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Livewire Data Platform-A Solution for Energy Efficient Mobility Systems (EEMS) Data Sharing

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June 14, 2023

DOE Vehicle Technologies Program
2023 Annual Merit Review and Peer Evaluation Meeting

eems066

Overview

- **Timeline**
  - Initially funded in FY19
    - https://livewire.energy.gov/ launched June 2019
  - Project start date (current round of funding): 10/1/2022
  - Project end date: 9/30/24
  - ~30% complete

- **Budget**
  - Total project funding (current round of funding): $5,130,000
    - DOE share: $5,130,000
  - Funding for FY 2022: $1,710,000
  - Funding for FY 2023: $1,710,000

- **Barriers**
  - Barriers addressed
    - Expansive community of relevant stakeholders
    - Difficulty in sourcing empirical real-world data applicable to new mobility technologies such as connectivity and automation

- **Partners**
  - Project leads
    - National Renewable Energy Laboratory (NREL)
      - Transportation Secure Data Center (TSDC)
      - Fleet DNA
    - Pacific Northwest National Laboratory (PNNL)
    - Idaho National Laboratory (INL)
  - Interactions/collaborations
    - EEMS research community
    - VTO-funded FOA awardees
    - Mobility researchers

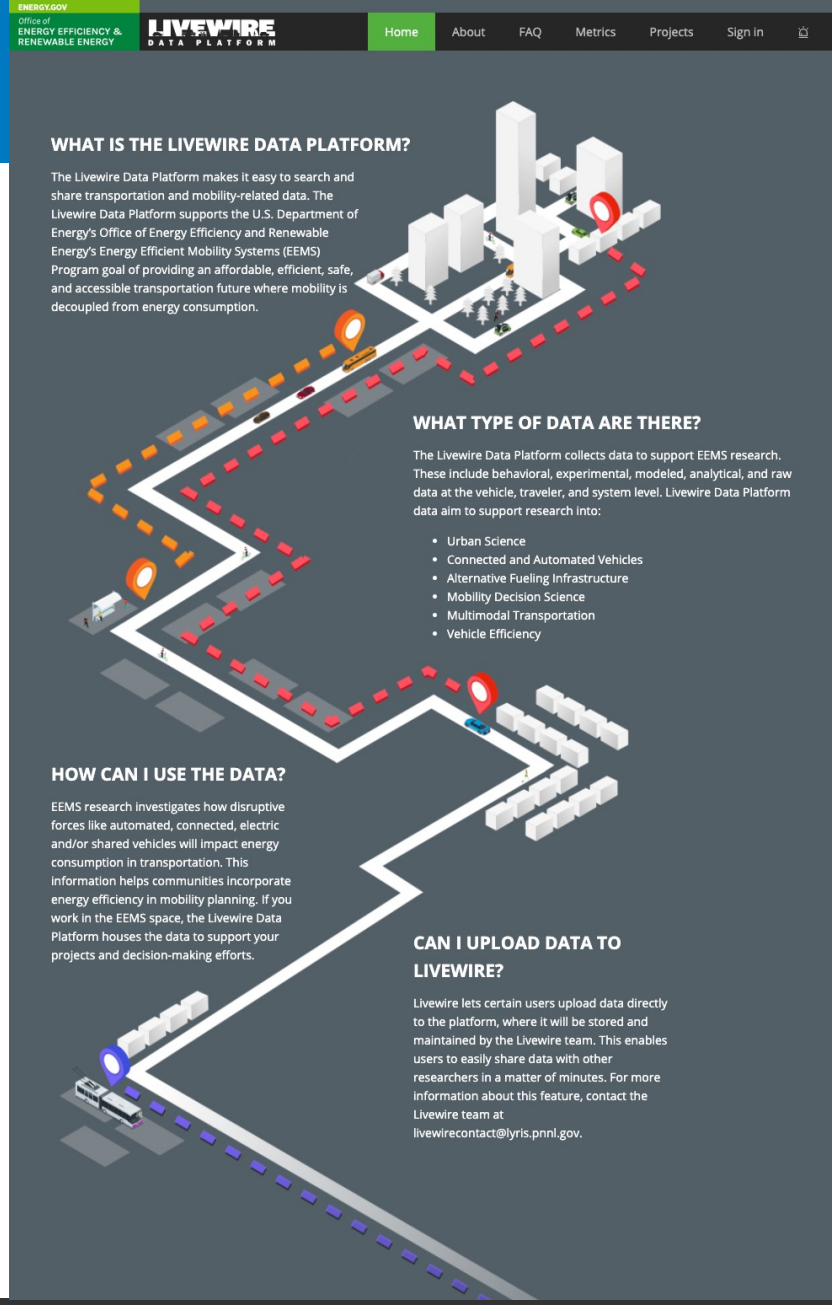
Relevance – What is Livewire?

