2021 DOE Vehicle Technologies Office Annual Merit Review

HIGH POWER CHARGING: CHARGE PROFILES

Daniel Dobrzynski
Argonne National Laboratory
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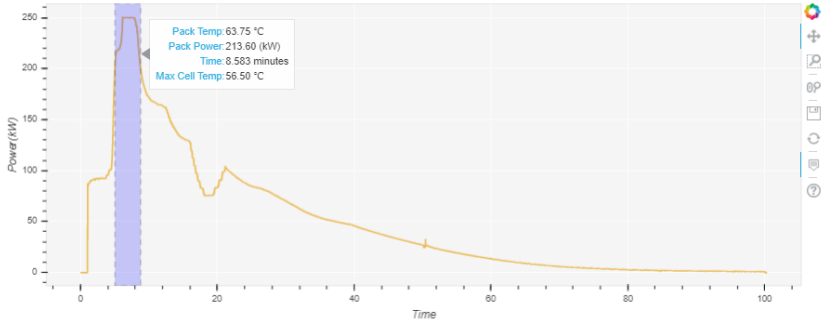
Project ID: elt266

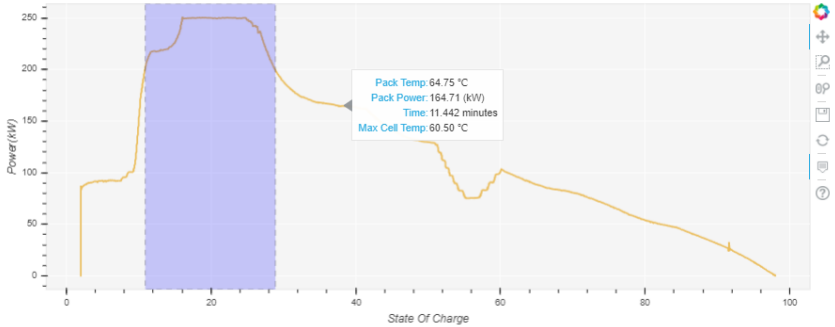
Project Introduction

Assess the likely portfolio of EVs and EVSE that are expected to utilize HPC.

High Power Charging > 200kW

- Complete charge system profile capture
- Assessments at baseline and modified temperatures.
- System responses to grid disturbances & charging management.
- Assess conductive and wireless systems
- Collaborate with OEMs and industry
  - Testing assets
  - Procedure development





Overview

Timeline

- Draft Procedures – Q2, FY 2021
- Finalized Procedures – Q4, FY 2021
- Profile Captures/Characterizations Milestones – Q2, FY 2022 through Q1, FY 2023
- Fleet Data Collection – Q2 FY 2023
- Result Analysis/ Reporting – Q4, FY 2023

Barriers/Challenges

- HPC charge profiles are unknown
- Lacking knowledge of system limits and system efficiencies
- Limited knowledge of boundary condition impacts on charging process
- Lack of understanding of DER integration, SCM, and grid services involving HPC

Total Budget – ANL, INL, NREL, ORNL

- FY2021 ~ $2000K
- FY2022 ~ $2000K
- FY2023 ~ $2000K

Collaborators

- US and non-US Vehicle and EVSE OEMs
- Metropolitan Transport Authorities
- Utilities, Government Programs, International Research

Relevance

DOE Grid & Infrastructure Objective:

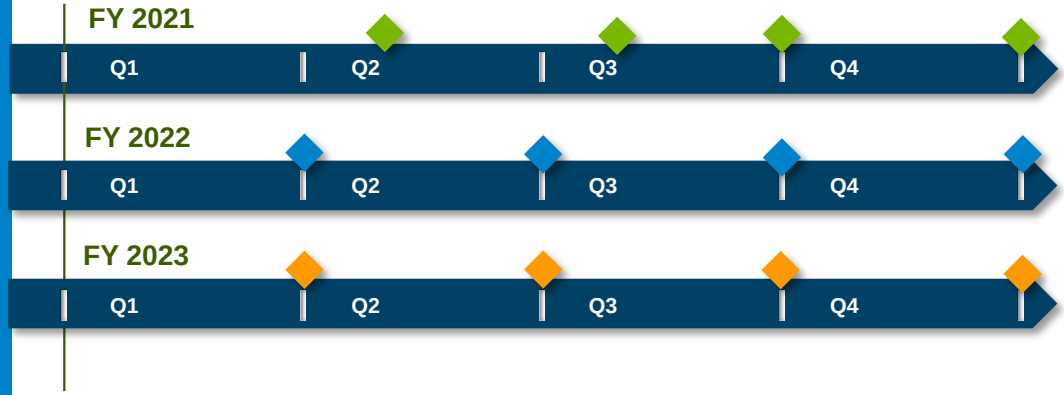
"Identify and assess system requirements and conduct research to enable extreme fast charging while minimizing impacts to the grid."

- Via systematic assessment and characterization of available HPC technologies this project aims to address the following questions associated with HPC:
  - What are the system limitations and efficiencies of HPC?
  - What are the HPC profiles that the grid will encounter?
  - How do boundary conditions effect the charging limits, efficiencies, and grid profile during HPC?

- The outputs of this project will function as a platform for the development of solutions that ensure energy reliability via the grid.
  - Grid planning efforts
  - Charging depot site sizing
  - DER/Storage integration; power level & capacity
  - Effective smart charge management strategies

Quote: Vehicle Technologies Office Electrification 2019 Annual Progress Report

Project Milestones



Planning

Execution

Analysis

Year 1 Milestones

- Solidify collaborator agreements
- Parameter definitions/draft procedure
- Procedure performance - refinement
- Finalized project procedures (Go/No-go)

Year 2 Milestones

- Fleet data collection review
- Capture conductive profile sets
- Complete EVSE characterizations
- Capture non-conductive profiles sets

Year 3 Milestones

- Capture conductive profiles sets
- Finalize fleet data collection
- Complete R&D profile EVSE characterization
- Analysis, results, and reporting

Approach - Programmatic

Align laboratory assets and capabilities

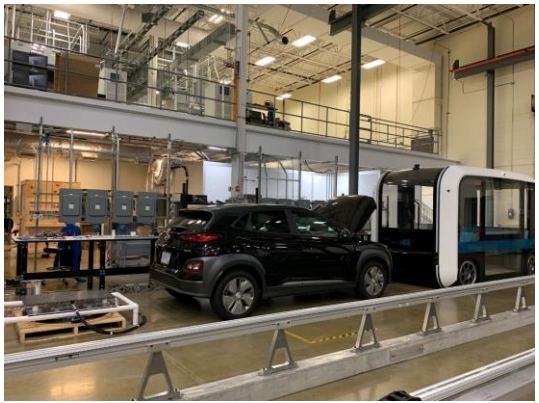
- 4 major 350kW EVSE systems
- Thermal conditioning systems
- Grid emulation and EV emulation capability
- Reconfigurable stationary and dynamic WPT systems

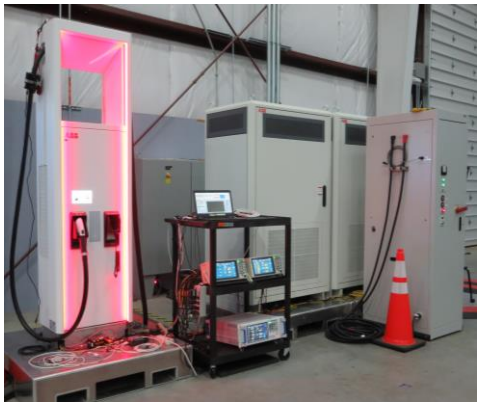
Leverage industry relationships

- 5 EV/EVSE manufacture letters of support
- 3 fleet manager letters of support
- 4 alternate stakeholder letters of support

Leverage DOE project outputs – XCEL

- XCEL – Fast Charging Battery Cell Evaluations
- Scale project findings to emulate future EV charge profiles.
- Evaluate Performance and Power Quality Impacts

