis, Missouri." Transportation Research Record. *https://doi.org/10.1177/03611981241262306*.

82. Finegan, Donal P.; Billman, Julia; Darst, Jacob; Hughes, Peter; Trillo, Jesus; Sharp, Matt; Benson, Alex; Pham, Martin; Kesuma, Inez; Buckwell, Mark; Reid, Hamish T.; Kirchner-Burles, Charlie; Fransson, Matilda; Petrushenko, David; Heenan, Thomas M. M.; Jervis, Rhodri; Owen, Rhodri; Patel, Drasti; Broche, Ludovic; Rack, Alexander; Magdysyuk, Oxana; Keyser, Matt; Walker, William; Shearing, Paul; Darcy, Eric. 2024. "The Battery Failure Databank: Insights from an Open-Access Database of Thermal Runaway Behaviors of Li-Ion Cells and a Resource for Benchmarking Risks." Journal of Power Sources 597: 234106. *https://www.nrel.gov/docs/fy24osti/87431.pdf*.

83. Fransson, Matilda; Pfaff, Jonas; Broche, Ludovic; Buckwell, Mark; Kirchner-Burles, Charlie; Reid, Hamish T.; Schopferer, Sebastian; Rack, Alexander; Finegan, Donal P.; Shearing, Paul R. 2024. "Exploring Thermal Runaway Propagation in Li-Ion Batteries through High-Speed X-Ray Imaging and Thermal Analysis: Impact of Cell Chemistry and Electrical Connections." Journal of Power Sources 617: 234916. *https://doi.org/10.1016/j.jpowsour.2024.234916*.

84. Furat, Orkun; Finegan, Donal P.; Yang, Zhenzhen; Neumann, Matthias; Kim, Sangwook; Tanim, Tanvir R.; Weddle, Peter; Smith, Kandler; Schmidt, Volker. 2023. "Quantifying the Impact of Operating Temperature on Cracking in Battery Electrodes, Using Super-Resolution of Microscopy Images and Stereology." Energy Storage Materials 64: 103036. *https://doi.org/10.1016/j.ensm.2023.103036*.

85. Gasper, Paul; Sunderlin, Nathaniel; Dunlap, Nathan; Walker, Patrick; Finegan, Donal P.; Smith, Kandler; Thakkar, Foram. 2024. "Lithium Loss, Resistance Growth, Electrode Expansion, Gas Evolution, and Li Plating: Analyzing Performance and Failure of Commercial Large-Format NMC-Gr Lithium-Ion Pouch Cells." Journal of Power Sources 604: 234494. *https://dx.doi.org/10.1016/j.jpowsour.2024.234494*.

86. Gromala, Przemyslaw; Luo, Fang; Narumanchi, Sreekant. 2024. "Foreword: Special Section on Multiphysics Aspects of Power Electronics Packaging - Power Die, Power Module, and Converter Level - Part 1." IEEE Transactions on Components, Packaging, and Manufacturing Technology 14 (5): 751–753. *https://doi.org/10.1109/TCPMT.2024.3393588*.

87. Guittet, Darice; Gasper, Paul; Shirk, Matt; Mitchell, Matt; Gilleran, Madeline; Bonnema, Eric; Smith, Kandler; Mishra, Partha; Mann, Margaret. 2024. "Levelized Cost of Charging of Extreme Fast Charging with Stationary LMO/LTO Batteries." Journal of Energy Storage 82: 110568. *https://dx.doi.org/10.1016/j.est.2024.110568*.

88. Hassanaly, Malik; Weddle, Peter J.; King, Ryan N.; De, Subhayan; Doostan, Alireza; Randall, Corey R.; Dufek, Eric J.; Colclasure, Andrew M.; Smith, Kandler. 2024. "PINN Surrogate of Li-Ion Battery Models for Parameter Inference, Part I: Implementation and Multi-Fidelity Hierarchies for the Single-Particle Model." Journal of Energy Storage 98 (B): 113103. *https://doi.org/10.1016/j.est.2024.113103*.

89. Hassanaly, Malik; Weddle, Peter J.; King, Ryan N.; De, Subhayan; Doostan, Alireza; Randall, Corey R.; Dufek, Eric J.; Colclasure, Andrew M.; Smith, Kandler. 2024. "PINN Surrogate of Li-Ion Battery Models for Parameter Inference, Part II: Regularization and Application of the Pseudo-2D Model." Journal of Energy Storage 98 (B): 113104. *https://doi.org/10.1016/j.est.2024.113104*.

90. Hoehne, Christopher; Muratori, Matteo; Jadun, Paige; Bush, Brian; Yip, Arthur; Ledna, Catherine; Vimmerstedt, Laura; Podkaminer, Kara; Ma, Ookie. 2023. "Exploring Decarbonization Pathways for USA Passenger and Freight Mobility." Nature Communications 14: 6913. *https://doi.org/10.1038/s41467-023-42483-0*.

91. Huey, Zoey; Carroll, G. Michael; Coyle, Jaclyn; Walker, Patrick; Neale, Nathan R.; DeCaluwe, Steven; Jiang, Chunsheng. 2024. "Impacts of Curing-Induced Phase Segregation in Silicon Nanoparticle-Based Electrodes." Batteries 10 (9): 313. *https://doi.org/10.3390/batteries10090313*.

92. Jia, Yikai; Zhao, Peng; Finegan, Donal P.; Xu, Jun. 2024. "Dynamics of Intra-Cell Thermal Front Propagation in Lithium-Ion Battery Safety Issues." Advanced Energy Materials: 2400621. *https://doi.org/10.1002/aenm.202400621*.

93. Jin, Ling; Jackson, Connor P.; Wang, Yuhan; Chen, Qianmiao; Ho, Tin; Spurlock, C. Anna; Brooker, Aaron; Holden, Jacob; Gonder, Jeffrey; Bouzaghrane, Mohamed Amine; Sun, Bingrong; Sharda, Shivam; Garikapati, Venu; Wenzel, Tom; Caicedo, Juan. 2024. "Technology Progress and Clean Vehicle Policies on Fleet Turnover and Equity: Insights from Household Vehicle Fleet Micro-Simulations with ATLAS." Transportation Planning and Technology. *https://dx.doi.org/10.1080/03081060.2024.2353784*.

94. Kim, Jae Ho; Huey, Zoey; Veith, Gabriel M.; Jiang, Chun-Sheng; Neale, Nathan R.; Carroll, G. Michael. 2024. "Blended 1D Carbon Nanostructures Synergistically Enhance Electron and Ion Transport in Silicon Nanoparticle Electrodes." Cell Reports Physical Science 5 (6): 101974. *https://doi.org/10.1016/j.xcrp.2024.101974*.

95. Ko, Youngmin; Bae, Jiwoong; Chen, Gan; Baird, Michael A.; Yan, Jiajun; Klivansky, Liana; Kim, Dong-Min; Trask, Stephen E.; Rodrigues, Marco-Tulio Fonseca; Carroll, Gerard M.; Neale, Nathan R.; Helms, Brett A. 2024. "Topological Considerations in Electrolyte Additives for Passivating Silicon Anodes with Hybrid Solid-Electrolyte Interphases." ACS Energy Letters 9 (7): 3448–3455. *https://doi.org/10.1021/acsenergylett.4c01331*.

96. Kosmacher, Gabriel; Shankari, K. 2023. "Evaluating the Interplay Between Trajectory Segmentation and Mode Inference Error." Transportation Research Record. *https://doi.org/10.1177/03611981231208154*.

97. Kukkadapu, Goutham; Whitesides, Russell; Wang, Mengyuan; Wagnon, Scott W.; Mehl, Marco; Westbrook, Charles K.; McCormick, Robert; Sung, Chih-Jen; Pitz, William J. 2023. "Development of a Diesel Surrogate for Improved Autoignition Prediction: Methodology and Detailed Chemical Kinetic Modeling." Applications in Energy and Combustion Science 16: 100216. *https://doi.org/10.1016/j.jaecs.2023.100216*.

98. Kwon, Heungdong; Wu, Qianying; Kong, Daeyoung; Hazra, Sougata; Jiang, Kaiying; Narumanchi, Sreekant; Lee, Hyoungsoon; Palko, James W.; Dede, Ercan M.; Asheghi, Mehdi; Goodson, Kenneth E. 2024. "Capillary-Enhanced Two-Phase Micro-Cooler Using Copper-Inverse-Opal Wick with Silicon Microchannel Manifold for High-Heat-Flux Cooling Application." International Communications in Heat and Mass Transfer 156: 107592. *https://dx.doi.org/10.1016/j.icheatmasstransfer.2024.107592*.

99. Ledna, Catherine; Muratori, Matteo; Yip, Arthur; Jadun, Paige; Hoehne, Christopher; Podkaminer, Kara. 2024. "Assessing Total Cost of Driving Competitiveness of Zero-Emission Trucks." iScience 27 (4): 109385. *https://www.nrel.gov/docs/fy24osti/86401.pdf*.

100. Lee, Dong-Yeon; McDermott, Melanie H.; Sovacool, Benjamin K.; Isaac, Raphael. 2024. "Toward Just and Equitable Mobility: Socioeconomic and Perceptual Barriers for Electric Vehicles and Charging Infrastructure in the United States." Energy and Climate Change 5: 100146. *https://doi.org/10.1016/j.egycc.2024.100146*.

101. Li, Yang; ul-Hassan, Mustafeez; Mirza, Abdul Basit; Xie, Yang; Deng, Shiyue; Vala, Sama Salehi; Luo, Fang; Feng, Xuhui; Narumanchi, Sreekant; Flicker, Jack David. 2024. "State-of-the-Art Medium- and High-Voltage Silicon Carbide Power Modules, Challenges and Mitigation Techniques: A Review." IEEE Transactions on Components, Packaging and Manufacturing Technology. *https://doi.org/10.1109/TCPMT.2024.3391653*.

102. Liu, Zhaocai; Borlaug, Brennan; Meintz, Andrew; Neuman, Christopher; Wood, Eric; Bennett, Jesse. 2023. "Data-Driven Method for Electric Vehicle Charging Demand Analysis: Case Study in Virginia." Transportation Research Part D: Transport and Environment 125: 103994. *https://doi.org/10.1016/j.trd.2023.103994*.

103. Lu, Hannah; Rischpater, Katie; Shankari, K. 2024. "Learning From User Behavior: A Survey-Assist Algorithm for Longitudinal Mobility Data Collection." Travel Behaviour and Society 36: 100761. *https://doi.org/10.1016/j.tbs.2024.100761*.

104. McBrayer, Josefine D.; Harrison, Katharine L.; Allcorn, Eric; Minteer, Shelley D. 2023. "Chemical Contributions to Silicon Anode Calendar Aging are Dominant Over Mechanical Contributions." Frontiers in Batteries and Electrochemistry. *https://doi.org/10.3389/fbael.2023.1308127*.

105. McBrayer, Josefine D.; Schorr, Noah B.; Lam, Mila Nhu; Meyerson, Melissa L.; Harrison, Katharine L.; Minteer, Shelley D. 2024. "Scanning Electrochemical Microscopy Reveals That Model Silicon Anodes Demonstrate Global Solid Electrolyte Interphase Passivation Degradation During Calendar Aging." ACS Applied Materials & Interfaces 16 (15): 19663–19671. *https://doi.org/10.1021/acsami.3c14361*.

106. McCormick, Robert L.; Fioroni, Gina M.; Mohamed, Samah Y.; Naser, Nimal; Alleman, Teresa L.; Kim, Seonah; Wang, Ziyu; Lin, Ying; Ju, Yiguang; Kar, Kenneth. 2024. "Fuel Property Evaluation of Unique Fatty Acid Methyl Esters Containing β-Hydroxy Esters from Engineered Microorganisms." Fuel Communications 19: 100120. *https://doi.org/10.1016/j.jfueco.2024.100120*.

107. McCormick, Robert L.; Fioroni, Gina M.; Naser, Nimal; Luecke, Jon. 2024. "Properties That Potentially Limit High-Level Blends of Biomass-Based Diesel Fuel." Energy & Fuels 38 (10): 8829–8841. *https://doi.org/10.1021/acs.energyfuels.4c00912*.

108. Moriano, Pablo; Berres, Andy; Xu, Haowen; Sanyal, Jibonananda. 2023. "Spatiotemporal Features of Traffic Help Reduce Automatic Accident Detection Time." Expert Systems with Applications 244: 122813. *https://doi.org/10.1016/j.eswa.2023.122813*.

109. Myllenbeck, Nicholas R.; Monroe, Eric; Sarwar, Mysha; Alleman, Teresa; Hays, Cameron; Luecke, Jon; Zhu, Junqing; McEnally, Charles; Pfefferle, Lisa; George, Anthe; Davis, Ryan W. 2024. "High Performance Alkyl Dialkoxyalkanoate Bioderived Transportation Fuels Accessed Using a Mild and Scalable Synthetic Protocol." Sustainable Energy & Fuels 8: 1085–1093. *https://doi.org/10.1039/D3SE00804E*.

110. Pach, Gregory F.; Adhikari, Pashupati R.; Quinn, Joseph; Wang, Chongmin; Singh, Avtar; Verma, Ankit; Colclasure, Andrew; Kim, Jae Ho; Teeter, Glenn; Veith, Gabriel M.; Neale, Nathan R.; Carroll, Gerard M. 2024. "Boron-Silicon Alloy Nanoparticles as a Promising New Material in Lithium-Ion Battery Anodes." ACS Energy Letters 9 (6): 2492–2499. *https://dx.doi.org/10.1021/acsenergylett.4c00856*.

111. Powell, Bonnie; Acharya, Sailesh; Zakaria, Ruqayya; Grahn, Rick; Henao, Alejandro; Young, Stanley E. 2024. "Mobility Energy Productivity Evaluation of On-Demand Transit: A Case Study in Arlington, Texas." Transportation Research Record. *https://dx.doi.org/10.1177/03611981241234901*.

112. Putsche, Victoria L.; Pattany, Jasmine; Ghosh, Tapajyoti; Atnoorkar, Swaroop; Zuboy, Jarett; Carpenter, Alberta; Takeuchi, Esther S.; Marschilok, Amy C.; Takeuchi, Kenneth J.; Burrell, Anthony; Mann, Margaret K. 2023. "A Framework for Integrating Supply Chain, Environmental, and Social Justice Factors During Early Stationary Battery Research." Frontiers in Sustainability. *https://doi.org/10.3389/frsus.2023.1287423*.