- **A platform for sharing, preserving, and discovering energy efficiency and mobility research data**
- Growing catalog of transportation and mobility-related data funded by VTO and maintained by experts at NREL, INL, and PNNL

Livewire addresses technical and cultural challenges to enable research, collaboration, and data sharing by providing state-of-the-art data management capabilities and services

livewire.energy.gov

- The Livewire Data Platform (LDP) enables **secure data management**, an essential part of DOE's research infrastructure
  - Lower costs, better management capabilities, reduction of silos, improved research
  - Shared resources and insights

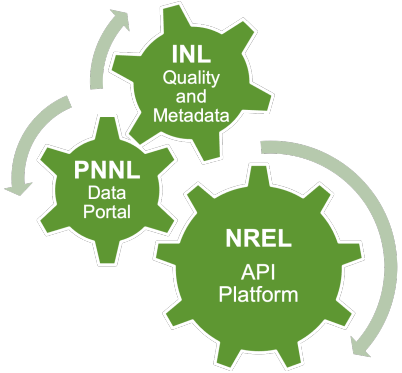


Milestones

*Milestone Name/Description	*Due Date	*Type
(PNNL) To ensure that users with the right privileges have access to the Tier 3 (restricted) datasets, implement quarterly validation of users for Tier 3 (restricted) data.	12/31/22	Quarterly Progress Measure (Regular)
(INL) Identify one or more potential platform enhancements and their impact for platform users enabled by low-level (detailed) metadata being produced for each dataset within the Livewire catalog	12/31/22	Quarterly Progress Measure (Regular)
(NREL, INL) Develop reference document categories and update existing docs associated with datasets	3/31/23	Quarterly Progress Measure (Regular)
(INL) Data quality characterization: Continue expanding the low-level metadata and quality characterization coverage of datasets within the platform catalog, assisting platform users in dataset selection and enabling additional platform capabilities.	3/31/23	Quarterly Progress Measure (Regular)
(PNNL, INL, NREL) Design a capability for users with editor privileges to add and update reference documents to datasets, ensuring that supporting and supplementary materials are current.	6/30/23	Quarterly Progress Measure (Regular)
(NREL, PNNL) Create a template for and deliver inaugural quarterly email newsletter informing users of platform and data feature updates	6/30/23	Quarterly Progress Measure (Regular)
(INL) Data quality characterization: Continue expanding the low-level metadata and quality characterization coverage of datasets within the platform catalog, assisting platform users in dataset selection and enabling additional platform capabilities.	9/30/23	Quarterly Progress Measure (Regular)
(PNNL) Publications database (which includes newsletters as pub type)	9/30/23	Quarterly Progress Measure (Regular)
(PNNL, INL) Demonstrate progress on implementation of one or more platform enhancements (from the list developed in FY 2023 Q1) enabled by having low-level (detailed) metadata for datasets in the Livewire catalog.	9/30/23	Quarterly Progress Measure (Regular)
(NREL - TSDC) Summarize TSDC activities—demonstrating steady growth in included datasets, data users, and publications enabled by access to TSDC-hosted data.	9/30/23	Annual Milestone (Regular)
(NREL) Fleet DNA – Connect NCVDF and Livewire data platforms to enhance both DOE funded activities.	9/30/23	Annual Milestone (Regular)
(PNNL, INL, NREL) Enhance the Livewire Data Platform to support cross-federation of datasets to/from other similar catalogs (e.g., DOT's data.transportation.gov), providing an expansion of the datasets listed within each catalog; broadening exposure of DOE's research projects, resulting data, and publications; and facilitating expanded opportunities for mobility research across Federal agencies.	9/30/23	Annual Milestone (Stretch)
GO/NO GO		
(NREL, PNNL, INL) Add datasets at each permission level: Tier 1 (Open) – 3 datasets; Tier 2 (Privileged) – 5 datasets; Tier 3 (Restricted) – 1 dataset	3/31/23	Go/No-Go

Approach

- **Leverage experience building successful data platforms**
- Multi-pronged approach focuses on:
  - Platform development and security
  - Data quality characterization
  - Catalog growth
  - User support



- Core services and platform capabilities include:
  - Free, secure data storage
  - Access management that allows data owners to control who sees their data
  - Data collection and preservation
  - Quality characterization
  - Detailed access and download metrics
  - Increased visibility of projects and data
- Ongoing support of foundational Transportation Secure Data Center (TSDC) and Fleet DNA data capabilities
- Livewire Data Working Group (DWG) was established in 2021 to provide a forum for feedback and input from data owners and data users

Technical Accomplishments and Progress

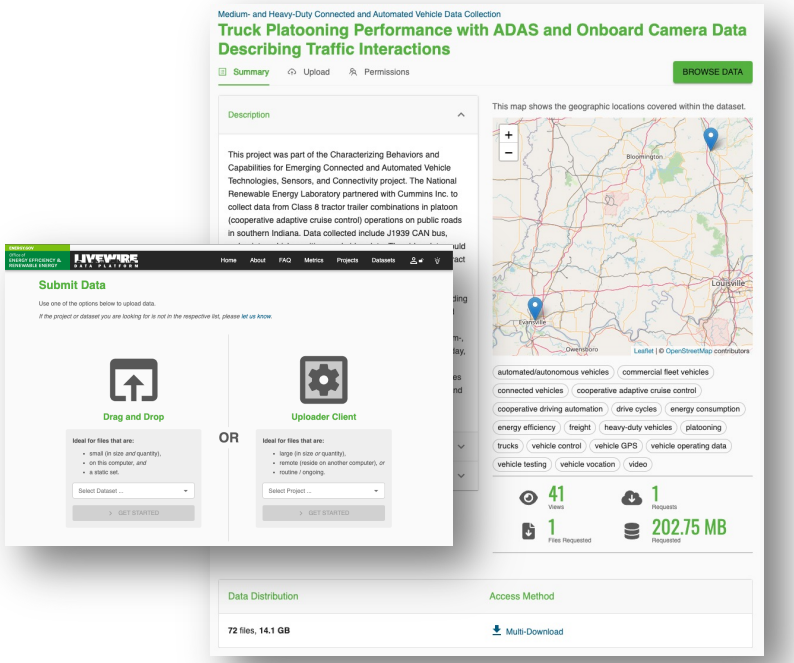
- Enabled **self-service upload capability** for large and/or ongoing data (**FY22 Q3 milestone**)

