



Visualization within the Department of Energy: NREL IEEE VIS Application Spotlight

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NATIONAL RENEWABLE ENERGY LABORATORY



Foundational Science
Biological Systems Science
Materials Science
Computational Science and Visualization



Renewable Power
Geothermal
Solar
Water
Wind



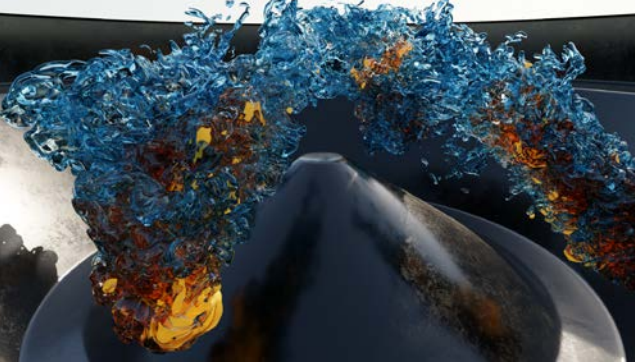
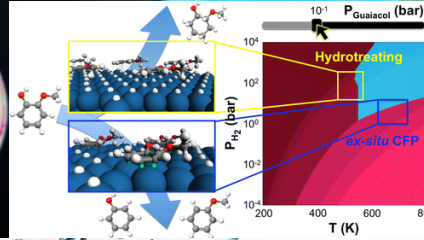
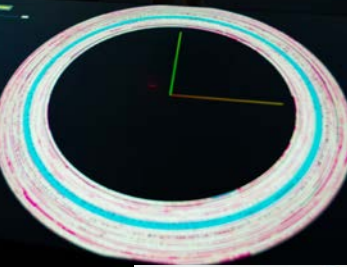
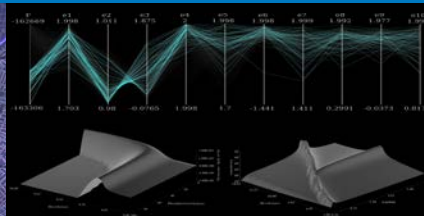
Sustainable Transportation
Bioenergy
Hydrogen and Fuel Cells
Transportation and Mobility



Energy Efficiency
Advanced Manufacturing
Buildings
State, Local, and Tribal Governments

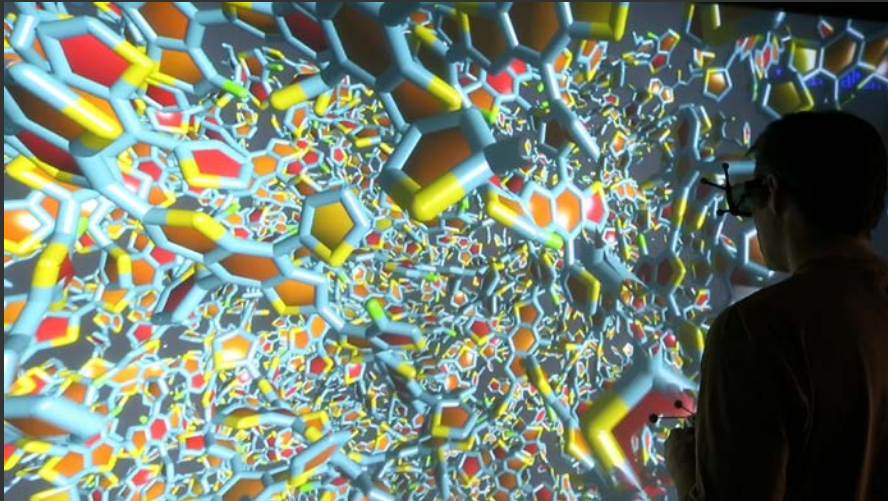


Energy Systems Integration
Energy Security and Resilience
Grid Modernization
Integrated Energy Solutions



IMMERSIVE VISUALIZATION

An environment created with a combination of hardware and software that provides the user with a psycho-physical experience of being immersed in a computer-generated scene.



- Immersive Particle Advection through the Scales of Renewable Energy (Brunhart-Lupo & Gruchalla 2023)
- Immersive Industrialized Construction Environments for Energy Efficiency Construction Workforce (Podder, et al. 2022)
- Collaborative Exploration of Scientific Datasets using Immersive and Statistical Visualization (Brunhart-Lupo, et al. 2020)
- The Utility of Virtual Reality for Science and Engineering (Gruchalla & Brunhart-Lupo 2019)



IMMERSIVE ANALYTICS

Facilitate the exploration of high-dimensional or multivariate data, uncovering patterns, correlations, and trends that might be obscured in traditional 2D representations.