113. Rasheed, Marium; Hassan, Rohail; Kamel, Mohamed; Wang, Hongjie; Zane, Regan; Tong, Shijie; Smith, Kandler. 2023. "Active Reconditioning of Retired Lithium-ion Battery Packs from Electric Vehicles for Second Life Applications." IEEE Journal of Emerging and Selected Topics in Power Electronics. *https://doi.org/10.1109/JESTPE.2023.3325251*.

114. Rodriguez-Roman, Daniel; Carlo, Hector J.; Sperling, Joshua; Duvall, Andrew; Leoncio-Caban, Ruben E.; del Puerto, Carla Lopez. 2024. "Optimizing the Location and Configuration of Disaster Resilience Hubs Under Transportation and Electric Power Network Failures." Transportation Research Interdisciplinary Perspectives 24: 101179. *https://doi.org/10.1016/j.trip.2024.101079*.

115. Rom, Christopher L.; Yox, Philip; Cardoza, Abby M.; Smaha, Rebecca W.; Phan, Maxwell Q.; Martin, Trevor R.; Maughan, Annalise E. 2024. "Expanding the Phase Space for Halide-Based Solid Electrolytes: Li-Mg-Zr-Cl Spinels." Chemistry of Materials 36 (15): 7283–7291. *https://doi.org/10.1021/acs.chemmater.4c01160*.

116. Saxon, Aron; Yang, Chuanbo; Santhanagopalan, Shriram; Keyser, Matthew; Colclasure, Andrew. 2024. "Li-ion Battery Thermal Characterization for Thermal Management Design." Batteries 10 (4): 136. *https://doi.org/10.3390/batteries10040136*.

117. Shams, Andalib; Wang, Qichao; Ugirumurera, Juliette; Severino, Joseph; Jones, Wesley; Sanyal, Jibonananda. 2024. "Simulation Evaluation of a Large-Scale Implementation of Virtual-Phase Link-Based Model Predictive Control." Journal of Transportation Engineering, Part A: Systems 150 (9). *https://doi.org/10.1061/JTEPBS.TEENG-8079*.

118. Sharda, Shivam; Garikapati, Venu M.; Goulias, Konstadinos G.; Reyna, Janet L.; Sun, Bingrong; Spurlock, C. Anna; Needell, Zachary. 2023. "The Electric Vehicles-Solar Photovoltaics Nexus: Driving Cross-Sectoral Adoption of Sustainable Technologies." Renewable and Sustainable Energy Reviews 191: 114172. *https://doi.org/10.1016/j.rser.2023.114172*.

119. Singh, Avtar; Song, Jihun; Li, Wei; Martin, Trevor; Xu, Hongyi; Finegan, Donal P.; Zhu, Juner. 2024. "Microstructure-Chemomechanics Relations of Composite Electrodes in Solid-State Batteries." Extreme Mechanics Letters 69: 102164. *https://doi.org/10.1016/j.eml.2024.102164*.

120. Siripanich, Amarin; Rashidi, Taha H.; Kalyanaraman, Shankari; Waller, Travis S.; Saberi, Meead; Dixit, Vinayak; Nair, Divya. 2024. "Using Facebook to Recruit Urban Participants for Smartphone-Based Travel Surveys." Transportation Research Interdisciplinary Perspectives 25: 101116. *https://doi.org/10.1016/j.trip.2024.101116*.

121. Soto, Mel; Fink, Kae; Zweifel, Christof; Weddle, Peter J.; Spotte-Smith, Evan Walter Clarke; Veith, Gabriel M.; Persson, Kristin A.; Colclasure, Andrew M.; Tremolet de Villers, Bertrand J. 2024. "Solubilities of Ethylene and Carbon Dioxide Gases in Lithium-Ion Battery Electrolyte." Journal of Chemical & Engineering Data 69 (6): 2236–2243. *https://doi.org/10.1021/acs.jced.3c00692*.

122. Taghikhani, Kasra; Singh, Avtar; Weddle, Peter B.; Colclasure, Andrew M.; Smith, Kandler; Berger, J. R.; Kee, Robert J. 2024. "Consequences of Plane-Strain and Plane-Stress Assumptions in Fully Coupled Chemo-Mechanical Li-Ion Battery Models." Electrochimica Acta 479: 143790. *https://dx.doi.org/10.1016/j.electacta.2024.143790*.

123. Tancin, Ryan J.; Ozdogru, Bertan; Dutta, Nikita S.; Finegan, Donal P.; Tremolet de Villers, Bertrand J. 2024. "Direct Reuse of Graphite and Lithium Nickel Manganese Cobalt Oxide (NMC) Recovered from Ultrafast-Laser Ablation Debris in Li-Ion Battery Electrodes." Journal of Power Sources 596: 234027. *https://dx.doi.org/10.1016/j.jpowsour.2023.234027*.

124. Tancin, Ryan J.; Sulas-Kern, Dana B.; Usseglio-Viretta, Francois L. E.; Finegan, Donal P.; Tremolet de Villers, Bertrand J. 2024. "Characterization of Ultrafast-Laser Ablation of Micro-Structures in Li-Ion Battery Anode and Cathode Materials: Morphology, Rate, and Efficiency." Journal of Power Sources 596: 234078. *https://dx.doi.org/10.1016/j.jpowsour.2024.234078*.

125. Ucer, Emin; Kisacikoglu, Mithat J. 2024. "Development of a Hardware-in-the-Loop Testbed for a Decentralized, Data-Driven Electric Vehicle Charging Control Algorithm." IEEE Transactions on Industry Applications. *https://dx.doi.org/10.1109/tia.2024.3384480*.

126. Ugirumurera, Juliette; Bensen, Erik A.; Severino, Joseph; Sanyal, Jibonananda. 2024. "Addressing Bias in Bagging and Boosting Regression Models." Scientific Reports 14: 18452. *https://doi.org/10.1038/s41598-024-68907-5*.

127. Usman, Adil; Rajpurohit, Bharat Singh. 2023. "Condition Monitoring of Permanent Magnet AC Machines for All-Electric Transportation Systems: State of the Art." IET Energy Systems Integration. *https://doi.org/10.1049/esi2.12125*.

128. Usseglio-Viretta, Francois L. E.; Weddle, Peter J.; Tremolet de Villers, Bertrand J.; Dunlap, Nathan; Kern, Dana; Smith, Kandler; Finegan, Donal P. 2023. "Optimizing Fast Charging and Wetting in Lithium-Ion Batteries with Optimal Microstructure Patterns Identified by Genetic Algorithm." Journal of the Electrochemical Society 170 (12): 120506. *https://doi.org/10.1149/1945-7111/ad0a7a*.

129. Verma, Ankit; Colclasure, Andrew M.; Coyle, Jaclyn. 2023. "Developing Rapid Electrochemical Relithiation Protocols for Scalable Relithiation of Lithium-Ion Battery Cathode Materials." Frontiers in Batteries and Electrochemistry 2. *https://doi.org/10.3389/fbael.2023.1293939*.

130. Verma, Ankit; Schulze, Maxwell C.; Colclasure, Andrew. 2024. "Micelle-Like Bulk Structure of Localized High-Concentration Electrolytes." Joule 8 (1): 10–12. *https://dx.doi.org/10.1016/j.joule.2023.12.024*.

131. Verma, Ankit; Schulze, Maxwell C.; Colclasure, Andrew; Rodrigues, Marco-Tulio Fonseca; Turczynski, Andrew; Trask, Stephen E.; Pupek, Krzysztof; Abraham, Daniel P. 2024. "Significant Improvements to Si Calendar Lifetime Using Rapid Electrolyte Screening via Potentiostatic Holds." Journal of the Electrochemical Society 171 (7): 070539. *https://doi.org/10.1149/1945-7111/ad6376*.

132. Verma, Ankit; Singh, Avtar; Colclasure, Andrew. 2023. "On the Impact of Mechanics on Electrochemistry of Lithium-ion Battery Anodes." JOM: Journal of the Minerals, Metals & Materials Society. *https://doi.org/10.1007/s11837-023-06274-8*.

133. Wang, Chen; Singh, Avantika; Rognerud, Erik G.; Murray, Robynne; Musgrave, Grant M.; Skala, Morgan; Murdy, Paul; DesVeaux, Jason S.; Nicholson, Scott R.; Harris, Kylee; Canty, Richard; Mohr, Fabian; Shapiro, Alison J.; Barnes, David; Beach, Ryan; Allen, Robert D.; Beckham, Gregg T.; Rorrer, Nicholas A. 2023. "Synthesis, Characterization, and Recycling of Bio-Derivable Polyester Covalently Adaptable Networks for Industrial Composite Applications." Matter 7 (2): 550–568. *https://doi.org/10.1016/j.matt.2023.10.033*.

134. Xu, Haowen; Shao, Yunli; Chen, Jianfei; Wang, Cheh (Ross); Berres, Andy. 2023. "Semi-Automatic Geographic Information System Framework for Creating Photo-Realistic Digital Twin Cities to Support Autonomous Driving Research." Transportation Research Record. *https://doi.org/10.1177/03611981231205884*.

135. Xu, Haowen; Yuan, Jinghui; Berres, Andy; Shao, Yunli; Wang, Chieh (Ross); Li, Wan; LaClair, Tim J.; Sanyal, Jibonananda; Wang, Hong. 2023. "A Mobile Edge Computing Framework for Traffic Optimization at Urban Intersections Through Cyber-Physical Integration." IEEE Transactions on Intelligent Vehicles 9 (1). *https://dx.doi.org/10.1109/tiv.2023.3332256*.

136. Xu, Xiaodan; Yang, Hung-Chia; Jeong, Kyungsoo; Bui, William; Ravulaparthy, Srinath; Laarabi, Haitam; Needell, Zachary A.; Spurlock, C. Anna. 2024. "Teaching Freight Mode Choice Models New Tricks Using Interpretable Machine Learning Methods." Frontiers in Future Transportation 5. *https://www.nrel.gov/docs/fy24osti/88901.pdf*.

137. Yin, Zehui; Rybarczyk, Greg; Zheng, Anran; Su, Lin; Sun, Bingrong; Yan, Xiang. 2023. "Shared Micromobility as a First- and Last-Mile Transit Solution? Spatiotemporal Insights from a Novel Dataset." Journal of Transport Geography 114: 103778. *https://doi.org/10.1016/j.jtrangeo.2023.103778*.

138. Zhao, Lujin; Ottinger, Elizabeth R.; Yip, Arthur Hong Chun; Helveston, John Paul. 2023. "Quantifying Electric Vehicle Mileage in the United States." Joule 7 (11): 2537–2551. *https://doi.org/10.1016/j.joule.2023.09.015*.

139. Zhu, Huayang; Evans, Tyler A. P.; Weddle, Peter J.; Colclasure, Andrew M.; Chen, Bor-Rong; Tanim, Tanvir R.; Vincent, Tyrone L.; Kee, Robert J. 2024. "Extracting and Interpreting Electrochemical Impedance Spectra (EIS) from Physics-Based Models of Lithium-Ion Batteries." Journal of the Electrochemical Society 171. *https://doi.org/10.1149/1945-7111/ad4399*.

Management Reports

140. 140. 2023. Vehicle Technologies Fiscal Year 2023 Annual Report. *https://www.nrel.gov/docs/fy24osti/87835.pdf*.

Other Marketing Materials

141. 2023. "Data and Tools for Integrated Mobility Systems." *https://www.nrel.gov/docs/gen/fy24/88356.pdf*.

142. 2023. "NREL OpenPATH: An Open-Source, Configurable Platform To Collect Travel Behavior Data." *https://www.nrel.gov/docs/gen/fy24/88437.pdf*.

143. 2024. "Alternative Fuels Data Center (Citation Only)."

144. 2024. "Battery Technologies." *https://www.nrel.gov/docs/gen/fy24/90178.pdf*.

145. 2024. "Deployment and Technical Assistance." *https://www.nrel.gov/docs/gen/fy24/90179.pdf*.

146. 2024. "Electric Vehicle Charging and Systems Integration." *https://www.nrel.gov/docs/gen/fy24/90177.pdf*.

147. 2024. "Electric Vehicle Charging Resources for Tribal Nations." *https://www.nrel.gov/docs/fy24osti/89624.pdf*.

148. 2024. "Equity, Energy Justice, and Environmental Justice." *https://www.nrel.gov/docs/gen/fy24/90161.pdf*.

149. 2024. "EVI-X Postcard." *https://www.nrel.gov/docs/gen/fy24/89659.pdf*.

150. 2024. "Heavy Vehicle Decarbonization." *https://www.nrel.gov/docs/gen/fy24/90181.pdf*.

151. 2024. "High-Performance Computing and Data Analytics." *https://www.nrel.gov/docs/gen/fy24/90190.pdf*.

152. 2024. "Lightweight Materials." *https://www.nrel.gov/docs/gen/fy24/90191.pdf*.

153. 2024. "Low-Carbon Fuels." *https://www.nrel.gov/docs/gen/fy24/90192.pdf*.

154. 2024. "Mobility Systems Analysis." *https://www.nrel.gov/docs/gen/fy24/90194.pdf*.

155. 2024. "Modeling, Mapping, and Analysis Consortium: Integrated Insights Across Manufacturing and Energy Supply Chains." *https://www.nrel.gov/docs/gen/fy24/89114.pdf*.

156. 2024. "Power Electronics and Electric Machines." *https://www.nrel.gov/docs/gen/fy24/90180.pdf*.

157. 2024. "Renewable Hydrogen." *https://www.nrel.gov/docs/gen/fy24/90193.pdf*.

158. 2024. "Transforming Energy Through Sustainable Mobility: Expanding Low-Carbon Transportation R&D Solutions." *https://www.nrel.gov/docs/gen/fy24/88520.pdf*.

Patents

159. Cousineau, Emily; Moreno, Gilbert; Bennion, Kevin Scott; Roan, Thomas; Singh, Brij N. 2023. "Condensers and Electronic Assemblies." U.S. Patent No. 11,778,782 B2.