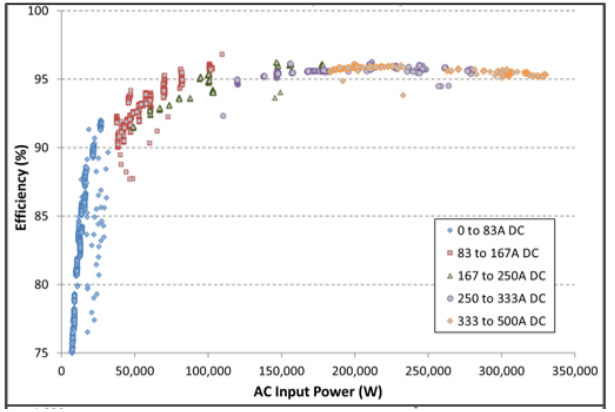


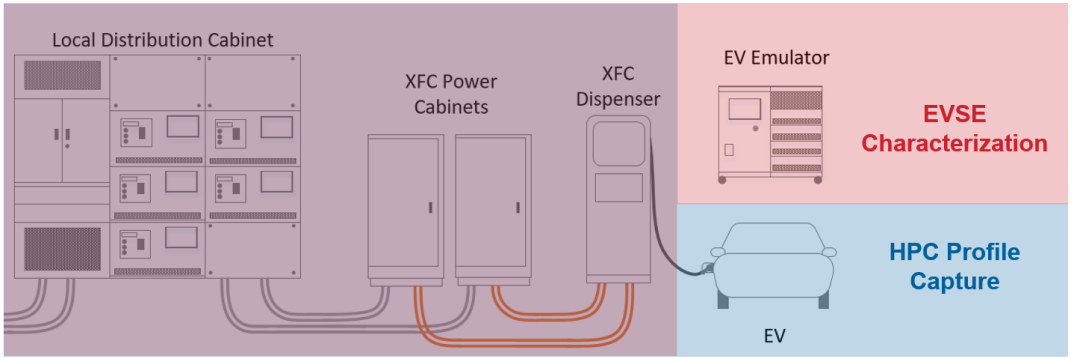


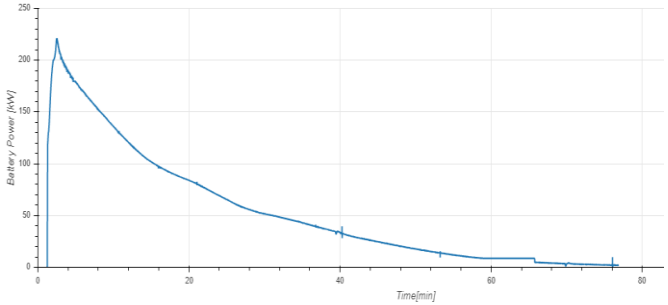
Approach - Technical

Testing Methodology

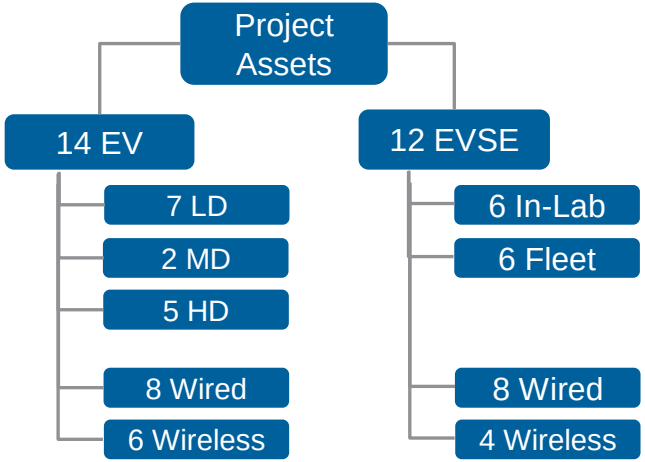
- HPC Profile Capture – Capture EV driven system profiles: Baseline and boundary condition cases
- EVSE Characterization – Quasi steady-state analysis over EVSE system entire operating range
- Fleet Utilization and Charging
  - Long term day to day data gathering
  - On-site detailed charge event measurement