- Automated a method to **validate that each user with access to a Tier 3 dataset** still belongs to the institution that signed the NDA (**FY23 Q1 milestone**)
  - A user with access to Tier 3 (2FA restricted) datasets will see a banner on every website page after logging in with instructions to re-validate email address
  - The expiring link in the email will reset the "last verified" date of the user's account
  - Access to Tier 3 (2FA restricted) datasets is restored for next three months

- Wrote a **whitepaper** describing example platform enhancements (**FY23 Q1 milestone**)
  - Expand/extend platform's search capability
  - Expose additional dataset attributes in UI
  - Include dataset viz (e.g., maps, trends) in UI
  - Add query capability for dataset exploration
  - Evolve toward a combined LDP data resource

- Developed **reference document categories** and categorized all references within Livewire catalog (**FY23 Q2 milestone**)
  - Reviewed references listed in complete Livewire catalog
  - Developed/documented initial set of 13 categories of references
  - Updated Livewire platform's schema to support assignment of category to each reference
  - Updated complete Livewire catalog to categorize all references

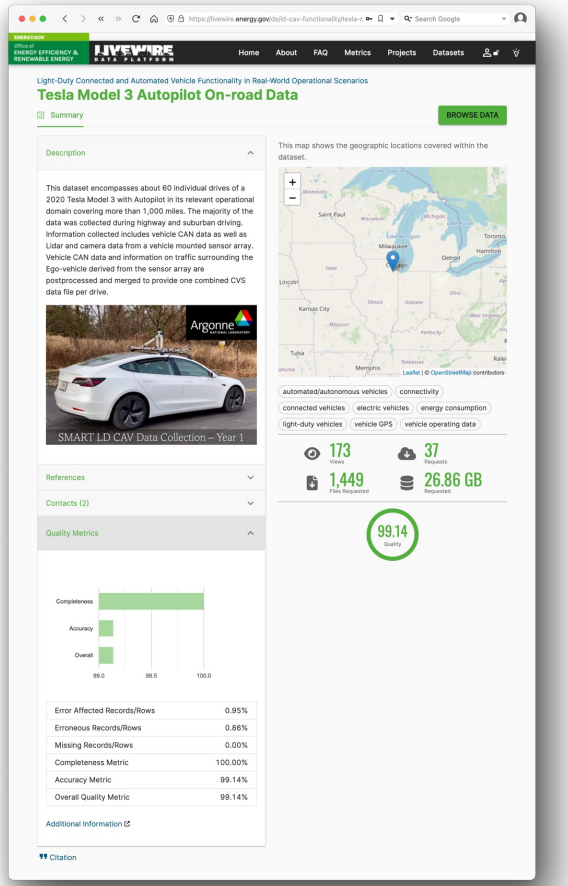
Impact: Enables additional UI capabilities to assist users in locating useful datasets and supporting references; enables significant UI expansion for data owners to manage references and publications for their projects within Livewire



"We uploaded our SMART CAV data to Livewire using the uploader client. The client was easy to use and made setting up the schema for selecting files very simple. It allowed us to easily upload over 70 files and share them with our DOE/ANL team to meet a quarterly milestone. Without the client, manually uploading the approx. 15 GB of data would have taken a lot more time, taking time away from other parts of this project."

- Tyler Christenson, Medium- and Heavy-Duty Connected and Automated Vehicle Data Collection

Technical Accomplishments and Progress



Transportation.gov
U.S. Department of Transportation

- Published **detailed metadata and quality characterization** for 32 datasets (**FY23 Q2 milestone**)
  - Objective analysis of dataset for completeness, statistical outliers, likely errors, and impact of likely errors

  Impact: Assists platform users in dataset selection and enables additional platform capabilities

- Launched ability to collect publications and make them discoverable through a Livewire **publications database** (**FY23 Q4 milestone**)

- Engaged in ongoing collaboration with the Fleet DNA team to scope and develop a way to connect Livewire and the **National Commercial Vehicle Data Framework** (NCVDF) (**FY23 Q4 milestone**)

  Impact: Leverage work done to enhance both DOE-funded activities

- Added data to the TSDC, including from e-bike studies and under a new **transit survey branch launched in collaboration with FTA**

- Enabled Livewire to **support cross-federation of datasets** to/from other similar catalogs (e.g., DOT's data.transportation.gov) (**FY23 Stretch milestone**)

  Impact: Broadens exposure of DOE's research projects, resulting data, and publications; and facilitates expanded opportunities for mobility research across Federal agencies

- Saw an **increase in all usage** metrics in FY23 Q2
  - Number of projects
  - Number of users
  - GB stored
  - Number of datasets
  - Number of files stored

Responses to Previous Year Reviewers' Comments

- …the overall addition of datasets seems to be relatively modest after more than 3 years into the project.
- The project appears to have been slow off the mark in identifying and expanding collaboration and coordination with other potential user entities. This may have been a leading reason Livewire has seen relatively limited use to date.

In years 1-3, access to Livewire was restricted to members of the EEMS research community. This limited both the number of users and pool of data that could be shared and accessed on Livewire. Increased attendance at relevant meetings (e.g. Annual Merit Review, Transportation Research Board Annual Meeting) and outreach efforts (e.g. webinars and demos) are helping the Livewire team identify and pursue potential users and data.

- It might also be useful to consider explicit targeted outreach of data resources where the team identifies a need (e.g., for policy actors, equity considerations, etc.).