160. Moreno, Gilbert; Narumanchi, Sreekant Venkat Jagannath; Feng, Xuhui; Osman, Ammar; Myers, Steve Michael; Kelly, Brian James; Paret, Paul Philip. 2024. "Cooling Automotive Power Electronics." Patent No. US 12,004,332 B2. *https://image-ppubs.uspto.gov/dirsearch-public/print/downloadPdf/12004332*.

161. Smith, Kandler Alan; Santhanagopalan, Shriram; Sunderlin, Nathaniel Alexander; Colclasure, Andrew Michael; Ban, Chunmei; Li, Xuemin; Netter, Judy C.; Finegan, Donal Patrick; Fink, Kaitlin Elizabeth; Coyle, Jaclyn Elizabeth. 2024. "Methods and Devices for Electrochemical Relithiation of Lithium-Ion Batteries." Patent No. US 11,870,044 B2. *https://image-ppubs.uspto.gov/dirsearch-public/print/downloadPdf/11870044*.

162. Wang, Chen; Murray, Robynne E.; Beckham, Gregg Tyler; Mauger, Scott; Rorrer, Nicholas A. 2024. "Bioderived Recyclable Epoxy-Anhydride Thermosetting Polymers and Resins." Patent No. US 11,970,575 B2. *https://image-ppubs.uspto.gov/dirsearch-public/print/downloadPdf/11970575*.

Posters

163. Akcicek, Cemal; Aemmer, Zack; Shankari, K.; Duvall, Andrew. 2024. "Freewheeling: What Six Locations, 61,000 Trips, and 242,000 Miles in Colorado Reveal about How E-Bikes Improve Mobility Options." Presented at the TRB 2024 Annual Meeting, Washington, D.C., 9 Jan. 2024. *https://www.nrel.gov/docs/fy24osti/88303.pdf*.

164. Borlaug, Brennan; Hale, Elaine; Anwar, Muhammad Bashar; Lavin, Luke; Liu, Bo; Ledna, Catherine; Matsuda-Dunn, Reiko; Reinicke, Nick; Sun, Jiayun; Yip, Arthur. 2024. "Managing Increased Electric Vehicle Shares on Decarbonized Bulk Power Systems." *https://www.nrel.gov/docs/fy24osti/89540.pdf*.

165. Bruchon, Matthew; Alexeenko, Polina; Liu, Zhaocai; He, Yi; Borlaug, Brennan; Jonas, Tim; Liu, Bo; Sun, Jiayun; Le, Nhat; Bennett, Jesse; Wood, Eric. 2024. "Characterizing National Operations, Local Electricity Loads, and Demand Flexibility for Medium- and Heavy-Duty Electric Vehicle (Citation Only)."

166. Chaudhary, Rajneesh; Cousineau, Emily; Feng, Xuhui; Kekelia, Bidzina; Tomerlin, Jeff; Rallabandi, Vandana; Mohammad, Mostak; Anderson, Iver; Monson, Todd; Joshi, Yogendra; Kumar, Satish; Hossain, Jubayer; Sarlioglu, Bulent; Jahns, Thomas. 2024. "Electric Motor Thermal Management." Presented at the DOE Vehicle Technologies Program 2024 Annual Merit Review and Peer Evaluation Meeting, 3–6 June 2024. *https://www.nrel.gov/docs/fy24osti/89511.pdf.*

167. Cousineau, Emily; DeVoto, Doug; Feng, Xuhui; Kekelia, Bidzina; Tomerlin, Jeff; Rallabandi, Vandana; Mohammad, Mostak; Anderson, Iver; Monson, Todd; Joshi, Yogendra; Kumar, Satish; Sarlioglu, Bulent; Jahns, Thomas. 2024. "Electric Motor Thermal Management." Presented at the DOE Vehicle Technologies Program 2023 Annual Merit Review and Peer Evaluation Meeting, 12–15 June 2023. *https://www.nrel.gov/docs/fy24osti/85896.pdf*.

168. DeVoto, Douglas; Major, Joshua; Paret, Paul; Allen, Bob; Miscall, Joel; Xue, Lincoln; Herczeg, Susan; Smith, Greg. 2024. "Advanced Packaging Designs." Presented at the DOE Vehicle Technologies Program 2023 Annual Merit Review and Peer Evaluation Meeting, 12–15 June 2023. *https://www.nrel.gov/docs/fy24osti/85897.pdf*.

169. Esteban, Johnny; Grahn, Rick; Powell, Bonnie; Young, Stanley. 2024. "Community Public Mobility Using On-Demand, Low-Speed Electric Vehicles: A Case Study in Downtown St. Louis, Missouri." Presented at the TRB 2024 Annual Meeting, Washington, D.C., Jan. 2024. *https://www.nrel.gov/docs/fy24osti/88265.pdf*.

170. Esteban, Johnny; Grahn, Rick; Powell, Bonnie; Young, Stanley. 2024. "Community Public Mobility Using On-Demand, Low-Speed Electric Vehicles: A Case Study in Downtown St. Louis, Missouri (Citation Only)."

171. Ficenec, Karen; Ledna, Catherine; Ravi, Vikram; Hanig, Lily; Wood, Eric; Xu, Xiaodan; Jin, Ling; Wang, Yuhan; Scown, Corinne; McNeil, Wilson; Guirado, Carlos; Spurlock, Anna. 2024. "A Modeling Framework for Evaluating the Environmental, Health, and Equity Impacts of Large-Scale U.S. Charging Infrastructure Deployment (Citation Only)."

172. Greenlee, Jack; Raei, Alireza; Barry, Sebastian; Tabasi, Maliheh; Siripanich, Amarin; Rashidi, Taha Hossein; Shankari, K. 2024. "From Simple Labels to Time-Use Integrations: Supporting the Spectrum of Qualitative Travel Behavior Data." Presented at the TRB 2024 Annual Meeting, Washington, D.C., 7–11 Jan. 2024. *https://www.nrel.gov/docs/fy24osti/88306.pdf*.

173. Hassanaly, Malik; Weddle, Peter J.; Randall, Corey R.; Dufek, Eric J.; Smith, Kandler. 2024. "Rapid Inverse Parameter Inference Using Physics-Informed Neural Network." *https://www.nrel.gov/docs/fy24osti/89869.pdf*.

174. He, Mingyi; Sun, Bingrong; Garikapati, Venu; Ge, Yanbo; Liu, Zhaocai; Wang, Qichao; Hoshiko, Joshua. 2023. "A Hierarchical Optimization Method (HOME) for Vertiport Siting (Citation Only)." Presented at the Transportation Research Board (TRB) 102nd Annual Meeting, Washington, D.C., 8–12 Jan. 2023.

175. Kekelia, Bidzina; Cousineau, Emily; Narumanchi, Sreekant; Tomerlin, Jeff; Rallabandi, Vandana; Muhammad, Mostak; Wilkins, Jon; Barua, Himel; Bullock, Steve; Chowdhury, Shajjad; Sarlioglu, Bulent; Jahns, Thomas; Anderson, Iver. 2024. "Integrated Traction Drive Thermal Management: Keystone Project 3." Presented at the DOE Vehicle Technologies Program 2023 Annual Merit Review and Peer Evaluation Meeting, 12–15 June 2023. *https://www.nrel.gov/docs/fy24osti/85913.pdf*.

176. Khan, Faisal; Zhao, Shuofeng. 2024. "Power Module Precursors and Prognostics." Presented at the DOE Vehicle Technologies Program 2023 Annual Merit Review and Peer Evaluation Meeting, 12–15 June 2023. *https://www.nrel.gov/docs/fy24osti/86021.pdf*.

177. Khan, Faisal; Zhao, Shuofeng. 2024. "Power Module Precursors and Prognostics." Presented at the DOE Vehicle Technologies Program 2024 Annual Merit Review and Peer Evaluation Meeting, 3–6 June 2024. *https://www.nrel.gov/docs/fy24osti/89455.pdf*.

178. Le, Nhat; Bruchon, Matthew; Jonas, Tim; Borlaug, Brennan; Nguyen, Hieu T. 2023. "Electrifying Education: Insights into Charging Electric School Buses in the United States." Presented at the North American Power Symposium, Asheville, NC, 15–17 Oct. 2023. *https://www.nrel.gov/docs/fy24osti/87322.pdf*.

179. Moreno, Gilbert; Chaudhary, Rajneesh; Major, Josh; Narumanchi, Sreekant; Tomerlin, Jeff; Zhao, Shuofeng. 2024. "Power Electronics Thermal Management." Presented at the DOE Vehicle Technologies Program 2024 Annual Merit Review and Peer Evaluation Meeting, 3–6 June 2024. *https://www.nrel.gov/docs/fy24osti/89404.pdf*.

180. Muratori, Matteo; Hoehne, Christopher; Jadun, Paige; Yip, Arthur; Ledna, Catherine. 2023. "Long-Term Scenarios of Transportation Decarbonization." Presented at the 16th Integrated Assessment Modeling Consortium (IAMC) Annual Meeting, Venice, Italy, 14–16 Nov. 2023. *https://www.nrel.gov/docs/fy24osti/87963.pdf*.

181. Paret, Paul; Major, Joshua; DeVoto, Douglas; Narumanchi, Sreekant. 2023. "Power Electronics Materials and Bonded Interfaces – Reliability and Lifetime." Presented at the 2022 Vehicle Technologies Office Annual Merit Review, Washington, D.C., 21–23 June 2022. *https://www.nrel.gov/docs/fy24osti/82682.pdf*.

182. Paret, Paul; Major, Joshua; DeVoto, Douglas; Narumanchi, Sreekant. 2024. "Power Electronics Materials and Bonded Interfaces - Reliability and Lifetime." Presented at the DOE Vehicle Technologies Program 2024 Annual Merit Review and Peer Evaluation Meeting, 3–6 June 2024. *https://www.nrel.gov/docs/fy24osti/89407.pdf*.

183. Sharda, Shivam; Hoehne, Christopher; Acharya, Sailesh; Allen, Michael; Garikapati, Venu M.; Nag, Ambarish; Huang, Yantao. 2024. "Navigating Urban Mobility: Evaluating Infrastructure Strategies for Enhanced Energy-Efficient Access for Micromobility." Presented at the TRB 2024 Annual Meeting, Washington, D.C., 7–11 Jan. 2024. *https://www.nrel.gov/docs/fy24osti/88269.pdf*.

184. Tancin, Ryan J.; Sulas-Kern, Dana B.; Usseglio-Viretta, Francois; Schulze, Max; Brow, Ryan; Martin, Trevor; Weddle, Peter; Colclasure, Andrew; Finegan, Donal P.; Tremolet de Villers, Bertrand J. 2023. "Ultrafast-Laser Processing of Li-Ion Battery Materials for Enhanced Performance and Manufacturing (Citation Only)." Presented at the RD20 Summer School, Prapoutel, France, 2–7 July 2023.

185. Thurlbeck, Alastair P.; Siddiquee, Ashraf; Kisacikoglu, Mithat John; Sozer, Yilmaz. 2023. "Active SOC Balancing for a Multi-Chemistry Battery Pack with Reduced Number of Converters (Citation Only)." Presented at the IEEE Energy Conversion Congress & Expo (ECCE), Nashville, TN, 29 Oct.–2 Nov. 2023.

186. Usseglio-Viretta, Francois L. E.; Colclasure, Andrew M.; Allen, Jeffery M.; Finegan, Donal P.; Graf, Peter; Smith, Kandler. 2024. "When and Where Lithium Plating Occurs, Its Correlation with Microstructure Heterogeneity, and the Mechanisms That Initiate and Self-Regulate Electrochemical Heterogeneity (A02-0444)." Presented at the 245th Electrochemical Society Meeting, 26–30 May 2024, San Francisco, CA. *https://www.nrel.gov/docs/fy24osti/89923.pdf*.

187. Usseglio-Viretta, Francois L. E.; Colclasure, Andrew M.; Allen, Jeffery; Finegan, Donal P.; Graf, Peter; Smith, Kandler. 2024. "On the Representativity of Electrode Microstructure Parameters and Their Electrochemical Response for Lithium Ion Batteries." Presented at the 245th Electrochemical Society Meeting, 26–30 May 2024, San Francisco, CA. *https://www.nrel.gov/docs/fy24osti/89968.pdf*.

188. Viz, Nicole; Sharda, Shivam; Garikapati, Venu M.; Stenger, Katelyn; Goulias, Konstadinos G.; Hoehne, Christopher; Graffy, Elisabeth A. 2024. "The Triple Effect: Unraveling the Joint Impact of Electric Vehicles, Solar Panels, and Work-From-Home Patterns on Household Electricity Costs." Presented at the TRB 2024 Annual Meeting, Washington, D.C., 7–11 Jan. 2024. *https://www.nrel.gov/docs/fy24osti/87672.pdf*.

Presentations

189. Allen, Michael; Shankari, K. 2023. "Estimating Travel Energy Consumption Uncertainty Based on Inferred Travel Mode and Sensed Travel Length." Presented at Bridging Transportation Researchers (BTR), 9–10 Aug. 2023. *https://www.nrel.gov/docs/fy24osti/86955.pdf*.

190. Bhogaraju, Sri Krishna; Saccon, Rodolfo; Paret, Paul; Busse, Dirk; Dalbudding, Alexander; Elger, Gordon. 2024. "Rapid, Low Temperature and Low Pressure Assisted Large Area Bonding with Copper Sinter Paste for High Power Electronics Packaging (Citation Only)."

191. Borlaug, Brennan. 2023. "EV Load Forecasting (Not Published Externally)." Presented to the ATE Load Forecasting Group, 10 May 2023. *https://www.nrel.gov/docx/gen/fy24/86249.pdf*.

192. Borlaug, Brennan; Ge, Yanbo; Lee, D.-Y.; Liu, Zhaocai; Rose, Eddie; Spath Luhring, Lauren; St. Louis-Sanchez, Maria; Wood, Eric; Yang, Fan. 2023. "Modeling Future Demand for EV Charging Infrastructure." Presented at Peak Load Management Association (PLMA) Dialogue, 1 Aug. 2023. *https://www.nrel.gov/docs/fy24osti/87021.pdf*.