- Collaborative Exploration of Scientific Datasets using Immersive and Statistical Visualization (Brunhart-Lupo, et al. 2020)
- The Utility of Virtual Reality for Science and Engineering (Gruchalla & Brunhart-Lupo 2019)
- Enabling Immersive Engagement in Energy System Models with Deep Learning (Bugbee, et al. 2019)
- Simulation Exploration through Immersive Parallel Planes (Brunhart-Lupo, et al. 2016)



HIGH-RESOLUTION VISUALIZATION

Enables the simultaneous exploration of both the context and details, offering fidelity at multiple scales to support comprehensive analysis of complex datasets.

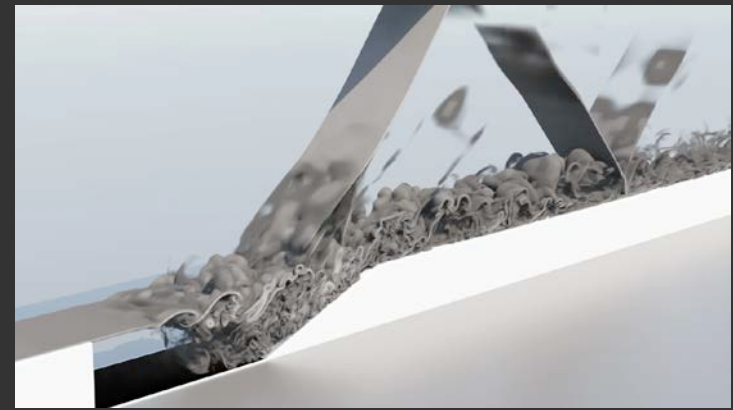
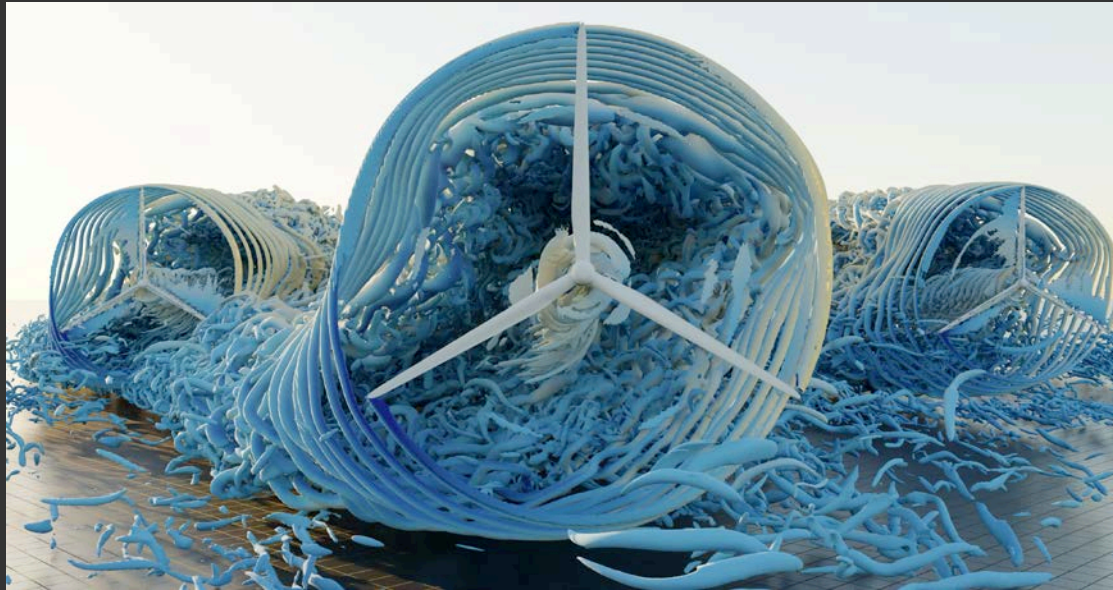


- Architecture for Web-Based Visualization of Large-Scale Energy Domains (Johnson, et al. 2024)
- Visualization of the Eastern Renewable Generation Integration Study (Gruchalla, et al. 2016)



FLOW ANALYSIS

Visual the exploration and interpretation of computational fluid dynamics data to reveal flow patterns, turbulence, and other fluid behaviors critical for engineering and scientific insights.