The Livewire Data Working Group will convene in FY23 to identify data priorities for the Livewire team to pursue.

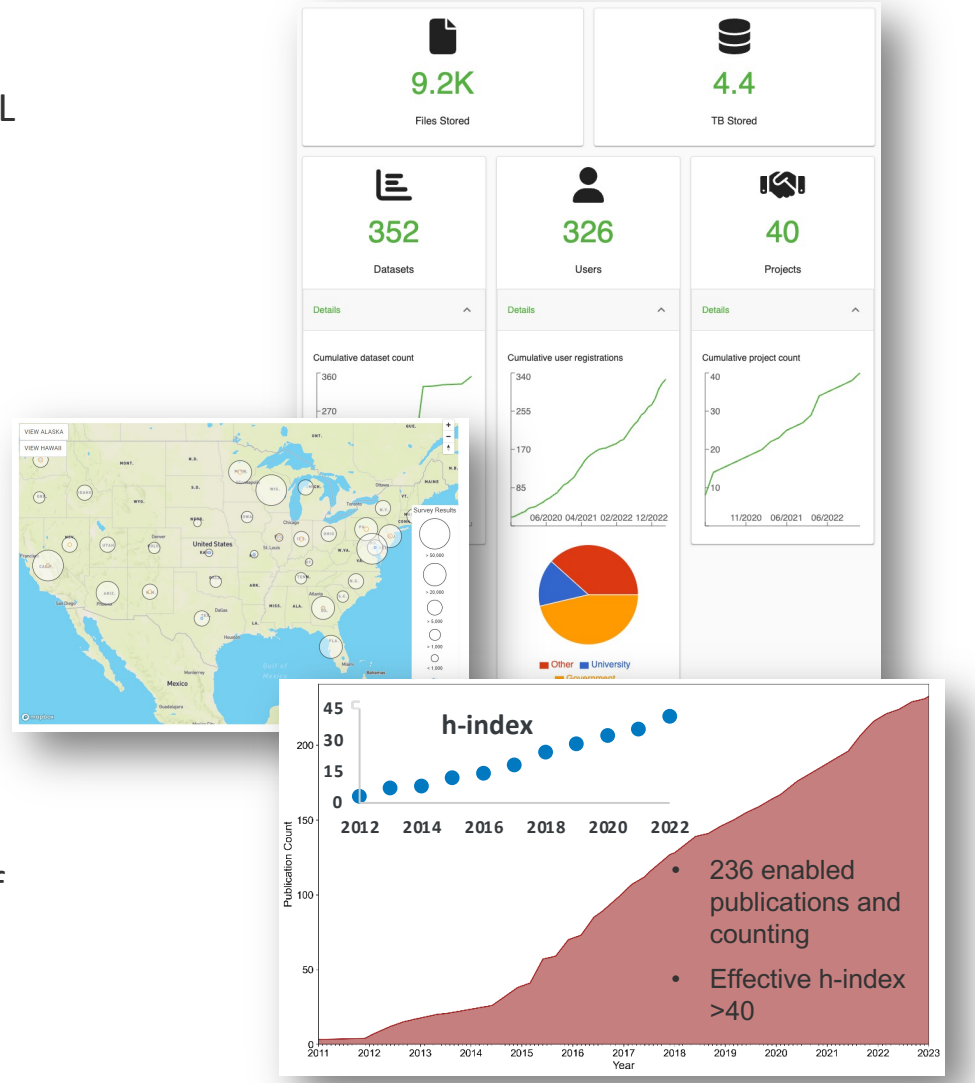
- …the metrics to truly gauge project success do not appear to have been comprehensively established.
- Additional work is needed to further clarify and substantiate metrics to conclusively determine (or not) Livewire's value.

The Livewire team developed three types of metrics to demonstrate growth. These were agreed upon at the June 2020 Go/No-Go decision and reported on quarterly.

	Usage	Engagement	Impact
	Quantifiable metrics that show how many users, projects, etc.	Shows how users engage with Livewire and will vary based on researcher needs, project requirements, and funding.	Demonstrates how Livewire has enabled a project or person to achieve a goal they could not have without Livewire.
What is measured	• Files stored; GB stored; Number of datasets; Number of users; Number of projects	• API hits; API users; Pageviews; Web User; Datasets downloaded; Size of files downloaded; Number of users downloading data; Number of files downloaded	• Written testimonial about the platform from Livewire user
Reporting commitment	Demonstrate quarterly growth on at least one usage metric	Demonstrate quarterly growth on at least two engagement metrics	Provide one quarterly impact testimonial about the platform.

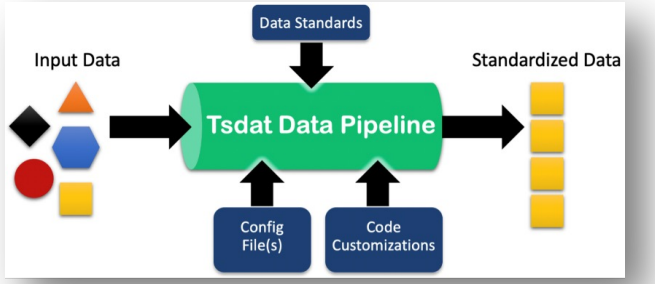
Collaboration and Coordination

- **Collaboration is essential to Livewire's success**
  - Strong collaboration within Livewire project team from INL, NREL, and PNNL
  - Partnership with EEMS, SMART, and TI
  - Growth helped by listening, outreach, and word of mouth
- **Livewire Data Working Group** established to help identify platform and data needs
- Continued **collaboration with DOT** for cross-catalog federation
- Project and data needs drive feature development and capabilities
  - Livewire team works closely with project teams and provides **ongoing support**
- Data on Livewire and Livewire users come from more than 60 organizations, DOE, national labs, and **many research partners** including:
  - CALSTART, Energetics, American Center for Mobility, National Association of State Energy Officials, Carnegie Mellon University, INRIX, Argonne National Lab, Lawrence Berkeley National Laboratory, Virginia Tech Transportation Institute