193. Borlaug, Brennan; Ge, Yanbo; Lee, D-Y; Liu, Zhaocai; Rose, Eddie; Spath Luhring, Lauren; St. Louis-Sanchez, Maria; Wood, Eric; Yang, Fan. 2023. "Modeled Charging Infrastructure Needs for Future Electric Vehicles (Citation Only)." Presented at the Peak Load Management Association (PLMA) Hot Topic Conversation, 20 April 2023.

194. Borlaug, Brennan; Hale, Elaine; Jadun, Paige; Lavin, Luke; Ledna, Catherine; Muratori, Matteo; Yip, Arthur. 2023. "Managing Increased Electric Vehicle Shares on Decarbonized Bulk Power Systems." Presented at the 2023 Vehicle Technologies Office Annual Merit Review, 13 June 2023. *https://www.nrel.gov/docs/fy24osti/86000.pdf*.

195. Borlaug, Brennan; Wood, Eric; Lee, D.-Y.; Ge, Yanbo; Yang, Fan; Liu, Zhaocai. 2023. "The 2030 National Charging Network: Estimating U.S. Light-Duty Demand for EV Charging Infrastructure (Citation Only)." Presented at the Bay Area Council – December 2023 Meeting, 11 Dec. 2023.

196. Boyce, Leidy; Desai, Ranjit; Singer, Mark. 2024. "Take the Guesswork Out of the Fleet Electrification Transition Process (Citation Only)."

197. Bruchon, Matthew; Borlaug, Brennan; Liu, Bo; Jonas, Tim; Sun, Jiayun; Le, Nhat; Wood, Eric. 2024. "Vehicle Data for Analysis of Medium- and Heavy-Duty Electrification." *https://www.nrel.gov/docs/fy24osti/90099.pdf*.

198. Burrell, Anthony; Harrison, Katharine. 2024. "The Silicon Consortium Project: Mechanical Properties of Silicon Anodes." *https://www.nrel.gov/docs/fy24osti/89362.pdf*.

199. Burrell, Anthony; Neale, Nathan. 2024. "The Silicon Consortium Project: Next-Gen Materials for Silicon Anodes (Citation Only)."

200. Carroll, Mike; Doeren, Ryan; Urias, Fernando; Schulze, Max; Neale, Nathan. 2024. "Engineering Electrode Architecture and Interfacial Chemistry of High-Content, High-Loading Silicon Anodes to Improve Cycle and Calendar Life (Citation Only)."

201. Desai, Ranjit. 2024. "EVI-LOCATE: EVSE Planning Tool and Cost Estimator." *https://www.nrel.gov/docs/fy24osti/90858.pdf*.

202. Desai, Ranjit. 2024. "EVI-LOCATE: One Stop Solution for Estimating Cost of Installing EV Charging Stations." *https://www.nrel.gov/docs/fy24osti/89217.pdf*.

203. DeVoto, Douglas. 2024. "Advanced Packaging Designs (Keystone Project 1)." *https://www.nrel.gov/docs/fy24osti/89400.pdf*.

204. DeVoto, Douglas. 2024. "Thermomechanical Reliability Aspects of Automotive Power Electronics: Current Status and Future Trends." Presented at APEC 2023, 19–23 March 2023. *https://www.nrel.gov/docs/fy24osti/85209.pdf*.

205. Duvall, Andrew; Wheelis, Abigial. 2023. "Understanding Mobility Behavior Using OpenPATH." Presented at the Association for Commuter Transportation (ACT) Transportation Demand Management (TDM) Conference, Denver, CO, 26 Oct. 2023. *https://www.nrel.gov/docs/fy24osti/87744.pdf*.

206. Farrell, John; Muratori, Matteo. 2024. "SAE Government-Industry - Heavy-Duty Policy: Panel Discussion (G203)." *https://www.nrel.gov/docs/fy24osti/88577.pdf*.

207. Fink, Kae. 2024. "Materials Research for Battery Recycling." *https://www.nrel.gov/docs/fy24osti/90672.pdf*.

208. Fink, Kae E.; Schulze, Max; McKalip, Nick; Verma, Ankit; Berquist, Zach; Mangum, John; Colclasure, Andrew; Son, Seoung-Bum; Ingram, Brian. 2024. "Anode Upcycling via Tailored Solvent Treatment." *https://www.nrel.gov/docs/fy24osti/89971.pdf*.

209. Garikapati, Venu. 2023. "Metrics for Assessing the Impacts of Energy-Efficient Mobility Systems." Presented at the DOE – 2023 Vehicle Technologies Office Annual Merit Review, 12–15 June 2023. *https://www.nrel.gov/docs/fy24osti/86079.pdf*.

210. Garikapati, Venu. 2023. "Mobility Energy Productivity (MEP) Metric (Not Published Externally)." Presented at the CRC Sustainable Mobility Workshop, Golden, CO, 13–15 Dec. 2023. *https://www.nrel.gov/docx/gen/fy24/84833.pdf*.

211. Garikapati, Venu; Dobson, Colin. 2023. "Your Feedback on the Mobility Energy Productivity ('MEP') Urban Mobility Tool (Citation Only)." Presented at the MEP Virtual Roadshow, 8–15 March 2023.

212. Gasper, Paul; Knutson, Bryce; Sunderlin, Nathaniel; Keyser, Matthew. 2024. "Rapid Electrochemical Diagnosis of Battery Health and Safety from Cells to Modules." *https://www.nrel.gov/docs/fy24osti/87741.pdf*.

213. Gasper, Paul; Sunderlin, Nathaniel; Dunlap, Nathan; Walker, Patrick; Finegan, Donal; Smith, Kandler; Thakkar, Foram. 2024. "Challenges for Accelerating Life Testing of Commercial Lithium-Ion Batteries (Citation Only)."

214. Gasper, Paul; Sunderlin, Nathaniel; Dunlap, Nathan; Walker, Patrick; Finegan, Donal; Smith, Kandler; Thakkar, Foram. 2024. "Performance Evolution and Failure Mechanisms for Commercial Large-Format NMC-Gr Lithium-Ion Pouch Cells (Citation Only)."

215. Ge, Yanbo; Akcicek, Cemal; Garikapati, Venu; Chow, Chun Ho; Popovich, Natalie. 2024. "ETIPP Kauai, Task 2: Kauai Transportation Preference Survey Analysis (Citation Only)."

216. Ge, Yanbo; Akcicek, Cemal; Garikapati, Venu; Chow, Chun Ho; Popovich, Natalie. 2024. "ETIPP Kauai, Task 3: Kauai Electric Vehicle Charging Network Study (Citation Only)."

217. Gonder, Jeff. 2024. "Core Modeling & Decision Support Capabilities: FASTSim, RouteE, T3CO & OpenPATH (Citation Only)."

218. Hale, Elaine; Thom, Daniel; Liu, Lixi; Prasanna, Ashreeta; Mooney, Meghan. 2024. "Powered by dsgrid." *https://www.nrel.gov/docs/fy24osti/90646.pdf*.

219. Han, Sang-Don; Tremolet de Villers, Bertrand J.; Yang, Junghoon; Gim, Jihyeon. 2023. "In Situ Infrared Spectroscopy for High-Ni Li-Ion Battery Cathodes: Elucidating the Relationships Between Vibrational Signatures and Cathode-Electrolyte Interphase Phenomena (Not Published Externally)." Presented at the 2022 MRS Spring Meeting, 8–13 May 2022. *https://www.nrel.gov/docx/gen/fy24/83449.pdf*.

220. Hodge, Cabell. 2024. "Fleet Electrification Framework." *https://www.nrel.gov/docs/fy24osti/89570.pdf*.

221. Hodge, Cabell. 2024. "Supercharging Your ZEV Transition: Using the ZEV Ready Planning Process." *https://www.nrel.gov/docs/fy24osti/89226.pdf*.

222. Hoehne, Chris. 2023. "Mobility Energy Productivity (MEP) Metric Overview (Citation Only)." Presented at the Innovations in Travel Analysis and Planning (ITAP) Conference, Indianapolis, IN, 4–6 June 2023.

223. Hoehne, Chris. 2023. "Mobility Energy Productivity (MEP) Metric Overview (Not Published Externally)." Presented at the CO/WY ITE Webinar, 25 Aug. 2023. *https://www.nrel.gov/docx/gen/fy24/87193.pdf*.

224. Hoehne, Chris; Garikapati, Venu; Eros, Emily. 2023. "Exploring the Integration of NREL's Mobility Energy Productivity Metric with StreetLight (Citation Only)." Webinar, 28 June 2023.

225. Hoehne, Christopher; Sharda, Shivam; Allen, Michael; Garikapati, Venu. 2023. "Leveraging an Open-Source Data Based Accessibility Metric Calculations to Highlight Transportation Equity Issues (Citation Only)." Presented at the Innovations in Travel Analysis and Planning (ITAP) Conference, Indianapolis, IN, 4–6 June 2023.

226. Hovsapian, Rob; Agalgaonkar, Yash; Rout, Biswajeet. 2024. "Modeling and Controls Assistance and Renewable Energy Resource Assessment: City and Borough of Sitka, Alaska." *https://www.nrel.gov/docs/fy24osti/88580.pdf*.

227. Jadun, Paige. 2023. "Electric Vehicle Load Forecasting (Citation Only)." Presented at the EVGrid Assist Webinar, 13 Oct. 2023.

228. Jadun, Paige; Muratori, Matteo; Ledna, Catherine; Yip, Arthur; Hoehne, Chris; Borlaug, Brennan. 2024. "Holistic Modeling of Future Transportation Energy Use and Emissions: Transportation Energy and Mobility Pathway Options (TEMPO) Model." *https://www.nrel.gov/docs/fy24osti/86046.pdf*.

229. Jeong, Kyungsoo; Zhang, Xi-Ying; Schlenker, Marty; Berndt, Mark; Garrett, Anderson; Dick, Tyler; Kontou, Eleftheria; Lustbader, Jason; Birky, Alicia. 2024. "INFORMES: Intermodal Freight Optimization for a Resilient Mobility Energy System (Citation Only)."

230. Kandt, Alicen. 2024. "Fast Charging Infrastructure for Electrifying Road Trips to and from National Parks in the Western United States." *https://www.nrel.gov/docs/fy24osti/89176.pdf*.

231. Kandt, Alicen. 2024. "GSA Bean Federal Center Decarbonization (Citation Only)."

232. Kandt, Alicen. 2024. "National Park Service: Spotlight on Partnerships." *https://www.nrel.gov/docs/fy24osti/89175.pdf*.

233. Kekelia, Bidzina. 2024. "Integrated Traction Drive Thermal Management: Keystone Project 3." *https://www.nrel.gov/docs/fy24osti/89395.pdf*.

234. Kekelia, Bidzina. 2024. "Reliability of Copper Inverse Opal Surfaces for Extreme-Heat-Flux Micro-Coolers in Low-Global-Warming-Potential Refrigerant R-1233zd Pool Boiling Experiments." *https://www.nrel.gov/docs/fy24osti/87860.pdf*.

235. Kekelia, Bidzina; Feng, Xuhui. 2024. "Tutorial - Electric Motor and Integrated Traction Drive Thermal Management." *https://www.nrel.gov/docs/fy24osti/87844.pdf*.

236. Khan, Faisal. 2024. "Live State of Health Monitoring of Inverter Subsystems." *https://www.nrel.gov/docs/fy24osti/89801.pdf*.

237. Khan, Faisal. 2024. "New Developments in Power Module Design and Characterization (Citation Only)."

238. Khan, Shafquat; Kelly, Ken; Kisacikoglu, John. 2024. "Ontario International Airport Fleet Electrification Blueprint: Zero-Emission Vehicle Technology Assessment for Energy Optimization." *https://www.nrel.gov/docs/fy24osti/85482.pdf*.

239. Kirwa, Cyrus; Coyle, Jaclyn; Luo, Hongmei. 2024. "Direct Recycling of End-of-Life Cathode Material Through Redox Chemistry Mediators." *https://www.nrel.gov/docs/fy24osti/86361.pdf*.

240. Kisacikoglu, John; Davidson, Keith Alan; Wells, Landon; Thurlbeck, Alastair; Kandula, Prasad; Campbell, Steven; Wojda, Rafal; Harter, Jonathan; Boone, Christian; Chinthavali, Madhu; Ali, Akram Syed; Ucer, Emin. 2024. EVs@Scale Lab Consortium High-Power Charging Pillar Deep-Dive Technical Meeting. *https://www.nrel.gov/docs/fy24osti/89136.pdf*.

241. Kisacikoglu, John; Ratrout, Sadam; Jackson, Derek; Kandula, Prasad; Campbell, Steven; Wojda, Rafal; Harter, Jonathan; Boone, Christian; Kimpara, Marcio; Chinthavali, Madhu; Ali, Akram Syed. 2024. EVs@Scale High-Power Charging (HPC) Pillar Deep-Dive Technical Meeting. *https://www.nrel.gov/docs/fy24osti/89760.pdf*.

242. Kotz, Emily. 2024. "EVSE and ZEV Fast Reporting (Citation Only)."

243. Kotz, Emily. 2024. "Vehicle Charging Considerations (NREL Internal Use Only)." *https://www.nrel.gov/docx/gen/fy24/89181.pdf*.

244. Li, Xiaoling. 2024. "IEEE Electronics Packaging Society Emerging Technology Technical Committee Meeting." *https://www.nrel.gov/docs/fy24osti/90407.pdf*.

245. Liu, Zhaocai. 2024. "Enabling Scalable and Efficient Data Analysis, Simulation, and Optimization for Sustainable Mobility with High Performance Computing (Citation Only)."

246. Liu, Zhaocai; He, Yi; Song, Ziqi. 2024. "Integrated Charging Infrastructure Planning and Charging Scheduling for Battery Electric Bus Systems (Citation Only)."

247. Luecke, Jon; Mylrea, Ian; Heyne, Josh; McCormick, Bob. 2024. "Comparison of Derived Cetane Number and Indicated Cetane Number for Jet Fuels and Correlation with Lean Blowout." *https://www.nrel.gov/docs/fy24osti/89581.pdf*.