Technical Accomplishments



Collaborator Progress

- 14 collaborator agreements in progress or planned
  - 4 EV OEMs
  - 4 EVSE manufactures
  - 4 Fleet agencies
  - 2 Stakeholder agencies

Breadth vs Depth Targets

- Secured a wide breadth of EV and EVSE assets
  - Maintained a balanced outreach to LD, MD, and HD EV targets
  - Established non-conductive representation among multiple EV classes
  - Defined efficient set out boundary conditions

Data Dissemination Policy

- Public results and analysis
  - High level – mostly graphical and informative
- Project partner results
  - Curated anonymized data
- Individual participant results
  - Complete data sets

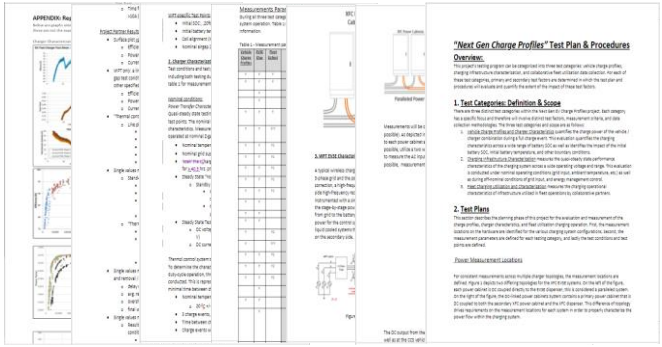
Wide Breadth

	Vehicle Class	LD	MD/ HD Bus / Truck	LD	MD/HD Bus/Truck
	Charger Class	XFC (≥200kW)	XFC (≥200kW)	WPT (≥200kW)	WPT (≥200kW)
In-Depth	Nominal Conditions: Charge Profile & Charger Performance	X	X	X	X
	Hot Ambient Impacts	X	X		X
	Cold Ambient Impacts	X	X		X
	Grid Disturbance Response	X		X	X
	Response to Energy Management	X			

Technical Accomplishments

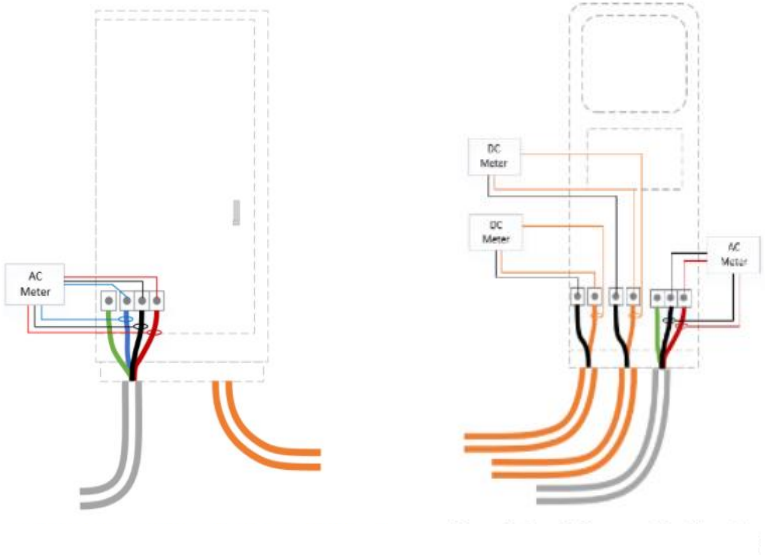
Procedure Development

- Draft Sections:
  - Test Categories: Definition and Scope
  - Test Plans – baseline and boundary condition plans
  - Test Procedures
  - Analysis and Results



- Measurement Metrics & Locations
  - AC & DC power measurements
  - Thermal measurements
  - Power management signals
  - Varied HPC system topologies
  - HPC sub-component locations
  - Wireless coil locations/alignment

- Testing Outputs
  - Charging power plots
  - System efficiency plots
  - Aux. load and thermal analysis
  - Duration above 200kW
  - Peak ramp rates
  - Response latencies to SCM signals