Remaining Challenges and Barriers & Proposed Future Research

Challenge	Proposed Future Research
Low level (detailed) metadata inside files is not standardized	Develop a pipeline to standardize and curate metadata and data
Manual processes for creating and submitting high level (descriptive) metadata are time and labor intensive	Create methods for project owners and editors to submit required information through the platform itself



Example data pipeline

Impact: Enables analysis closer to data instead of the traditional method of downloading and then analyzing data; reduce technical and/or cultural barriers to sharing data; enable platform enhancements; and move Livewire closer to a shared data resource and the next stage of data management

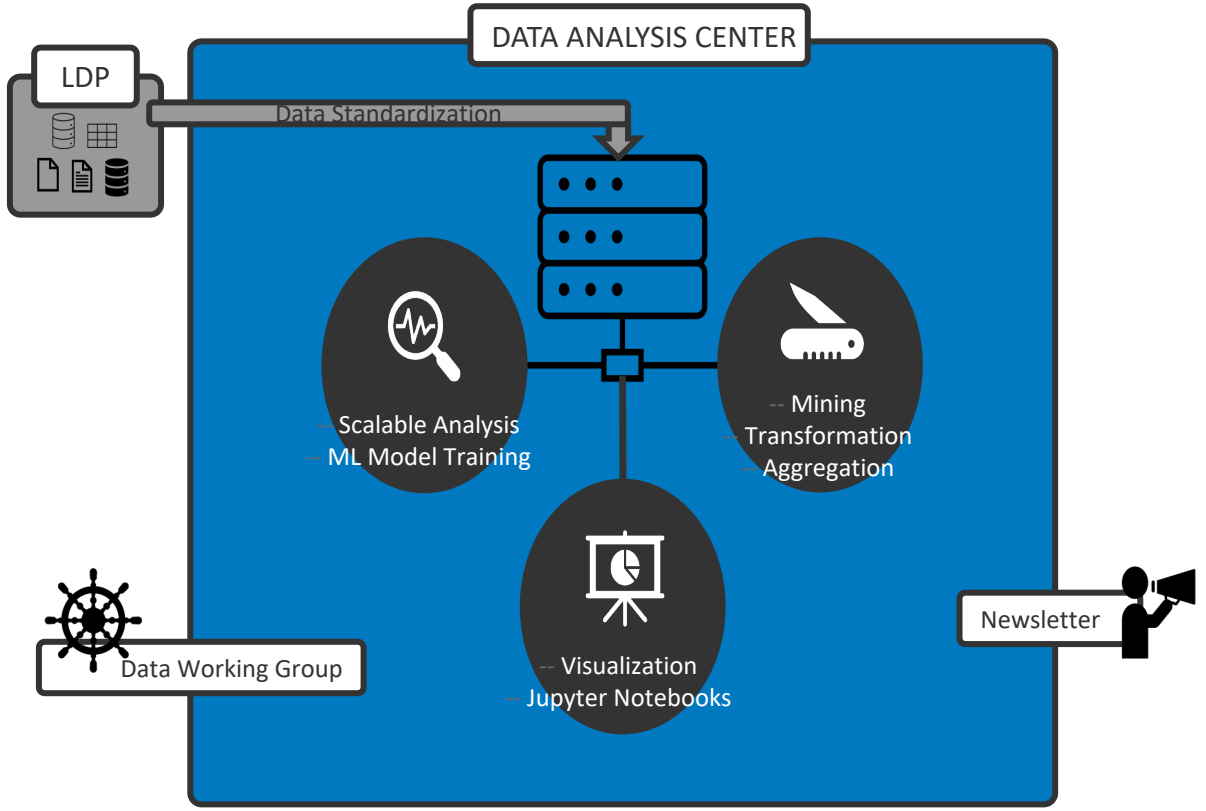
- **Other proposed future research:**
  - Integrate new reference categories into UI and design a capability for users with editor privileges to add and update reference documents to datasets, ensuring that supporting and supplementary materials are current (**FY23 Q3 milestone**)
  - Create a template for and deliver inaugural quarterly email newsletter informing users of platform and data feature updates (**FY23 Q3 milestone**)
  - Demonstrate progress on implementation of one or more platform enhancements from the list developed in FY23 Q1 (**FY23 Q4 milestone**)
  - Continue to add low level metadata and quality analysis, approaching complete dataset coverage by end of FY 2024
  - Add to collection of **cross-federated data** from data.transportation.gov and other repositories
  - Demonstrate growth and continued impact of **TSDC** and **Fleet DNA**

Any proposed future work is subject to change based on funding levels.

Proposed Future Research

Data Analysis Center

- A data processing pipeline that **automatically** ingests data; cleans, curates, and standardizes data based on the metadata schema developed in the project;)
- **Reuse** of data processing pipeline for multiple datasets irrespective of data source
- Support for **real-time data streaming and visualization**
- Enhanced **user insights** into time-series data, such as filtering by measurements of interest and time span without the need to download the entire dataset.



Any proposed future work is subject to change based on funding levels.