248. Lustbader, Jason; Baker, Chad; Payne, Grant; Reinicke, Nicholas; Smith, Kandler; Bruchon, Matt; Birky, Alicia; et al. 2023. "ALTRIOS – Advanced Locomotive Technology and Rail Infrastructure Optimization System." Presented at the Railroad Environmental Conference, Champaign, IL, 2–3 Nov. 2022. *https://www.nrel.gov/docs/fy24osti/84507.pdf*.

249. Major, Joshua; DeVoto, Douglas; Khan, Faisal; Zhao, Shuofeng; Islam, Sarwar; Narumanchi, Sreekant. 2024. "Rapid Module Prototyping (Citation Only)."

250. Manne, Nithin; Harper, Jason D.; Yousaf, Salman; Nystrom, Bryan; Choi, Jeewon; Haines, Thad; Lave, Matt; Mammoli, Andrea; Moog, Emily; Vining, Will; Sundarrajan, Manoj; Schmidt, Steven; Bruchon, Matthew; He, Yi; Liu, Zhaocai; Bennett, Jesse; Alexeenko, Polina. 2024. "Smart Charge Management and Vehicle Grid Integration Deep Dive." *https://www.nrel.gov/docs/fy24osti/89751.pdf*.

251. Martin, Trevor; Rynearson, Leah; Kuller, Mackenzie; Quinn, Joseph; Wang, Chongmin; Lucht, Brett; Neale, Nathan. 2023. "Utilizing Conjugated Imine Polymers to Stabilize Nanoparticle Silicon Anodes." Presented at the 244th Electrochemical Society, Gothenburg, Sweden, 8–12 Oct. 2023. *https://www.nrel.gov/docs/fy24osti/85851.pdf*.

252. Meintz, Andrew; Birky, Alicia; Sigler, Cory; Panneer Selvam, Harish; Alexeenko, Polina; Miller, Eric. 2024. "TCO Analysis Approach and Regional Analysis of dWPT for Class 8 Tractors." *https://www.nrel.gov/docs/fy24osti/88804.pdf*.

253. Meintz, Andrew; Kisacikoglu, John; Thurston, Sam; Carlson, Barney; Starke, Michael; Carroll, Thomas E.; Bennett, Jesse; et al. 2023. "EVs@Scale Lab Consortium Semi-Annual Stakeholder Meeting." Presented at the Electric Vehicles at Scale (EVs@Scale) Laboratory Consortium Semi-Annual Stakeholder Meeting, Lemont, IL, 27–28 Sept. 2023. *https://www.nrel.gov/docs/fy24osti/87781.pdf*.

254. Meintz, Andrew; Lipman, Tim; Palmintier, Bryan; Panossian, N.; Laarabi, H.; Chaudhari, K.; Neuman, C.; et al. 2023. "Grid-Enhanced, Mobility-Integrated Network Infrastructures for Extreme Fast Charging (GEMINI-XFC)." Presented at the DOE Vehicle Technologies Office (VTO) Annual Merit Review, Washington, D.C., 21–23 June 2022. *https://www.nrel.gov/docs/fy24osti/82826.pdf*.

255. Mirletz, Brian; Bannister, Michael; Vimmerstedt, Laura; Stright, Dana; Heine, Matthew. 2023. "Annual Technology Baseline: ATB-calc Open Source Tools." Presented at the ATB-Calc Open-Source Tools Webinar, Golden, CO, 26 Sept. 2023. *https://www.nrel.gov/docs/fy24osti/87622.pdf*.

256. Moreno, Gilbert. 2024. "Power Electronics Thermal Management." *https://www.nrel.gov/docs/fy24osti/85894.pdf*.

257. Moreno, Gilbert; Narumanchi, Sreekant. 2024. "Advanced Power Electronics and Electric Machines (Citation Only)."

258. Muratori, Matteo. 2023. "Enabling a Sustainable Future: Zero-Emission Vehicles Cost Analysis to Inform Decarbonization Pathways." Presented at Energy Insights 2022, Washington, D.C., 8–9 Dec. 2022. *https://www.nrel.gov/docs/fy24osti/84729.pdf*.

259. Muratori, Matteo. 2023. "Impact of Large-Scale EV Adoption on Electricity Systems (Citation Only)." Presented at the Columbia Forum - Smart Electric Energy and Transportation, 31 March 2023.

260. Muratori, Matteo. 2023. "Steering the Titanic: Decarbonizing Transportation within Systems of Incremental Change (Citation Only)." Presented at the Transportation Research Board Annual Meeting, Washington, D.C., 8–12 Jan. 2023.

261. Muratori, Matteo. 2024. "Electric Vehicles: A Sustainable Solution for Transportation Systems." *https://www.nrel.gov/docs/fy24osti/91331.pdf*.

262. Muratori, Matteo. 2024. "Energy Systems Decarbonization: Perspectives on Electric Vehicles and Grid Integration." *https://www.nrel.gov/docs/fy24osti/88775.pdf*.

263. Muratori, Matteo; Yip, Arthur. 2024. "Projecting Electric Vehicle Electricity Demands and Charging Loads." *https://www.nrel.gov/docs/fy24osti/89775.pdf*.

264. Murrell, Jeffery; Ford, Benjamin; Kotz, Emily. 2024. "Workshop: Advanced Metering for Decarbonization: Electric Vehicles and 24/7 Carbon-Free Electricity." *https://www.nrel.gov/docs/fy24osti/89184.pdf*.

265. Nag, Ambarish; Hoehne, Chris; Garikapati, Venu; Fitzgerald, Robert; Young, Stanley; Hou, Yi. 2023. "Quantifying Equitable Access: An Approach Using the Mobility Energy Productivity (MEP) Metric (Citation Only)." Presented at the Transportation Research Board Annual Meeting, Washington, D.C., 8–12 Jan. 2023.

266. Narumanchi, Sreekant. 2024. "Advanced Power Electronics and Electric Machines (APEEM) Packaging, Thermal Management, and Reliability for Electric-Drive Mobility Applications (Citation Only)."

267. Narumanchi, Sreekant. 2024. "Advanced Power Electronics and Electric Machines (APEEM) Packaging, Thermal Management, and Reliability for Electric-Drive Mobility Applications (Citation Only)."

268. Narumanchi, Sreekant. 2024. "Advanced Power Electronics and Electric Machines (APEEM) Packaging, Thermal Management, and Reliability for Electric-Drive Mobility Applications (Citation Only)."

269. Narumanchi, Sreekant. 2024. "Advanced Power Electronics and Electric Machines (APEEM) Packaging, Thermal Management, and Reliability for Electric-Drive Mobility Applications (Citation Only)."

270. Narumanchi, Sreekant. 2024. "Advanced Power Electronics and Electric Machines (APEEM) Packaging, Thermal Management, and Reliability for Electric-Drive Vehicles (Citation Only)."

271. Narumanchi, Sreekant. 2024. "Advanced Power Electronics and Electric Machines (APEEM) Packaging, Thermal Management, and Reliability for Electric-Drive Vehicles (Citation Only)."

272. Narumanchi, Sreekant. 2024. "Advanced Power Electronics and Electric Machines (APEEM) Packaging, Thermal Management, and Reliability for Electric-Drive Vehicles (Citation Only)."

273. Narumanchi, Sreekant. 2024. "Advanced Power Electronics and Electric Machines for Electric-Drive Mobility Applications (Citation Only)."

274. Narumanchi, Sreekant. 2024. "Advanced Power Electronics and Electric Machines for Electric-Drive Mobility Applications (Citation Only)."

275. Narumanchi, Sreekant. 2024. "Advanced Power Electronics and Electric Machines for Electric-Drive Mobility Applications: Packaging, Thermal Management, and Reliability Aspects (Citation Only)."

276. Narumanchi, Sreekant. 2024. "Advanced Power Electronics and Electric Machines Packaging, Thermal Management, and Reliability for Electric-Drive Mobility Applications (Citation Only)."

277. Narumanchi, Sreekant. 2024. "Advanced Power Electronics and Electric Machines Packaging, Thermal Management, and Reliability for Electric-Drive Mobility Applications (Citation Only)."

278. Narumanchi, Sreekant. 2024. "Advanced Power Electronics Packaging, Thermal Management, and Reliability for Electric-Drive Mobility Applications (Citation Only)."

279. Narumanchi, Sreekant. 2024. "Advanced Power Electronics Packaging, Thermal Management, and Reliability for Electric-Drive Mobility Applications (Citation Only)."

280. Narumanchi, Sreekant. 2024. "Advanced Power Electronics Packaging, Thermal Management, and Reliability for Electric-Drive Mobility Applications (Citation Only)."

281. Narumanchi, Sreekant. 2024. "Dielectric Liquid-Based Thermal Management for Power Electronics (Citation Only)."

282. Narumanchi, Sreekant. 2024. "NREL Electric Drive Technologies (EDT) Efforts: Lessons Learned (Citation Only)."

283. Neale, Nate. 2023. "The Silicon Consortium Project: Next-Generation Materials (Citation Only)." Presented at the USDRIVE Battery Tech Team - Si Portfolio Review, 8 Dec. 2023.

284. Neale, Nathan R. 2024. "Tuning Ionic and Electrical Conductivity with Molecular Coatings on Silicon Nanoparticles for Lithium-Ion Battery Anodes (Citation Only)."

285. Ollila, Sarah; Slezak, Lee; Meintz, Andrew; Kisacikoglu, John; Thurston, Sam; Chinthavali, Madhu; Kandula, Prasad; Galigekere, Veda; Starke, Michael; Varghese, Benny; Carroll, Thomas E.; Stanton, Don; Pennington, Tim; O'Neil, Lori; Bohn, Theodore; Kintner-Meyer, Michael; Bennett, Jesse; Carlson, Barney; Harris, Brendan; Slowinske, Michael; Smith, Jordan. 2024. "2024 Electric Vehicles at Scale Semiannual Stakeholder Meeting." *https://www.nrel.gov/docs/fy24osti/89059.pdf*.

286. Paret, Paul. 2024. "Power Electronics Materials and Bonded Interfaces - Reliability and Lifetime." *https://www.nrel.gov/docs/fy24osti/85899.pdf*.

287. Paret, Paul; Bhogaraju, Sri Krishna; Busse, Dirk; Dahlbudding, Alexander; Elger, Gordon; Narumanchi, Sreekant. 2024. "Thermomechanical Degradation of Sintered Copper under High-Temperature Thermal Shock (Citation Only)."

288. Pereira, Drew J.; Fink, Kae; Harrison, Katharine L. 2024. "Investigation of Nonflammable Electrolytes for Behind-the-Meter Storage Batteries." *https://www.nrel.gov/docs/fy24osti/90689.pdf*.

289. Pesaran, Ahmad. 2024. "Strategies on How to Manage Battery Heat Under Fast Charge Conditions." *https://www.nrel.gov/docs/fy24osti/84463.pdf*.

290. Powell, Bonnie. 2024. "A Mobility Energy Productivity Evaluation of On-Demand Transit: A Case Study in Arlington, Texas." *https://www.nrel.gov/docs/fy24osti/88432.pdf*.

291. Powell, Bonnie. 2024. "The Evolution of Airport Terminal Wayfinding Technologies." *https://www.nrel.gov/docs/fy24osti/89833.pdf*.

292. Powell, Bonnie. 2024. "The Evolution of Wayfinding Within Airports." *https://www.nrel.gov/docs/fy24osti/88433.pdf*.

293. Prabakar, Kumaraguru. 2024. "Understanding Line Losses and Transformer Losses in Rural Isolated Distribution Systems." *https://www.nrel.gov/docs/fy24osti/89699.pdf*.

294. Preimesberger, Juliane; Kirwa, Cyrus; Coyle, Jaclyn. 2024. "Studying the Mechanics of NMC Cathode Particles for Direct Battery Recycling (Citation Only)."

295. Rorrer, Nicholas A. 2023. "Bio-Based, Inherently Recyclable Epoxy Resins to Enable Facile Carbon-Fiber-Reinforced Composites Recycling." Presented at the VTO 2023 AMR Presentation, 12–15 June 2023. *https://www.nrel.gov/docs/fy24osti/86075.pdf*.

296. Rorrer, Nicholas A. 2023. "Developing a Roadmap for Bio-Derivable and Recyclable Composites: Re-Design and Scale-Up Considerations." Presented at ACS Fall 2023, San Francisco, CA, 13–17 Aug. 2023. *https://www.nrel.gov/docs/fy24osti/87186.pdf*.

297. Rorrer, Nicholas A. 2024. "Converting Poly(ethylene terephthalate) to Rigid Thermosets: Performance and Recycling Considerations." *https://www.nrel.gov/docs/fy24osti/85240.pdf*.

298. Shankari, K.; Duvall, Andrew; Akcicek, Cemal; Aemmer, Zack. 2023. "The CanBikeCO Full Pilot: Long-Term Results and Analysis." Presented at Behavior, Energy and Climate Change (BECC), Sacramento, CA, 12–15 Nov. 2023. *https://www.nrel.gov/docs/fy24osti/88057.pdf*.

299. Sharda, Shivam. 2024. "The Debate on Vehicle Triad: Examining the Utilization Patterns of Gasoline, Hybrid, and Electric Vehicles in Households." *https://www.nrel.gov/docs/fy24osti/91001.pdf*.

300. Sharda, Shivam. 2024. "Triple Effect Economics: How Do Electric Vehicles, Solar Photovoltaics, and Work-from-Home Transform Household Electricity Cost?" *https://www.nrel.gov/docs/fy24osti/89928.pdf*.

301. Sharda, Shivam; Hoehne, Christopher; Acharya, Sailesh; Allen, Michael; Garikapati, Venu M.; Nag, Ambarish; Huang, Yantao. 2023. "Navigating Urban Mobility: Evaluating Infrastructure Strategies for Enhanced Energy-Efficient Access for Micromobility (Citation Only)." Presented at the International Road Federation (IRF) Global R2T Conference, Phoenix, AZ, 14–17 Nov. 2023.

302. Sherman, David; Matthews, Gabe; Jin, Xia; Garikapati, Venu; Sharda, Shivam. 2023. "MEP: Mobility Energy Productivity; Assessment of the Tool for Applications in Florida (Not Published Externally)." Florida DOT webinar, 26 June 2023. *https://www.nrel.gov/docx/gen/fy24/86661.pdf*.