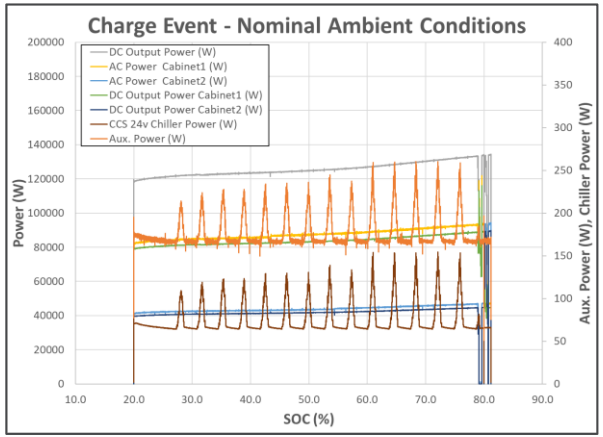
Technical Accomplishments

Vehicle Charge Profile Trail Run

Test Articles
- MCI J4500e – All-Electric Coach
- ABB Terra HP – 350kW HPC charger

Procedure Usage
- HPC Profile Capture
- Baseline boundary conditions
- 20% to 80% State of Charge

Data Analysis
- Results analysis is in progress
- Final outputs will be published per the programmatic process along with other project results.



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Responses to Previous Reviewer Comments

This is the first year for the project; it was not reviewed last year

Collaboration and Coordination

Team Members	Roles	Responsibilities
ANL **ORNL** **INL** **NREL**	- Principal investigators	Management, procedure development, testing execution, analysis / reporting
LD, MD, HD Vehicle OEMs	- EV asset contributors - Reviewers	Provide testing articles, Procedure review, Interoperability support if needed
EVSE OEMs EVBox, BTCP, ABB, Momentum Dynamics & others	- EVSE asset contributors - Reviewers	Provide testing articles, Procedure review, Interoperability support if needed
EV Fleet Operators CTA, Republic Sanitation & others.	- Data contributors - EV asset contributors	Data sharing, Asset access, Procedure review
Utility/Regulatory/Agency Energy Star, CEO, PGE	- Reviewers	Procedure review
EC Joint Research Center	- Reviewer - Technical Support	Procedure support, Data sharing

Remaining Challenges and Barriers

Collaborative follow-through

- Existing letters of support need to translate into asset loans. Multiple issues may arise including NDA disagreement, data sharing issues, scheduling conflicts, insurance issues, etc.

Initiating new collaborative relationships as qualifying assets come to market

- Project timeline will align with numerous qualifying next generation EV and EVSE announcements.
- Project team will need to communicate project value to capture new collaborative partnerships.

Ensure representative data quality from multiple sources

- Procedures will be executed at 4 different laboratories and in various field data gathering scenarios.
- Available equipment and data acquisition systems will vary by location.

Lack of stakeholder consensus on procedures and process

- The project requests many procedure and data reviewers to ensure project data is highly useful.
- High reviewer count may lead to risk of disagreement on methodology and process.
- High reviewer count may lead to scope creep on measurement metrics and boundary conditions.

Future Research and Collaboration

Fleet Data Collection
- Integrate with established data gathering systems
- Supplement existing data gathering systems
- Plan and schedule site visit gathering sessions

EVSE Characterization
- Wireless system characterization – ORNL W-XFC
- ABB, Efacec, and BTCP EVSE characterization

HPC Profile Capture
- Baseline charging event capture
- Conductive and wireless profiles
- Boundary condition event capture when possible

Collaborative Engagements
- Maintain existing collaborators
- Engage in new opportunities

SUMMARY

Relevance

Characterization effort that supports DOE objectives to enable high power charging while minimizing grid impacts.

Approach

Multi-lab approach to leverage capabilities, outreach, and related projects.

Technical accomplishments and progress

- Executed a balanced collaborator outreach
- Developed comprehensive data dissemination plan
- Established foundational draft procedure: multiple testing approaches, detailed test metrics, expected outputs
- Completed first procedure test run

Future work & collaboration

Finalize procedures with consensus; coordinate laboratory assets; initiate fleet data collection; engage new opportunities.