Summary

- Livewire leverages over **30 years** of experience from experts at **three national labs** to enable sharing, discovery, and preservation of transportation and mobility data
- Provides **easy** and **secure** access to a continuously growing catalog of energy efficiency and mobility data influenced by user input from the Livewire Data Working Group
- Livewire can support **proprietary data** and **NDAs**; data owners **control who can access** their data
- Livewire **removes barriers** to researchers finding and sharing the data they need *and* produce in answering important transportation questions
- Supports DOE and partner research to **reduce energy consumption, improve mobility access**, and **accelerate decarbonization** of the transportation sector by shifting the burden of data management to LDP
- Visit Livewire at https://livewire.energy.gov/

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This work was authored in part by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Vehicle Technologies Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

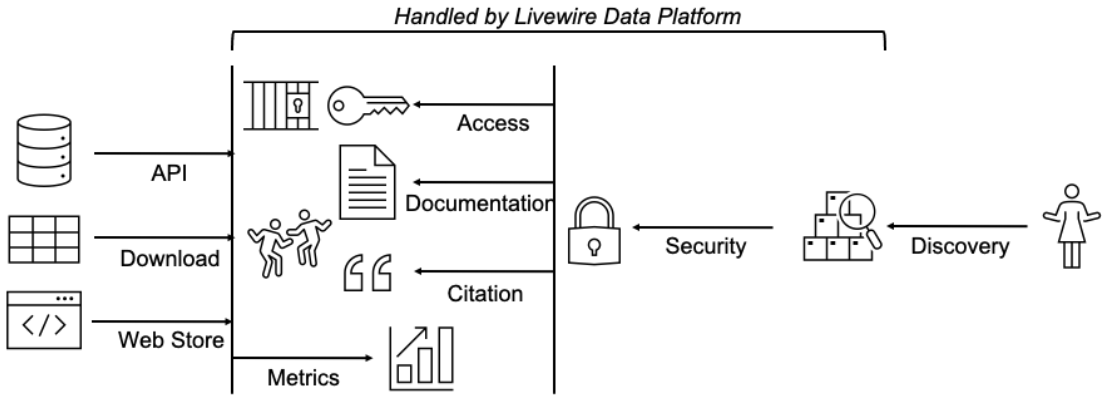
Technical Backup Slides

(Include this divider slide if you are including backup technical slides [maximum of five]. These backup technical slides will be available for your presentation and will be included in web PDF files released to the public.)

Core services and benefits of sharing data via Livewire

- Storage
  - Livewire can host up to 10 TB of data per project at no cost, but also supports other methods for sharing data
- Secure data platform
  - Livewire adheres to federal security standards, handles authorization and authentication
- Access management and control
  - Data owners can restrict at project or dataset level
  - Can store data that requires NDA
- Detailed metrics on downloads and API usage

- Increased visibility of projects and data
  - Livewire can display digital object identifiers
  - Livewire can provide citation guidance/standard language



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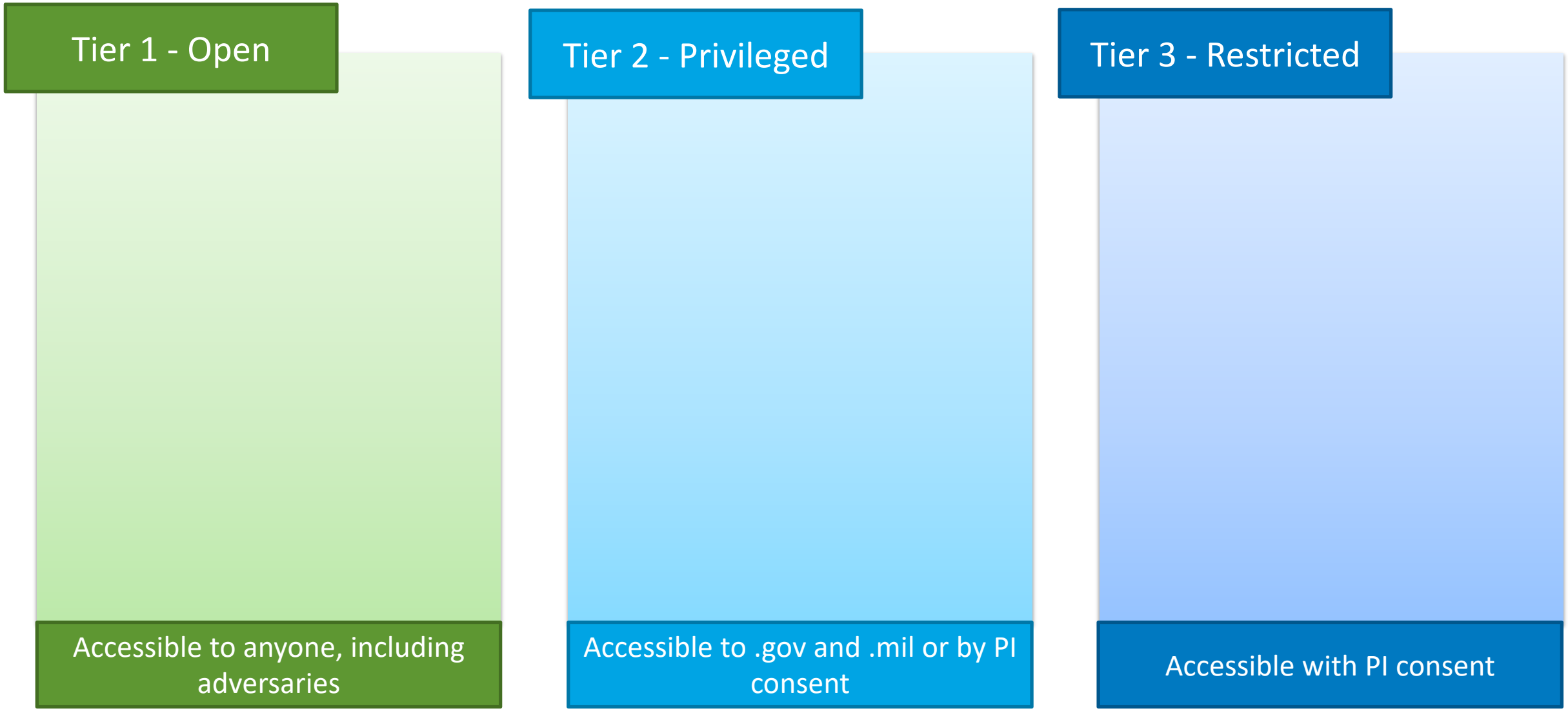