303. Teeter, Glenn. 2024. "Development of NAP-XPS In-Situ Electrochemical Cell (Citation Only)."

304. Thornburg, Nicholas E. 2024. "'A' is for Ammonia: Current Challenges, Emerging Research and NREL's Vision for a Decarbonized Future." *https://www.nrel.gov/docs/fy24osti/89437.pdf*.

305. Tremolet de Villers, Bertrand J.; Tancin, Ryan; Usseglio-Viretta, Francois; Dunlap, Nathan; Sulas-Kern, Dana; Weddle, Peter; Sunderlin, Nathaniel; Finegan, Donal. 2024. "Laser Ablation of Battery Electrodes for Improved Performance: Key Considerations for Advanced Manufacturing (Citation Only)."

306. Ugirumurera, Juliette; Severino, Joe; Liu, Zhaocai. 2024. "HPC-Enabled Tools and Capabilities to Empower the Operation and Planning of Future Mobility Systems (Citation Only)."

307. Usseglio-Viretta, Francois L. E.; Colclasure, Andrew M.; Dunlop, Alison R.; Trask, Stephen E.; Jansen, Andrew N.; Abraham, Daniel P.; Rodrigues, Marco-Tulio F.; Dufek, Eric J.; Tanim, Tanvir R.; Chinnam, Parameswara R.; Ha, Yeyoung; Smith, Kandler. 2024. "Carbon-Binder Optimization for Lithium-Ion Battery Extreme Fast Charge." *https://www.nrel.gov/docs/fy24osti/84234.pdf*.

308. Vercellino, Roberto; Mazzone, Dan. 2023. "Analysis of Benefits Associated With Projects and Technologies Supported by the Clean Transportation Program: 2023 Executive Summary." 3 Oct. 2023. *https://www.nrel.gov/docs/fy24osti/87699.pdf*.

309. Vimmerstedt, Laura; Desai, Ranjit; Heine, Matthew; Jadun, Paige; Tao, Ling; Yip, Arthur; Bafana, Adarsh; Cai, Hao; Elgowainy, Amgad; Islam, Ehsan; Lee, Uisung; Rousseau, Aymeric; Vijayogopal, Ram. 2023. "Annual Technology Baseline: The 2022 Transportation Update." 14 Dec. 2023. *https://www.nrel.gov/docs/fy24osti/87895.pdf*.

310. Wheelis, Abigail. 2024. "OpenPATH - Leveraging Technology to Measure Travel Behavior." *https://www.nrel.gov/docs/fy24osti/90944.pdf*.

311. Wood, Eric; Borlaug, Brennan; Lee, Dong-Yeon; Ge, Yanbo; Yang, Fan. 2023. "Enhancing the EVI-X National Framework to Address Emerging Questions on Charging Infrastructure Deployment." Presented at the 2023 Vehicle Technologies Office Annual Merit Review, 12–15 June 2023. *https://www.nrel.gov/docs/fy24osti/86030.pdf*.

312. Wood, Eric; Borlaug, Brennan; McKenna, Killian; Keen, Jeremy; Liu, Bo; Narang, Dave; Kiboma, Lawryn; Ge, Yanbo; Liu, Zhaocai; Yang, Fan; Sun, Jiayun; Ouren, Fletcher; Wang, Bin; Hong, Wanshi. 2024. "Transportation Electrification Impact Study (TEIS)." *https://www.nrel.gov/docs/fy24osti/89539.pdf*.

313. Wood, Eric; Lee, Dong-Yeon; Spath-Luhring, Lauren; Borlaug, Brennan; St. Louis-Sanchez, Maria; Ge, Yanbo; Yang, Fan. 2023. "EVI-X Updates and National Charging Assessment Report." Presented at the 2023 Vehicle Technologies Office Annual Merit Review, 12–15 June 2023. *https://www.nrel.gov/docs/fy24osti/86417.pdf*.

314. Yip, Arthur; Birky, Alicia. 2024. "Implications and Value of VIUS 2021 for Electrification & Decarbonization of Highway Trucks (NREL Internal Use Only)." *https://www.nrel.gov/docx/gen/fy24/90357.pdf*.

315. Young, Stanley E. 2023. "NREL Mobility Futures (Citation Only)." Presented at the FAV Summit, Tampa, FL, 6–8 Sept. 2023.

316. Young, Stanley E. 2024. "A Multi-Dimensional Benefit Assessment of Automated Mobility Platforms (AMP) for Large Facilities." *https://www.nrel.gov/docs/fy24osti/87358.pdf*.

317. Young, Stanley E.; Duvall, Andrew; Powell, Bonnie; Sperling, Joshua; Henao, Alejandro; Rischpater, Katie; Armbrister, LaQuinton; Weigl, Dustin. 2024. "Sustainable Public Transport: Providing Responsive, On-Demand Service with Clean Energy." *https://www.nrel.gov/docs/fy24osti/90059.pdf*.

318. Young, Stanley E.; Lott, J. Sam. 2024. "Safe Operations at Roadway Junctions: Intelligent Roadway Infrastructure as Functional Interlocking." *https://www.nrel.gov/docs/fy24osti/90055.pdf*.

319. Zakutayev, Andriy; Narumanchi, Sreekant; Mather, Barry; Farrell, John; Khan, Faisal. 2024. "Advanced Power Module Research (Citation Only)."

Technical Reports

320. Anderson, Kate; Day, Megan; Romero Lankao, Patricia; Berdahl, Sonja; Rauser, Casandra; Bowen, Thomas; Fournier, Eric Daniel; et al. 2023. LA100 Equity Strategies. *https://www.nrel.gov/docs/fy24osti/85960.pdf*.

321. Anderson, Shannon; Bopp, Kaylyn; Gonzalez, Didier Bolanos; Colon, Jasmira; Mendez, Mauricio Leon; Mountjoy-Venning, Cliff; Pratt, Tim; Rosner, Nicole; Spanswick, Jessica. 2024. Pathways Toward Electric Mobility: Communities LEAP in Hennepin County, Minnesota. *https://www.nrel.gov/docs/fy24osti/88626.pdf*.

322. Black, Doug; Panossian, Nadia; Liu, Jingjing; Nordman, Bruce; Farrell, John; Hodge, Cabell; Meintz, Andrew; Abdullah, Muhammad; Kisacikoglu, Mithat John; Bennett, Jesse; Yin, Rongxin; Agarwal, Shreya; Kirchstetter, Thomas. 2024. Survey and Gap Prioritization of U.S. Electric Vehicle Charge Management Deployments. *https://eta-publications.lbl.gov/sites/default/files/scm_gap_analysis_.pdf*.

323. Bouallegue, Miriam; Gilbert, Kelly; Nobler, Erin; Snelling, Amy; Reichelt, Lauren; Hoopes, Luna. 2024. Kansas City, Missouri, Streetlight Electric Vehicle Charging (Citation Only).

324. Bracci, Justin; Koleva, Mariya; Chung, Mark. 2024. Levelized Cost of Dispensed Hydrogen for Heavy-Duty Vehicles. *https://www.nrel.gov/docs/fy24osti/88818.pdf*.

325. Brown, Abby; Cappellucci, Jeff; Heinrich, Alexia; Cost, Emma. 2024. Electric Vehicle Charging Infrastructure Trends from the Alternative Fueling Station Locator: Third Quarter 2023. *https://www.nrel.gov/docs/fy24osti/88223.pdf*.

326. Brown, Abby; Cappellucci, Jeff; Heinrich, Alexia; Gaus, Madeline; Cost, Emma. 2024. Electric Vehicle Charging Infrastructure Trends from the Alternative Fueling Station Locator: First Quarter 2024. *https://www.nrel.gov/docs/fy24osti/90288.pdf*.

327. Brown, Abby; Cappellucci, Jeffrey; Heinrich, Alexia; Cost, Emma. 2024. Electric Vehicle Charging Infrastructure Trends from the Alternative Fueling Station Locator: Fourth Quarter 2023. *https://www.nrel.gov/docs/fy24osti/89108.pdf*.

328. Brown, Abby; Cappellucci, Jeffrey; White, Emily; Heinrich, Alexia; Cost, Emma. 2023. Electric Vehicle Charging Infrastructure Trends from the Alternative Fueling Station Locator: Second Quarter 2023. *https://www.nrel.gov/docs/fy24osti/87033.pdf*.

329. Bruchon, Matthew; Borlaug, Brennan; Liu, Bo; Jonas, Tim; Sun, Jiayun; Le, Nhat; Wood, Eric. 2024. Depot-Based Vehicle Data for National Analysis of Medium- and Heavy-Duty Electric Vehicle Charging. *https://www.nrel.gov/docs/fy24osti/88241.pdf*.

330. Davidson, Keith; Kogalur, Namrata; Tolbert, Isaac; Watt, Ed; Meintz, Andrew. 2024. EVs@Scale - Next-Gen Profiles: High Level Analysis and Procedures Report. *https://www.nrel.gov/docs/fy24osti/88898.pdf*.

331. Fish, Joe; Garikapati, Venu; Birky, Alicia; Jeong, Kyungsoo; Young, Stanley; Duvall, Andrew; Reichelt, Lauren; Gonder, Jeffrey. 2023. Envisioning Tomorrow's Sustainable Mobility Systems: Challenges & Opportunities (Not Published Externally). *https://www.nrel.gov/docx/gen/fy24/87244.pdf*.

332. Frasier, Ryan; Kotz, Emily; Cardinali, Sarah; Carron, William Scott; Jamison, Johanna. 2024. Zero-Emission Vehicle Adoption Resource Guide for Government Fleets in Jackson County, Illinois. *https://www.nrel.gov/docs/fy24osti/88407.pdf*.

333. Goldberg, Jacob; Pisano, Teresa; Hunter, Laura; Dunlap, Lauren; Grothen, Brett; Paddock, Arron; Goss, Kevin; Sawa, Joe; Leventhal, Jared; Pettifor, Giles; Sigler, Cory; Kotz, Andrew; Lammert, Michael; Jeffers, Matthew; Lustbader, Jason. 2024. The Port of Los Angeles Zero- and Near-Zero-Emission Freight Facilities Shore to Store Project. *https://www.nrel.gov/docs/fy24osti/89761.pdf*.

334. Hoehne, Christopher; Garikapati, Venu; Huang, Yantao. 2024. Integrating the Mobility Energy Productivity Metric into the CDOT Statewide Model. *https://rosap.ntl.bts.gov/view/dot/73805/dot_73805_DS1.pdf*.

335. Johnson, Caley; Joshi, Prateek; Weigl, Dustin; Esparza, Eliseo. 2023. Policy Framework to Improve Mobility Efficiency and Electrify Transportation in Tonga. *https://www.nrel.gov/docs/fy24osti/87827.pdf*.

336. Khan, Rabia; Johnson, Caley; Khan, Faisal. 2024. Standards Guidance for Electric Two- and Three-Wheelers and Charging Infrastructure in Pakistan. *https://www.nrel.gov/docs/fy24osti/87955.pdf*.

337. Kim, Clarisse Hyekyung; Zhang, Jingjing; Sperling, Joshua; Shuster, Erik; Stauff, Nicolas; Armaly, Anthony; Jenson, William; Larsen, Levi M.; Bracho, Riccardo; Efroymson, Rebecca; Doherty, Julie; Dargouth, Naim; Kline, Keith; Zhou, Nan. 2023. Fossil Fuel Transitions Framework: Case Studies of the Decision-Making Process for Energy and Economic Development Pathways. *https://www.anl.gov/sites/www/files/2024-01/Net-Zero-World-Fossil-Transition-Report_FINAL_1-8-2024.pdf*.

338. Kisacikoglu, Mithat John; Harper, Jason D.; Kandula, Rajendra Prasad; Thurlbeck, Alastair P.; Ali, Akram Syed; Ucer, Emin; Watt, Edward; Khan, Md Shafquat Ullah; Mahmud, Rasel. 2024. High-Power Electric Vehicle Charging Hub Integration Platform (eCHIP): Design Guidelines and Specifications for DC Distribution-Based Charging Hub. *https://www.nrel.gov/docs/fy24osti/86326.pdf*.

339. Kotz, Andrew; Jeffers, Matthew; Fakhimi, Setayesh; Miller, Eric; Squires, Anna; Meintsma, Sonja; Mladenovic, Kristi; Trowbridge, Bonnie; Woodruff, Hunter. 2024. Delivering Clean Air in Denver: Propane Trucks and Infrastructure in Mail Delivery Application. *https://www.nrel.gov/docs/fy24osti/88477.pdf*.

340. Lommele, Stephen; Desai, Ranjit R.; Johnson, Caley; Snelling, Amy; Brown, Abby; Singer, Mark; Bennett, Jesse; Cappellucci, Jeffrey; Levene, Johanna; Hoehne, Christopher. 2024. Assessment of Alternative Fueling Infrastructure in the United States. *https://www.nrel.gov/docs/fy24osti/88513.pdf*.

341. Markel, Tony. 2024. PHEV Distribution Grid Integration and Smart Systems Testing: Cooperative Research and Development Final Report, CRADA Number CRD-13-00510. *https://www.nrel.gov/docs/fy24osti/88679.pdf*.

342. McCormick, Robert. 2024. Research to Address Technical Barriers to Expanded Markets for Biodiesel and Biodiesel Blends, CRADA Number CRD-15-00593. *https://www.nrel.gov/docs/fy24osti/89192.pdf*.

343. Meintz, Andrew; Gaxiola, Marco; Singh, Vivek; Tolbert, Isaac; Shinde, Saroj; Moriarty, Kristi. 2024. Recommended Actions to Improve Adapter Safety. *https://www.nrel.gov/docs/fy24osti/91017.pdf*.

344. Moriarty, Kristi; McCormick, Robert. 2024. Sustainable Aviation Fuel Blending and Logistics. *https://www.nrel.gov/docs/fy24osti/90979.pdf*.

345. Moriarty, Kristi; Smart, John. 2024. Best Practices for Payment Systems at Public Electric Vehicle Charging Stations. *https://www.nrel.gov/docs/fy24osti/88821.pdf*.