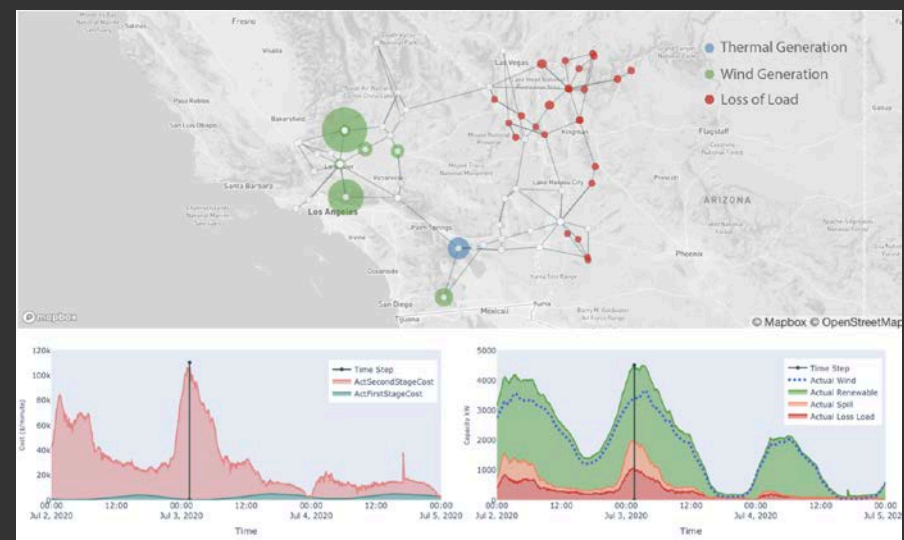
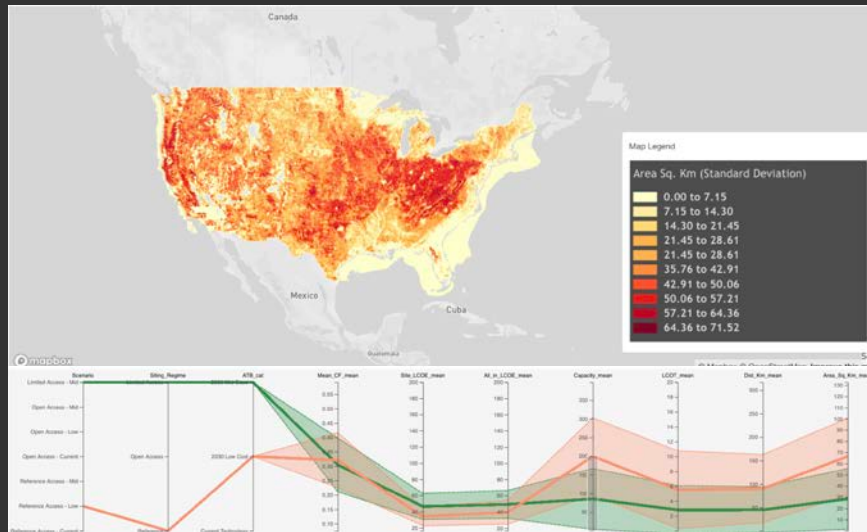


- ExaWind at NREL: Upping the Ante (Brunhart-Lupo & Sharma 2023)
- Immersive Particle Advection through the Scales of Renewable Energy (Brunhart-Lupo & Gruchalla 2023)
- Visualizations of direct fuel injection effects in a supersonic cavity flameholder (Sitaraman, et al. 2021)
- Blade-Resolved, Single-Turbine Simulations Under Atmospheric Flow (Lawson, et al. 2019)
- A simulation study demonstrating the importance of large-scale trailing vortices in wake steering (Fleming, et al, 2018)



UNCERTAINTY VISUALIZATION

Empower decision-making under uncertainty by clearly depicting data variability and uncertainty, helping users weigh options and make informed choices.

