WHO WE ARE
Argonne is a Member of U.S. DOE’s National Laboratory Complex
Argonne’s Center for Transportation Research

Multi-Physics Computation
- CFD Engine Combustion
- Exascale Computational Modeling

Vehicle and Mobility Systems
- Vehicle PT Energy & Controls
- Transportation System Models, ABM

AVTC Student Competitions
- EcoCAR Mobility Challenge
- Advanced Powertrain, ADAS Innovation, STEM Outreach

Basic & Applied Combustion
- LD/HD Fundamental Research
- Fuels and Aftertreatment
- Adv. Photon Source Fuel Spray

Advanced Mobility Technology Laboratory
- EEMS Technology Assessment, CAVs
- Vehicle, Component, System Evaluations

Advanced Mobility and Grid Integration Technology Research

EV-Smart Grid Interoperability
- Vehicle - EVSE – Grid Interactions
- Hardware, Software, Communication Prototyping
Breath of R&D at the SMART ENERGY PLAZA

- Vehicle-grid integration
  - Open source approach to benefit both customers and providers
- Test requirements and procedures for high power charging
  - Interoperability, cybersecurity and safety
- Enabling technologies and tools
  - Hardware and software for charging and integration with buildings
  - Diagnostic test equipment

Real-time power flow visualization

Diagnostic EV Adaptor (DEVA)

Low cost sub-meter (EUMD)
LIGHT-DUTY VEHICLE ELECTRIFICATION
LD PEV Sales Trends

- Significant reductions in EV battery system costs
- Wide range of future EV sales scenarios driven by systems cost reductions, total cost of ownership, incentives and policies

LD EV Battery Capacity/DCFC Trends

- Declining battery system costs contribute to a trend of increasing PEV battery capacities translating to longer EV range.

- Increasing battery capacities drive the need to increased charging power to achieve fast charging times.
Nominal versus actual charging characteristics

- Actual charging rates depend on a range of factors including vehicle and EVSE type, vehicle SOC, temperatures

- Nominal peak charging rates only achieved under ideal conditions

- Actual DCFC charge duration more important than nominal peak charging power rate
MEDIUM / HEAVY-DUTY VEHICLE ELECTRIFICATION
MD/HD Electrification Opportunities

- **Challenges with MD/HD Electrification**
  - Weight...added component mass; GWR road limits
  - Exemptions for Class 8 electric trucks
    - (82k lbs vs 80k lbs present highway limit)
  - Technology readiness
  - Charging infrastructure
  - Cost

- **Regional haul (<300 mile radius)**
  - Limited operating radius
  - Dedicated charging infrastructure

- **Transit buses**
  - Scheduled operation
  - Opportunity charging
Trends for MD/HD Battery Electric Vehicles

- 500V-1000V battery voltage; up to 1500V future
- Up to 1000 kWh battery packs for maximum range
- Range: 300 or 500 miles
- Energy Consumption: Less than 2 kWh per mile (application dependent)
- Fuel Savings: $200,000+ (fuel-price dependent)
Challenges with MW+ Charging Levels

- High currents require large wire sizes and large amounts of copper
- Active cable cooling requirements
- Mechanical stress on adjacent connectors
- Weight of cable/connectors (potentially requiring automated couplers)
- Large footprint, weight and cost of required power electronics (for multi-port systems)
- Multi-port MD/HD truck charging coordinates many vehicles at one location, limited to maximum available grid resources with local storage
GRID INTEGRATION OPPORTUNITIES
Vehicle to Home/Grid Connection

- Bi-directional electricity feed between vehicle and charger widely discussed
- Increased charge/discharge cycles (reducing total batt lifetime useable for driving)
- Currently only commercially available by one manufacturer
- **Vehicle to Home**
  - Use vehicle battery for power backup
  - Minimize energy costs
  - Support the adoption of renewable energy
  - Balance the demand on the grid
- **Vehicle to Grid**
  - Provide grid services
  - Benefit from utility incentives
Grid Storage

- Dedicated, stationary batteries to limit grid impact of (fast) charging
- Trade-off between high (but projected to decline rapidly) installation cost and demand charges
- Potential avenue for second life use of vehicle batteries

DC as-a-Service (DCaaS)

- Business case for utility owned power conversion, distribution, and storage investments, directly selling DC power
- Medium voltage AC-to-DC Converter
- Fixed or regulated DC XFC site distribution

Potential benefits
- Reduced total cost of ownership (demand charges)
- Enable innovative business models
- Improve efficiency/reduce losses
- Reduce equipment footprint
- More flexible and easier to expand
- New capabilities for grid integration

Representative Protocols:
- Energy System Interface (ESI role?)
- OpenADR (utility side)
- DNP3 (utility side)
- MESA (energy storage, PV, metering)
- Open Charge Point Protocol (OCPP)
- ISO15118 (EVSE-EV link only)
- Sunspec (IEEE 2030.5, SEP2)
- EE Bus (building energy management)

“Ebay for Energy” Transactive Coordination Framework

- Coordinate and fairly dispatch charging limits during time of congestion
- Maintains system revenue neutrality; includes rebate system to incentivize driver flexibility
- Bidding is based on urgency and budget
Summary

- Growth in vehicle battery capacity drives increasing (peak) charging needs to maintain relatively short fast charging times.

- Charging power characteristics vary greatly depending on vehicle, EVSE, ambient conditions etc.

- MD/HD electrification expanding rapidly starting from “beachhead” applications (transit, package delivery, drayage) into regional and long-haul.

- Opportunities to mitigate EV charging grid impacts and leverage into grid services.

- Institutional support to government agencies, utilities, OEMs, and regulators is a key and growing area in the DOE Grid Modernization Laboratory Consortium ‘Grid Modernization Multi-Year Program Plan’

Challenges and Opportunities with Vehicle Fast Charging

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UIC Workshops on Beneficial Electrification of Transportation

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