346. Muratori, Matteo. 2023. Zero-Emission Truck Policy Group at 2023 Climate Week NYC: Roundtable on Electric Vehicle Charging Infrastructure and the Grid. *https://www.nrel.gov/docs/fy24osti/87525.pdf*.

347. Nanayakkara, Sanjini; Sperling, Joshua; Johnson, Caley; Morris, Ellen; Bracho, Riccardo; Fang, Andrew. 2023. Just and Sustainable Mobility Transition in the Transport Sector: A Conceptual Framework and Gender-Mainstreaming Case Studies. *https://www.nrel.gov/docs/fy24osti/87449.pdf*.

348. Powell, Bonnie; Johnson, Caley. 2024. Impact of Electric Vehicle Charging Station Reliability, Resilience, and Location on Electric Vehicle Adoption. *https://www.nrel.gov/docs/fy24osti/89896.pdf*.

349. Powell, Bonnie; Young, Stanley E.; Duvall, Andrew. 2023. The Evolution of Wayfinding Within Airports. *https://www.nrel.gov/docs/fy24osti/83211.pdf*.

350. Singer, Mark; Johnson, Caley; Wilson, Alana. 2024. Clean Cities Coalitions 2022 Activity Report. *https://www.nrel.gov/docs/fy24osti/88443.pdf*.

351. Solanki, Bharatkumar; Sanders, Peyton; Miller, Eric; Paudyal, Priti; Rathod, Bhavesh; Abraham, Sherin Ann; Young, Michael; et al. 2023. Federal Aviation Administration Vertiport Electrical Infrastructure Study. *https://www.nrel.gov/docs/fy24osti/86245.pdf*.

352. Spurlock, C. Anna; Bouzaghrane, Mohamed Amine; Brooker, Aaron; Caicedo, Juan; Gonder, Jeff; Holden, Jake; Jeong, Kyungsoo; Jin, Ling; Laarabi, Haitam; Needell, Zachary; Poliziani, Cristian; Sharda, Shivam; Sun, Bingrong; Waddell, Paul; Wang, Yuhan; Waraich, Rashid; Wenzel, Tom; Xu, Xiaodan. 2024. Behavior, Energy, Autonomy & Mobility Comprehensive Regional Evaluator: Overview, Calibration and Validation Summary of an Agent-Based Integrated Regional Transportation Modeling Workflow. *https://eta-publications.lbl.gov/publications/behavior-energy-autonomy-mobility*.

353. Tolbert, Isaac; Kogalur, Namrata; Martin, Jonathan; Meintz, Andrew. 2024. CharIN Megawatt Charging System: 4th Event Summary Report. *https://www.nrel.gov/docs/fy24osti/89238.pdf*.

354. U.S. Department of Energy. 2024. (C2C): Clean Energy to Communities Annual Highlights 2023. *https://www.nrel.gov/docs/fy24osti/88541.pdf*.

355. Weigl, Dustin. 2023. EVI-Pro for Bogota Columbia. *https://www.nrel.gov/docs/fy24osti/85935.pdf*.

356. Weigl, Dustin; Bopp, Kaylyn; Rosner, Nicole. 2024. Electric Mobility Opportunities for Brooklyn Park, Minnesota. *https://www.nrel.gov/docs/fy24osti/86690.pdf*.

357. Wood, Eric; Borlaug, Brennan; McKenna, Killian; Keen, Jeremy; Liu, Bo; Sun, Jiayun; Narang, Dave; Kiboma, Lawryn; Wang, Bin; Hong, Wanshi; Giraldez, Julieta; Moran, Chuck; Everett, Margot; Horner, Trina; Hodges, Troy; Crisostomo, Noel; Walsh, Patrick. 2024. Multi-State Transportation Electrification Impact Study: Preparing the Grid for Light-, Medium-, and Heavy-Duty Electric Vehicles. *https://www.energy.gov/sites/default/files/2024-03/2024.03.18%20NREL%20LBNL%20Kevala%20DOE%20Multi-State%20Transportation%20Electrification%20Impact%20Study%20FINAL%20DOCKET.pdf*.

358. Young, Stanley; Duvall, Andrew; Henao, Alejandro; Gonder, Jeffrey. 2023. Inaugural Technologist in Communities Scanning Tour: Automated and Electrified On-Demand Mobility. *https://www.nrel.gov/docs/fy24osti/87448.pdf*.

Online NREL.gov Features, Press Releases, & News Items

1. Athena ZEV Takes Up Challenge of Electrifying Airports and De-Risking Investment (Oct. 2, 2023). *https://www.nrel.gov/news/program/2023/athena-zev-takes-up-challenge-of-electrifying-airports-and-de-risking-investment.html*

2. NREL-Developed Dashboard Fuels Decarbonization Across Commercial Fleets (Oct. 3, 2023). *https://www.nrel.gov/news/program/2023/fleetredi-dashboard-fuels-decarbonization-across-commercial-fleets.html*

3. Electric Vehicles Play a Surprising Role in Supporting Grid Resiliency (Oct. 12, 2023). *https://www.nrel.gov/news/program/2023/evs-play-surprising-role-in-supporting-grid-resiliency.html*

4. New Collaboration Balances Sustainability and Profitability of Lithium-Ion Battery Recycling (Oct. 18, 2023). *https://www.nrel.gov/news/program/2023/new-collaboration-balances-sustainability-profitability-lithium-ion-battery-recycling.html*

5. News Release: Deep Decarbonization Scenarios Reveal Importance of Accelerating Zero-Emission Vehicle Adoption (Nov. 1, 2023). *https://www.nrel.gov/news/press/2023/deep-decarbonization-scenarios-reveal-importance-of-zero-emission-vehicles.html*

6. NREL Study Investigates EV Fast-Charging Infrastructure Needed To Enable Travel to National Parks (Nov. 15, 2023). *https://www.nrel.gov/news/program/2023/nrel-study-investigates-ev-fast-charging-infrastructure-needed-to-enable-travel-to-national-parks.html*

7. Transportation Annual Technology Baseline Expands To Include New Technologies (Nov. 17, 2023). *https://www.nrel.gov/news/program/2023/transportation-annual-technology-baseline-expands-to-include-new-technologies.html*

8. NREL Merges Data Collection and Analysis Tools To Evaluate Emerging Transportation Modes (Dec. 1, 2023). *https://www.nrel.gov/news/program/2023/nrel-merges-data-collection-and-analysis-tools-to-evaluate-emerging-transportation-modes.html*

9. Douglas DeVoto Earns ASME Excellence in Mechanics Award (Dec. 13, 2023). *https://www.nrel.gov/news/program/2023/doug-devoto-earns-asme-excellence-in-mechanics-award.html*

10. NREL Joins $40 Million Effort To Advance Data Center Cooling Efficiency (Dec. 14, 2023). *https://www.nrel.gov/news/program/2023/nrel-joins-effort-to-advance-data-center-cooling-efficiency.html*

11. 20 Ways NREL Made an Impact in 2023 (Dec. 27, 2023). *https://www.nrel.gov/news/features/2023/20-ways-nrel-made-an-impact-in-2023.html*

12. NREL To Showcase Research at Transportation Research Board Meeting (Jan. 4, 2024). *https://www.nrel.gov/news/program/2024/nrel-to-showcase-research-at-transportation-research-board-meeting.html*

13. News Release: Green Wheels, Bright Skies: NREL Analysis Unveils the Connection Between Electric Vehicles and Photovoltaics (Jan. 9, 2024). *https://www.nrel.gov/news/press/2024/news-release-green-wheels-bright-skies-nrel-analysis-unveils-the-connection-between-electric-vehicles-and-photovoltaics.html*

14. NREL's Expert Contributions to Renowned Climate Change Assessment Strengthen Leaders' Ability To Make Informed Decisions (Jan. 13, 2024). *https://www.nrel.gov/news/program/2024/nrels-expert-contributions-to-renowned-climate-change-assessment-strengthen-leaders-ability-to-make-informed-decisions.html*

15. Computational Mobility Scientist Honored With Colorado Governor's Award for High-Impact Research (Jan. 18, 2024). *https://www.nrel.gov/news/program/2024/computational-mobility-scientist-honored-with-colorado-governors-award-for-high-impact-research.html*

16. John Kisacikoglu Tapped To Lead IEEE's Transportation Systems Committee (Jan. 19, 2024). *https://www.nrel.gov/news/program/2024/john-kisacikoglu-tapped-to-lead-ieee-transportation-systems-committee.html*

17. On the Ground in Colorado, NREL Is Simulating Sustainable Aviation Fuel Combustion During Flight (Jan. 29, 2024). *https://www.nrel.gov/news/features/2024/on-the-ground-in-colorado-nrel-is-simulating-sustainable-aviation-fuel-combustion-during-flight.html*

18. Shashank Yellapantula Receives American Institute of Aeronautics and Astronautics Fellow Designation (Jan. 29, 2024). *https://www.nrel.gov/news/program/2024/shashank-yellapantula-receives-american-institute-of-aeronautics-and-astronautics-fellow-designation.html*

19. Unleashing the Power: BatMan Project Revolutionizes Battery Manufacturing (Feb. 13, 2024). *https://www.nrel.gov/news/features/2024/unleashing-the-power-batman-project-revolutionizes-battery-manufacturing.html*

20. Clean Bus Planning Awards Support Fleet Electrification With Custom Transition Plans (Feb. 20, 2024). *https://www.nrel.gov/news/program/2024/clean-bus-planning-awards-support-fleet-electrification-with-custom-transition-plans.html*

21. NREL's Recyclable Carbon Fiber Composites Made Greener With Thermoforming (Feb. 27, 2024). *https://www.nrel.gov/news/program/2024/nrels-recyclable-carbon-fiber-composites-made-greener-with-thermoforming.html*

22. How Many Transformers Will US Distribution Grid Need by 2050? (March 4, 2024). *https://www.nrel.gov/news/program/2024/how-many-transformers-will-the-us-distribution-grid-need-by-2050.html*

23. NREL's Rail Optimization Software Is Putting Freight Electrification on the Fast Track (March 5, 2024). *https://www.nrel.gov/news/program/2024/nrels-rail-optimization-software-is-putting-freight-electrification-on-the-fast-track.html*

24. Electric Aircrafts Will Need Powerful Ports (March 7, 2024). *https://www.nrel.gov/news/program/2024/electric-aircrafts-will-need-powerful-ports.html*

25. Study Examines Cost Competitiveness of Zero-Emission Trucks (April 3, 2024). *https://www.nrel.gov/news/program/2024/study-examines-cost-competitiveness-of-zero-emission-trucks.html*

26. NREL Analysis Shows Snapshot of the Clean Supply Chain of the Future (April 8, 2024). *https://www.nrel.gov/news/program/2024/nrel-analysis-shows-snapshot-of-the-clean-supply-chain-of-the-future.html*

27. New Report Tackles Electric Vehicle Charging Payment Challenges and Offers Key Recommendations (April 17, 2024). *https://www.nrel.gov/news/program/2024/new-report-tackles-electric-vehicle-charging-payment-challenges-and-offers-key-recommendations.html*

28. Two Communities Find Electric Vehicle Options That Meet Local Goals Through Clean Energy to Communities (April 17, 2024). *https://www.nrel.gov/news/program/2024/two-communities-find-electric-vehicle-options-that-meet-local-goals-through-clean-energy-to-communities.html*

29. Short-Circuiting on Purpose: How NREL-Licensed Tech Continues To Make a Difference in Space (April 22, 2024). *https://www.nrel.gov/news/program/2024/short-circuiting-on-purpose-how-nrel-licensed-tech-continues-to-make-difference-in-space.html*

30. Zooming in on Electric Vehicles: How Duluth, Minnesota, Is Preparing for the EV Future (May 8, 2024). *https://www.nrel.gov/news/program/2024/zooming-in-on-evs-how-duluth-minnesota-is-preparing-for-the-ev-future.html*

31. NREL Battery Supply Chain Database Maps Out the State of North America's Manufacturing Base (May 15, 2024). *https://www.nrel.gov/news/program/2024/nrel-battery-supply-chain-database-maps-out-the-state-of-north-americas-manufacturing-base.html*

32. Mastering the Fundamentals: A First Step for Promising New Sustainable Vehicle Fuels (May 15, 2024). *https://www.nrel.gov/news/program/2024/mastering-fundamentals-first-step-for-promising-new-sustainable-vehicle-fuels.html*

33. NREL's Open-Source Vehicle and Mobility Tools Offer Routes to Reduce Transportation Energy Use, Emissions (May 16, 2024). *https://www.nrel.gov/news/program/2024/nrels-open-source-vehicle-and-mobility-tools-offer-routes-to-reduce-transportation-energy-use-emissions.html*

34. Venu Garikapati Designated as Chair of Transportation Research Board Committee on Travel Choices (May 20, 2024). *https://www.nrel.gov/news/program/2024/venu-garikapati-designated-as-chair-of-transportation-research-board-committee-on-travel-choices.html*

35. Advanced Spin Resonance Facility Accelerates Fundamental Understanding of Catalytic Mechanisms and Structural Characterization at Level of Electrons (June 10, 2024). *https://www.nrel.gov/news/program/2024/advanced-spin-resonance-facility-fundamental-understanding-catalytic-mechanisms-structural-characterization-electrons.html*

36. Next-Generation Profiles Project Makes Electric Vehicle High-Power Charging Safer and More Reliable (June 11, 2024). *https://www.nrel.gov/news/program/2024/next-generation-profiles-project-makes-electric-vehicle-high-power-charging-safer-reliable.html*

37. EVI-X Modeling Suite Accelerates Optimized Electric Vehicle Charging Infrastructure Deployments (June 17, 2024). *https://www.nrel.gov/news/program/2024/evi-x-modeling-suite-accelerates-optimized-electric-vehicle-charging-infrastructure-deployments.html*

38. Electric Vehicles Grow in the Desert: Peer Learning Helps Sedona Plan for Charging Infrastructure (June 26, 2024). *https://www.nrel.gov/news/program/2024/electric-vehicles-grow-in-the-desert-peer-learning-helps-sedona-plan-for-charging-infrastructure.html*

39. NREL Partners With Industry Leaders To Prove Out Grid Integration Solutions (June 27, 2024). *https://www.nrel.gov/news/program/2024/nrel-partners-with-industry-leaders-to-prove-out-grid-integration-solutions.html*