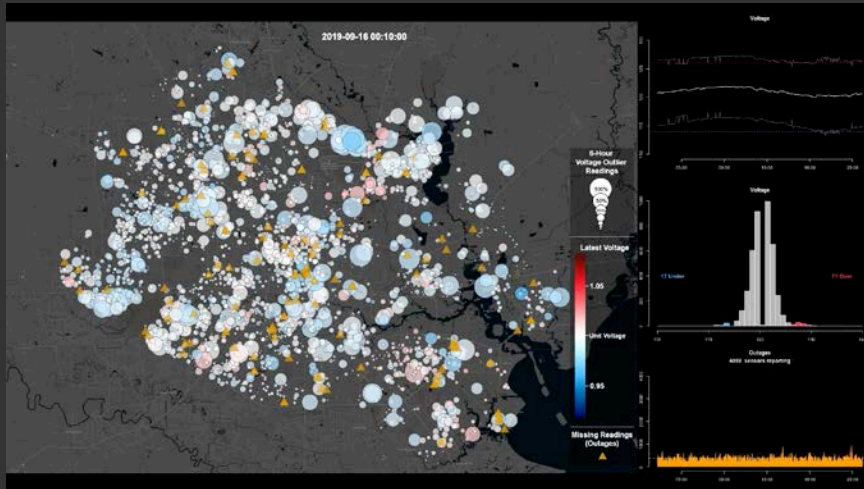
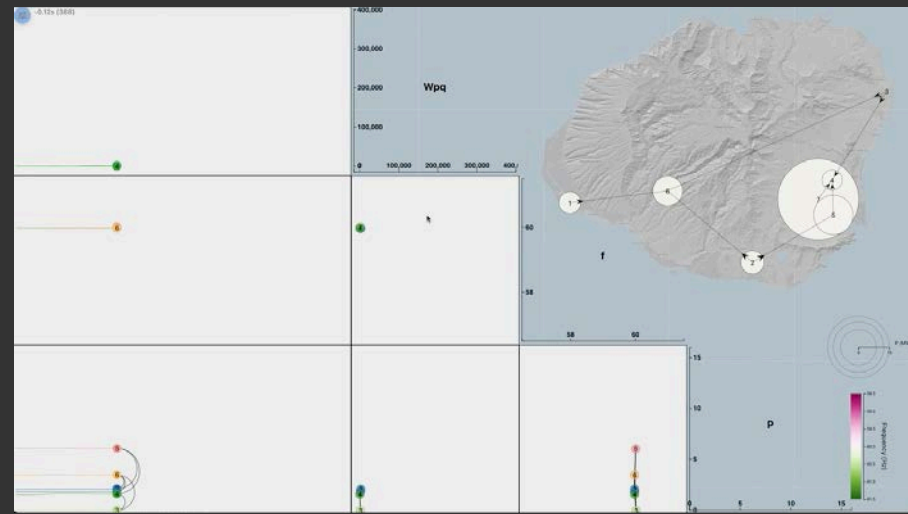


- Uncertainty Visualization Challenges in Decision Systems with Ensemble Data & Surrogate Models (Molnar et al. 2024)
- Opportunities and Challenges in the Visualization of Energy Scenarios for Decision-Making (Molnar, et al. 2024)
- Uncertainty Visualization for Renewable Energy Potential (Diaz, et al. 2021)
- Visualization of Multi-Fidelity Approximations of Stochastic Economic Dispatch (Panda, et al. 2021)



LABORATORY & FIELD DATA ANALYSIS

Facilitates the analysis of data collected from controlled laboratory settings or field sensors enabling data-driven analysis and insights.



- Vis-SAGA: Visual Analytics for Situational Awareness of Grid Anomalies (Johnson, et al. 2023)
- Visualization of the Oscillatory Dynamics of an Island Power System (Molnar, et al. 2023)
- Analysis of application power and schedule composition in a high-performance computing environment (Elmore, et al. 2016)



DIGITAL TWINS

Interactive, virtual replicas of physical systems, enabling monitoring, analysis, and scenario testing to enhance understanding and inform decision-making in complex environments.