Additional Accomplishments: Scope and Growth of the TSDC

TSDC

Includes hundreds of surveys / studies and millions of miles of travel data from across the U.S.

Cleansed Data ›

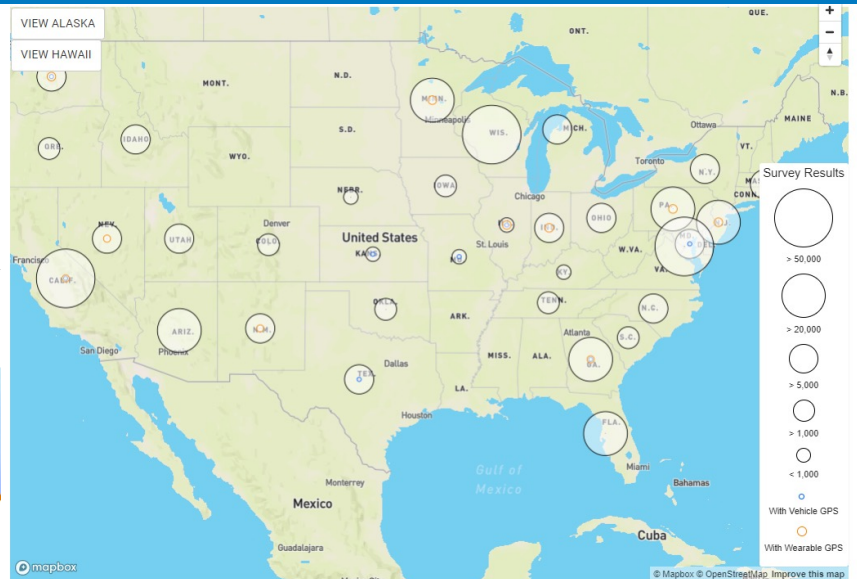
Easily search, filter, and browse data from hundreds of U.S. transportation studies and surveys.