40. NREL Transportation Researchers Recognized for Teamwork, Leadership, and Expertise at DOE Annual Merit Review (July 15, 2024). *https://www.nrel.gov/news/program/2024/nrel-transportation-researchers-recognized-for-teamwork-leadership-and-expertise-at-doe-annual-merit-review.html*

41. Sreekant Narumanchi Travels the Intersection of Heat Transfer, Power Electronics, and Electric Motors to Electrification of Vehicles (July 16, 2024). *https://www.nrel.gov/news/program/2024/sreekant-narumanchi-travels-intersection-heat-transfer-power-electronics-electric-motors-electrification-vehicles.html*

42. Decades of NREL Research Power Electric Vehicle Revolution *Progress (July 30, 2024). https://www.nrel.gov/news/features/2024/decades-of-nrel-research-power-electric-vehicle-revolution-progress.html*

43. Soft Cost Analysis of EV Charging Infrastructure Informs Transition to an Electric Fleet (Aug. 5, 2024). *https://www.nrel.gov/news/program/2024/soft-cost-analysis-of-ev-charging-infrastructure-informs-transition-to-an-electric-fleet.html*

44. Researcher Shafquat Khan Elevated to Institute for Electrical and Electronics Engineers Senior Member (Aug. 8, 2024). *https://www.nrel.gov/news/program/2024/researcher-shafquat-khan-elevated-to-institute-for-electrical-and-electronics-engineers-senior-member.html*

45. Lao Delegates Get Firsthand Look at State-of-the-Art Electric Vehicle Technologies—and So Much More (Sept. 5, 2024). *https://www.nrel.gov/news/program/2024/lao-delegates-get-firsthand-look-at-state-of-the-art-electric-vehicle-technologies-and-so-much-more.html*

46. NREL Research Points Path to Higher Blends of Biodiesel (Sept. 20, 2024). *https://www.nrel.gov/news/program/2024/nrel-research-points-path-to-higher-blends-of-biodiesel.html*

47. NREL Experts Accelerate Electrification of Department of Defense Nontactical Fleets (Sept. 25, 2024). *https://www.nrel.gov/news/program/2024/nrel-experts-accelerate-electrification-of-department-of-defense-nontactical-fleets.html*

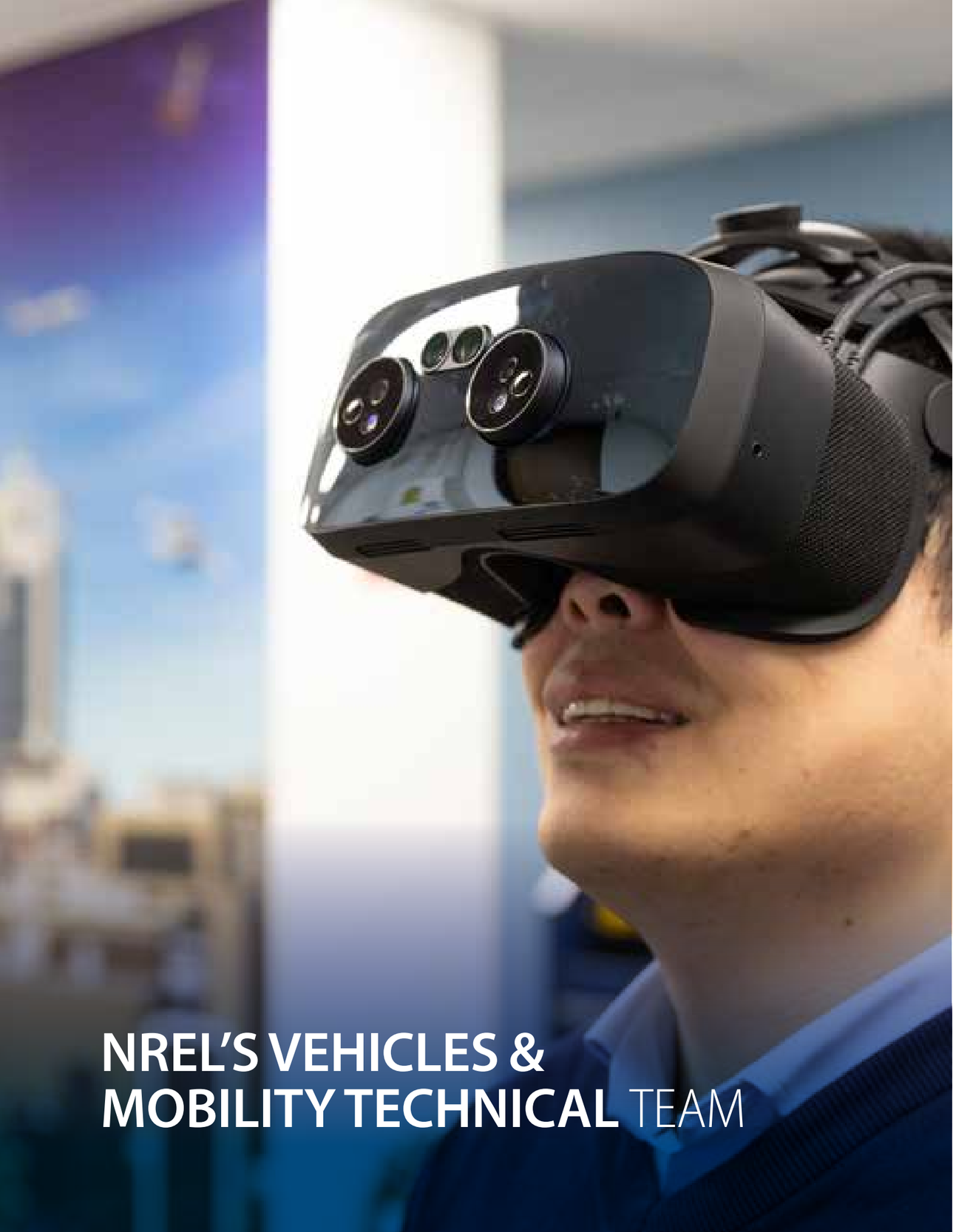
48. NREL Selected To Design Next-Generation Power Inverters for US Combat Vehicles (Sept. 30, 2024). *https://www.nrel.gov/news/program/2024/nrel-selected-to-design-next-generation-power-inverters-for-us-combat-vehicles.html*

49. Starting With Safety: NREL Approach Streamlines Early-Stage Battery Development (Sept. 30, 2024). *https://www.nrel.gov/news/program/2024/starting-with-safety-nrel-approach-streamlines-early-stage-battery-development.html*

50. NREL Researchers Survey the State of Smart Charge Management Nationwide (Sept. 30, 2024). *https://www.nrel.gov/news/program/2024/nrel-researchers-survey-the-state-of-smart-charge-management-nationwide.html*

Image Credits

Cover (front), photo by Gregory Cooper, NREL 91748; pages 2-3, photo from Getty Images, 1351823173; page 4, photo by Werner Slocum, NREL 78879; page 5, photo by Joe DelNero, NREL; page 6, photo by Joe DelNero, NREL 81937; page 7, photo from iStock, 1427504279, and Graphic by Cameron Nelson, NREL; page 8, photos from Dennis Schroeder, NREL 54631; page 9, Getty Images 1396387306, and Toyota Motor North America, NREL, 90386; page 10, Illustration by John Frenzel, NREL; page 11, photo by Dennis Schroeder, NREL 56661; page 12, Photo by Gregory Cooper, NREL 89541; page 13, photos by Joe DelNero, NREL 85390, and Parallel Systems; page 14, photo by Joe DelNero, NREL 82828; page 15, Photo from Paul Wessel, Clean Transportation Communities of Southern CT; page 16, Photo courtesy of Clean Cities and Communities; page 17, Photo by AnnaSquires, NREL, and Graphic by Cameron Nelson and logo by Liz Craig, NREL; page 18, photo by Werner Slocum, NREL 85492, NREL; page 20, Photo by Dennis Schroeder, NREL 49130; page 21, Video image by NREL; page 22, Photo from Getty Images, 1316185179; page 23, Photo by Joe DelNero, NREL 87671; page 24, Image by Army Staff Sgt. True Thao; page 25, Photo by Gregory Cooper, NREL 94034; page 26, Photo by Joe DelNero, NREL 91412; page 30, logo by NREL, and Illustration by Besiki Kazaishvili, NREL; page 28, Photo courtesy of Abby Brown, NREL, and Photo by Werner Slocum, NREL 82108; page 28, Photo from Getty Images, 1399328228, and Photo from Dave Cook, U.S. Department of Defense; page 30, Photo by Michael Tant, NREL 94349; page 31, Rendering of the EMAPS facility, and Graphic by SmithGroup, page 32; Photo by Werner Slocum, NREL 73787; page 33, Photo by Brian Cox, NREL, and Photo by Natasha Headland, NREL 89398; page 34, Photo from Wes Maurer, Photo by Joe DelNero, NREL 85477, and Photo by Werner Slocum, NREL 60771, 83659; page 35, Photo by Gregory Cooper, NREL 88836, Photo by Agata Bogucka, NREL 89150, Photo courtesy of Lissa Myers, NREL, Photo by Werner Slocum, NREL 83570, and Photo by Dennis Schroeder, NREL 22854; page 36, Photo courtesy of AMR 2024 Livewire, Photo by Josh Bauer, NREL 85006, 85071, Photo by Joe DelNero, NREL 75245, Photo by Dennis Schroeder, NREL 38991, and Photo by Bryan Bechtold, NREL 85248; page 37, Photo courtesy of Shafquat Khan, NREL, Photo by Werner Slocum, NREL 81981, 72574, and Photo courtesy of Saad Akhtar, NREL; page 38, Photo by Gregory Cooper, NREL 89825, 89711, Photo courtesy of Emily Cousineau, NREL, and Photo by Werner Slocum, NREL 83570; page 39, Photo by NACFE's Run on Less – Electric DEPOT; page 40, Photo by Gregory Cooper NREL 94005; page 42, Photo by Prateek Joshi, NREL 93485; page 44, Photo by Werner Slocum NREL 72408; page 47, photo from Getty Images, 868922846; page 48, Graphic by Cameron Nelson, NREL and photo from Getty Images, 1325919008; page 51, photo from Getty Images, 1448230113; page 53, photo by Dennis Schroeder, NREL 33296; page 55, Graphic by Cameron Nelson , NREL; page 57, photo by Natasha Headland , NREL 87536; Page 80, Photo by Joe DelNero, NREL 87629; cover (back), Photo by Bryan Bechtold, NREL 85431.



NREL'S VEHICLES & MOBILITY TECHNICAL TEAM

Technical Team and Facility Leaders

Advanced Biofuels and Combustion ..... **Robert McCormick**
Data Sciences ..... **Monte Lunacek**
Electric Vehicle Grid Integration ..... **John Kisacikoglu**
Commercial Vehicle Technologies ..... **Andrew Kotz**
Energy Storage – Systems Data Science and Modeling ..... **Kandler Smith**
Energy Storage – Advanced Cathode Material Development ..... **Rob Tenent**
Energy Storage – Materials Development and Modeling ..... **Andrew Colclasure**
Legislative/Regulatory Support ..... **Erin Andrews-Sharer**
Lightweight and Recyclable Composite Materials ..... **Nicholas Rorrer**
Mobility Systems ..... **Stan Young**
Power Electronics & Electric Machines ..... **Doug DeVoto and Gilbert Moreno**
Technology Integration/ Data & Tools ..... **Emmy Feldman**
Technology Integration/Technical Assistance ..... **Abby Brown**
Vehicle Modeling and Analysis ..... **Brennan Borlaug**

Directorate, Program & Center Leadership

Johney B. Green
Associate Lab Director, Mechanical & Thermal Engineering Sciences

John Farrell
Laboratory Program Manager, Vehicle Technologies Office

Chris Gearhart
Director, Integrated Mobility Sciences

Ray Grout
Director, Computational Science

Jao Van de Lagemaat
Director, Chemistry & Nanoscience

Tony Burrell
Chief Technologist, Energy Storage

Ken Kelly
Chief Engineer for Commercial Vehicle Electrification

Faisal Khan
Principal Researcher, Power Electronics

Andrew Meintz
Chief Engineer for EV Charging and Grid Integration

Margo Melendez
Chief Transportation Technology Deployment and Integration Engineer

Ahmad Pesaran
Chief Energy Storage Engineer

Sarah Cardinali
Group Manager Transportation Technical Assistance

Marc Day
Group Manager, High-Performance Algorithms & Complex Fluids

Gina Fioroni
Group Manager, Fuels & Combustion Science

Venu Garikapati
Group Manager (Acting), Behavior & Advanced Mobility

Jeff Gonder
Group Manager, Transportation Energy Transition Analysis

Cabell Hodge
Group Manager, Analysis of Vehicles and Infrastructure Deployment

Wesley Jones
Group Manager, Complex Systems Simulation and Optimization

Matt Keyser
Group Manager, Electrochemical Energy Storage

Lauren Spath Luhring
Group Manager (Acting), Transportation Applications & Data Analysis

Jason Lustbader
Group Manager, Advanced Vehicles & Charging Infrastructure

Juliane Mueller
Group Manager, AI, Learning, and Intelligent Systems

Sreekant Narumanchi
Group Manager, Advanced Power Electronics & Electric Machines

Nate Neale
Group Manager, Interfacial Materials Chemistry

Kristi Potter
Group Manager, Data, Analysis & Visualization

Jibo Sanyal
Group Manager, Hybrid Energy Systems

Elizabeth Weber
Group Manager, Sociotechnical Transportation Engagement Projects

Affiliated Lab-Wide Leadership

Adam Bratis
Associate Lab Director
Bioenergy Science and Technology

Juan Torres
Associate Lab Director
Energy Systems Integration

Bill Tumas
Associate Lab Director
Materials, Chemical & Computational Sciences

VEHICLE AND MOBILITY TECHNOLOGIES
2024 ANNUAL IMPACT REPORT

NREL
Transforming ENERGY

National Renewable Energy Laboratory
15013 Denver West Parkway, Golden, CO 80401
303-275-3000 • www.nrel.gov

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

NREL/MP-5400-91530 • October 2024

NREL prints on paper that contains recycled content.