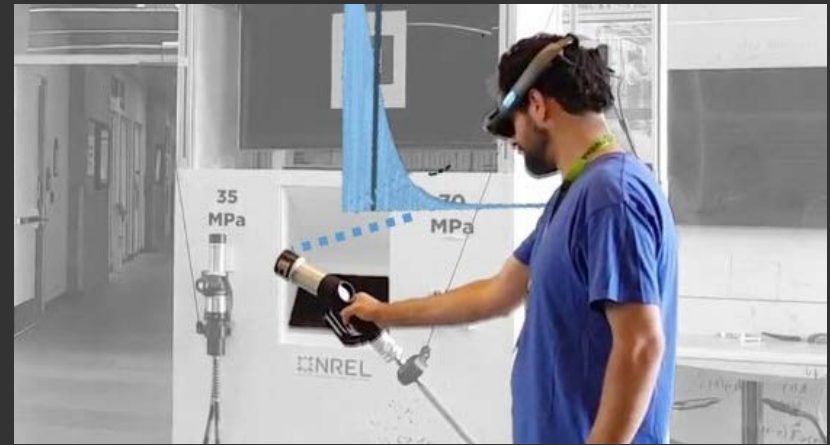


- Immersive Industrialized Construction Environments for Energy Efficiency Construction Workforce (Podder, et al. 2022)
- The Utility of Virtual Reality for Science and Engineering. (Gruchalla & Bruhart-Lupo 2019)
- Enabling Immersive Engagement in Energy System Models with Deep Learning (Bugbee, et al. 2019)
- Coupling Visualization, Simulation, and Deep Learning for Ensemble Steering of Complex Energy Models (Bush, et al. 2016)



SITUATED VISUALIZATION

Data visualizations situated in the physical environment, enabling users to interact with and interpret visualized information in context, enhancing real-time decision-making and understanding.

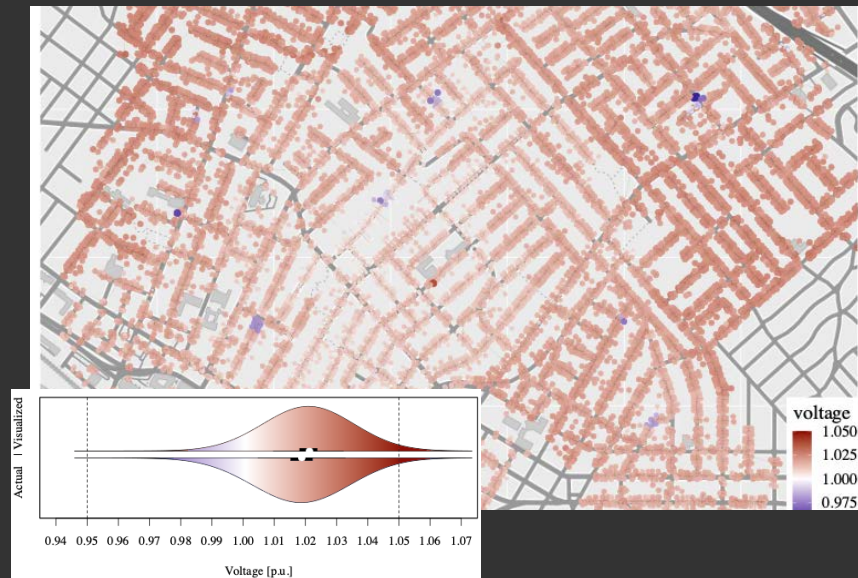
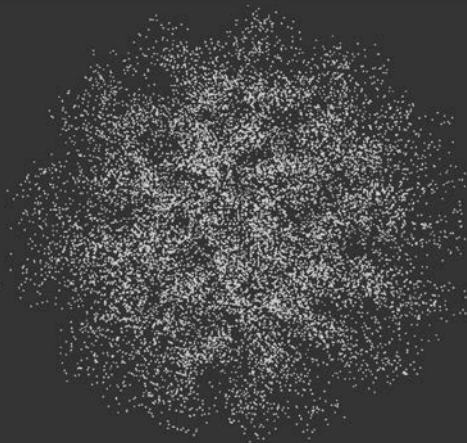


- Situated Visualization of Photovoltaic Module Performance for Workforce Development (Brunhart-Lupo, et al. 2024)
- Machine Learning for Advanced Building Construction (Eagan, et al. 2023)
- Learning and Tracking Ad Hoc Fiducial Markers in Spatial Augmented Reality (Gould, et al. 2021)
- HydrogenAR: Interactive Data-Driven Presentation of Dispenser Reliability (Whitlock, et al. 2020)



PERCEPTION & COGNITION

Fundamental research exploring how visual representations influence human understanding and decision-making, optimizing data presentation to enhance cognitive processing and improve insight extraction.



- Alternatives to Contour Visualizations for Power Systems Data (Lyons-Galante, et al. 2023)
- Reevaluating contour visualizations for power systems data (Gruchalla, et al. 2023)
- Structure Perception in 3D Point Clouds (Gruchalla, et al. 2021)



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