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Digital Twin Platform for 24/7 Carbon-Free Electrified Fleet Operations

Stanford researchers have developed a software platform featuring an integrated digital twin framework to enable 24/7, carbon-free operations of electric vehicle (EV) fleets. The platform intelligently coordinates vehicle charging schedules, route assignments, and energy resource management by leveraging on-site solar, battery storage, and real-time grid emissions data to eliminate carbon emissions while minimizing costs.

Electrification of transportation is critical for decarbonization, yet current EV charging often relies on grid electricity that is not carbon-free 24/7. The Stanford platform addresses this by forecasting grid emissions, solar availability, and vehicle energy needs to optimally schedule fleet operations. A built-in optimization engine then coordinates charging, discharging, and route assignments in a cost-effective, emissions-aware manner.

Validated on extensive real-world data from Stanford's Marguerite Shuttle system, the platform demonstrated the ability to reduce peak power demand by 99%, carbon emissions by 100%, and operating costs by thousands of dollars per week. Designed for scalability and real-world implementation, it offers transit agencies, corporate campuses, and municipalities a path to affordable, resilient, and fully decarbonized transportation.

Stage of Development
Proof of concept — simulated and field-tested with real-world operational data.

Applications

- Public and corporate EV fleet decarbonization

- Smart energy scheduling software for fleet operators
- Municipal and campus sustainability initiatives

Advantages

- Outperforms existing platforms by optimizing for both carbon emissions and energy costs
- Enables true 24/7 carbon-free EV operations
- Reduces electricity costs, emissions, and charging demands
- Integrates with existing solar, storage, and fleet systems

Publications

- Luke, J., de Castro Ribeiro, M.G., Martin, S., *et al.* (2025). Optimal coordination of electric buses and battery storage for achieving a 24/7 carbon-free electrified fleet. *Applied Energy*, **377** *(Part C)*, 124506.

Patents

- Published Application: 20250117720

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