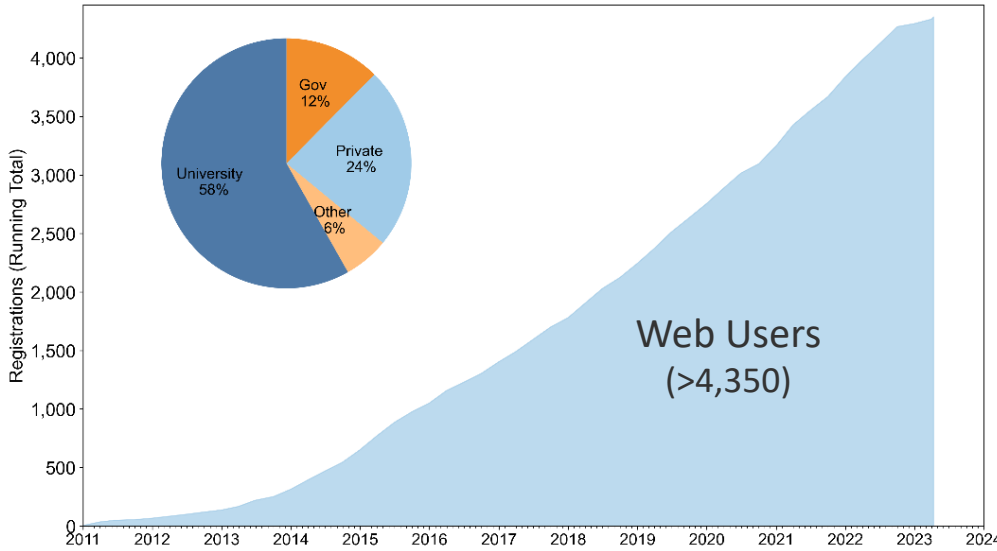
Household Travel Data

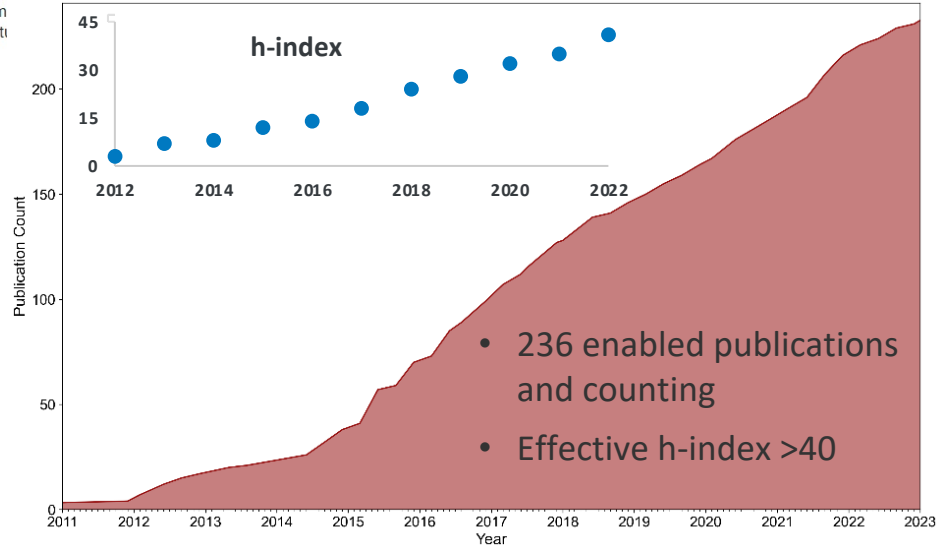
Transit Passenger Data

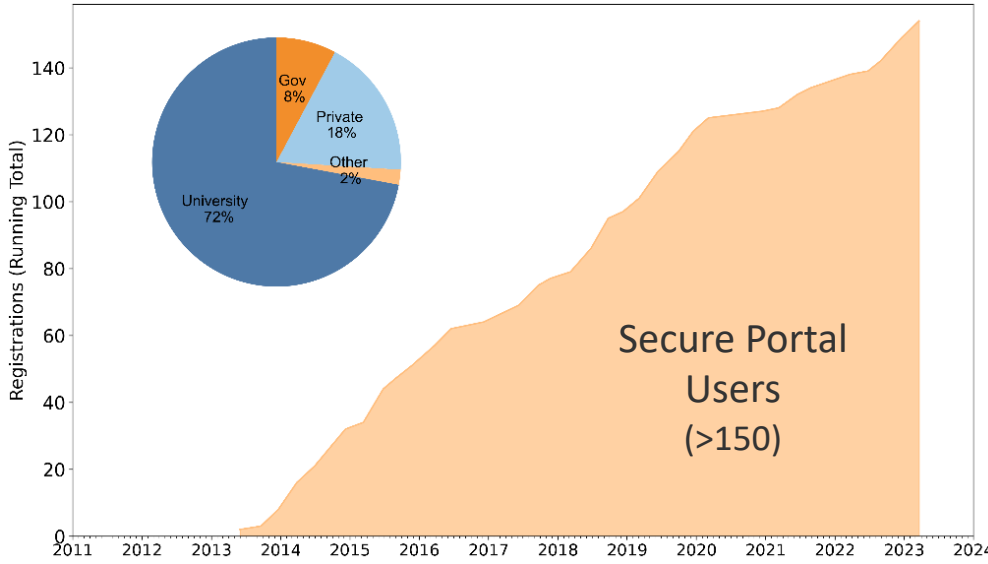
Spatial Data ›

An application is required to access latitude and longitude spatial data from transportation sti and surveys.









2023

1. Planning for Electric Vehicles Coupled With Urban Mobility
   Authors: Yanyan Xu, Serdar Colak, Emre C. Kara, Scott J. Moura, and Marta C. Gonzalez
   Report: Massachusetts Institute of Technology (March 2023)
2. Preferences for Zero-Emission Vehicle Attributes: Comparing Early Adopters With Mainstream Consumers in California
   Authors: Wenjian Jia, Zhiqiu Jiang, Qian Wang, Bin Xu, and Mei Xiao
   Journal: *Transport Policy* (March 2023)
3. Modelling and Analysis of Electric Two-Wheeler With Novel Planetary Gear Box Transmission
   Authors: Aditya Paranjape, Amey Kulkarni, Mihir Kulkarni, and Neeraj Kumbhojkar
   Journal: *International Journal of Electric and Hybrid Vehicles* (February 2023)
4. Modeling Vehicle-Miles of Travel Accounting for Latent Heterogeneity
   Authors: Fatemeh Nazari and Abolfazl (Kouros) Mohammadia
   Journal: *Transport Policy* (January 2023)
5. Assessing the Potential Impacts of Toll Discounts on Zero-Emission Vehicle Adoption
   Authors: Adam Wilkinson Davis, Joshua Stark, and Juan Carlos Garcia Sanchez
   Report: National Center for Sustainable Transportation (January 2023)

2022

1. Impact of Battery Cell Imbalance on Electric Vehicle Range
   Authors: Jun Chen, Zhaodong Zhou, Ziwei Zhou, Xia Wang, and Boryann Liaw
   Journal: *Green Energy and Intelligent Transportation* (December 2022)
2. Quantifying the Impact of Transportation on Climate – Energy Analytics Dashboard
   Authors: M.L. Franz, Stanley Young, Jeffrey Cappellucci, C. Xiong, Jake Holden, and W. Zhou
   Conference: Intelligent Transportation Society World Congress (October 2022)
3. A Bifurcation of the Peak: New Patterns of Traffic Peaking During the COVID-19 Era
   Authors: Yang Gao and David Levinson

LIVEWIRE DATA PLATFORM

Additional Accomplishments: Fleet DNA

- Established in 2002, Fleet DNA is NREL's database of in-use data for commercial vehicle operation capturing over 15 million miles of second-by-second vehicle and engine data
- Previous Livewire efforts include the addition of 105 Fleet DNA datasets to Livewire and establishing the basis for the modern Fleet DNA relational database
- The National Commercial Vehicle Data Framework (NCVDF) is an ongoing effort to capture and support commercial vehicle R&D efforts through a better understanding of energy use segments, dynamic market trends, vocational performance requirements, and technology impacts across a range of MD/HD applications