EVs@Scale

U.S. Department of Energy

Welcome

Burak Ozpineci

April 5, 2023

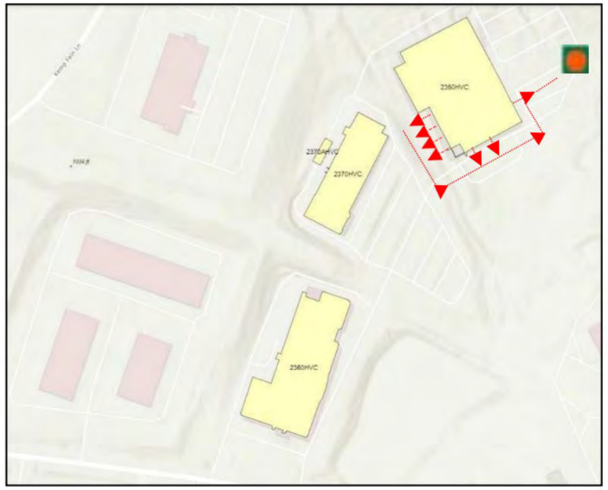
U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Safety/Building 2350 Information

Emergency Response

Building 2350 – 1st Floor: Egress Exits & Take Cover /Shelter In Place

Assembly Point:
Located east
of Building 2350



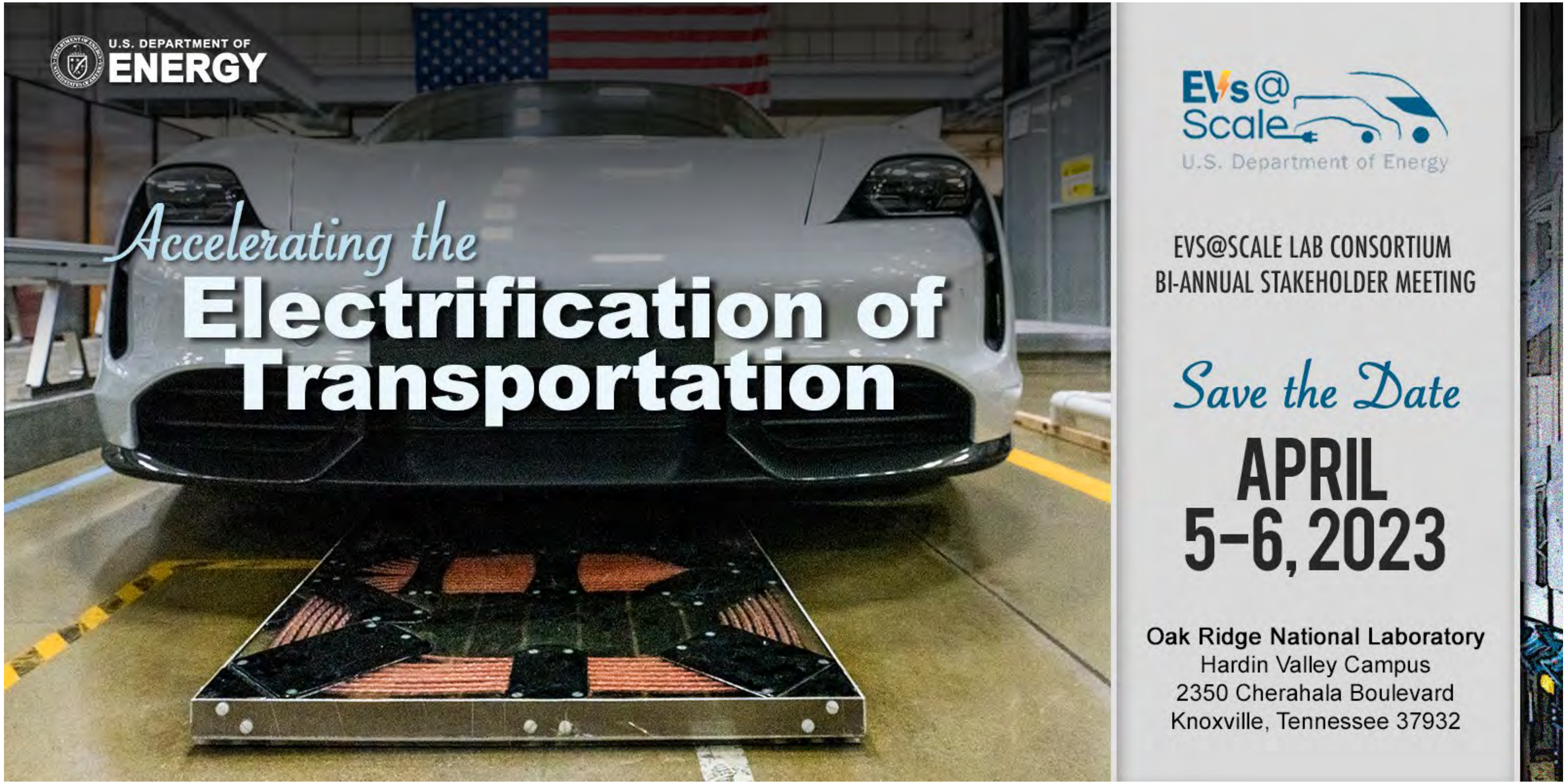
Building Information

Restroom: Located across hallway

Phone Charging Station: Lobby

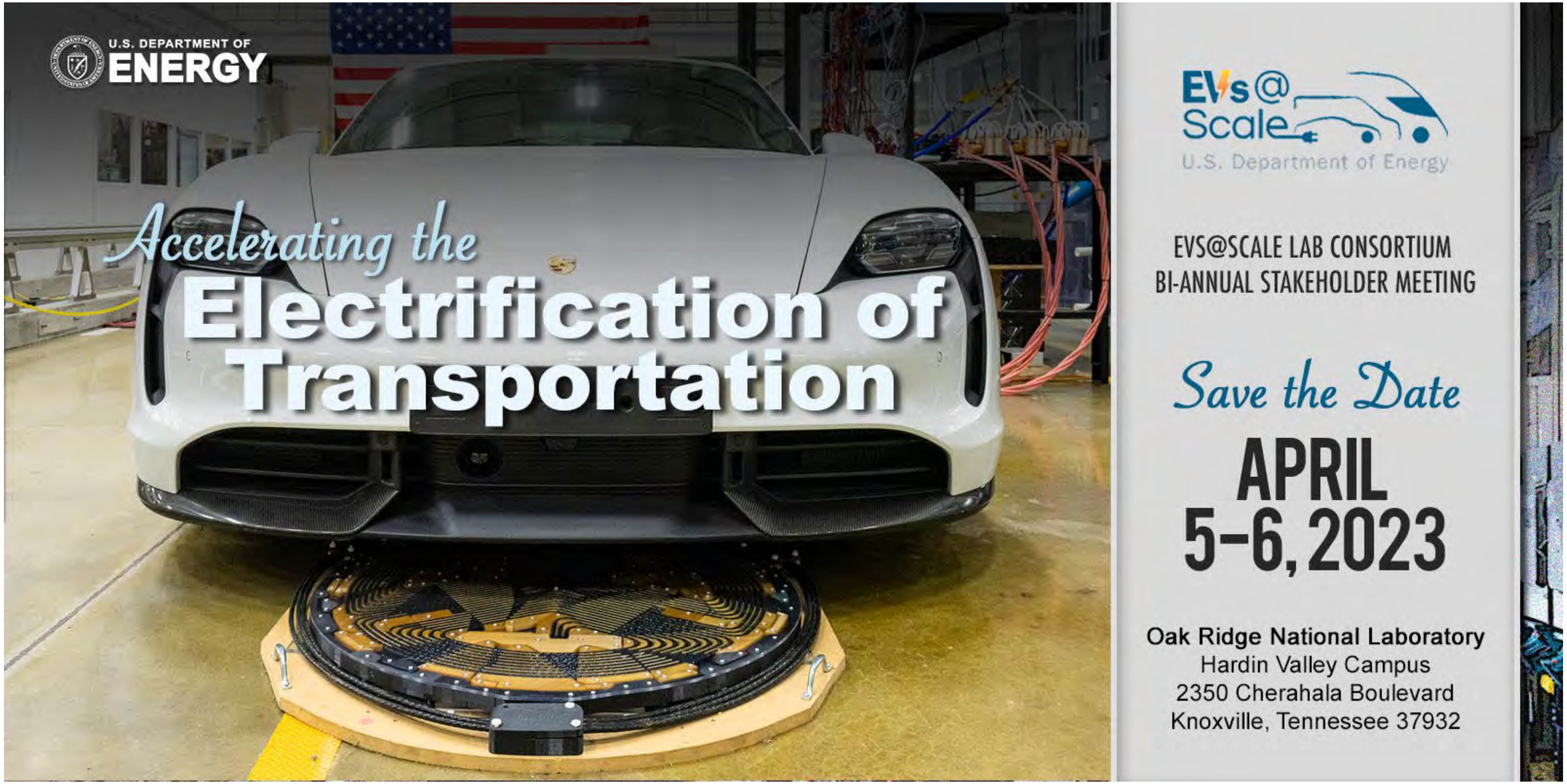
Designated Smoking Area:
Please keep 25ft from entrances

Welcome



U.S. DEPARTMENT OF ENERGY
Accelerating the
Electrification of Transportation
EVs@Scale
U.S. Department of Energy
EVS@SCALE LAB CONSORTIUM
BI-ANNUAL STAKEHOLDER MEETING
Save the Date
APRIL 5-6, 2023
Oak Ridge National Laboratory
Hardin Valley Campus
2350 Cherahala Boulevard
Knoxville, Tennessee 37932

Welcome



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Accelerating the
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VTO Electrification Program

Mike Weismiller

April 5, 2023

Big things happening at DOE!

- **Bipartisan Infrastructure Law (BIL) – Nov 2021**
  - Historic investment in energy infrastructure programs, with many programs managed by DOE
  - $7B investment in the domestic supply chain for EV batteries
  - $7.5B to deploy a convenient, reliable, and Made-in-America electric vehicle (EV) charging network
  - Builds on E.O. 14037 [Aug 2021] – setting goal of **50%** new cars and light trucks sold in 2030 be battery electric, plug-in hybrid electric, or fuel cell electric vehicles.

DOE- VTO:
Budget continues to grow

Subprograms (dollars in thousands)	FY21 Enacted	FY22 Enacted	FY23 Enacted	FY24 Request
Battery and Electrification Technologies	**$178,700**	**$200,000**	**$211,500**	**$266,016**
Decarbonization of Off-Road, Rail, Marine, Aviation Technologies (Advanced Engine and Fuel Technologies)	$70,000	$35,000	$35,000	$35,579
Materials Technology	$40,000	$45,000	$42,500	$45,000
Energy Efficient Mobility Systems	$45,000	$54,000	$54,000	$54,000
Technology Integration	$60,300	$80,000	$106,000	$117,162
Data, Modeling, and Analysis	$6,000	$6,000	$6,000	$9,185
Total	**$400,000**	**$420,000**	**$455,000**	**$526,942**

New DOE Organization

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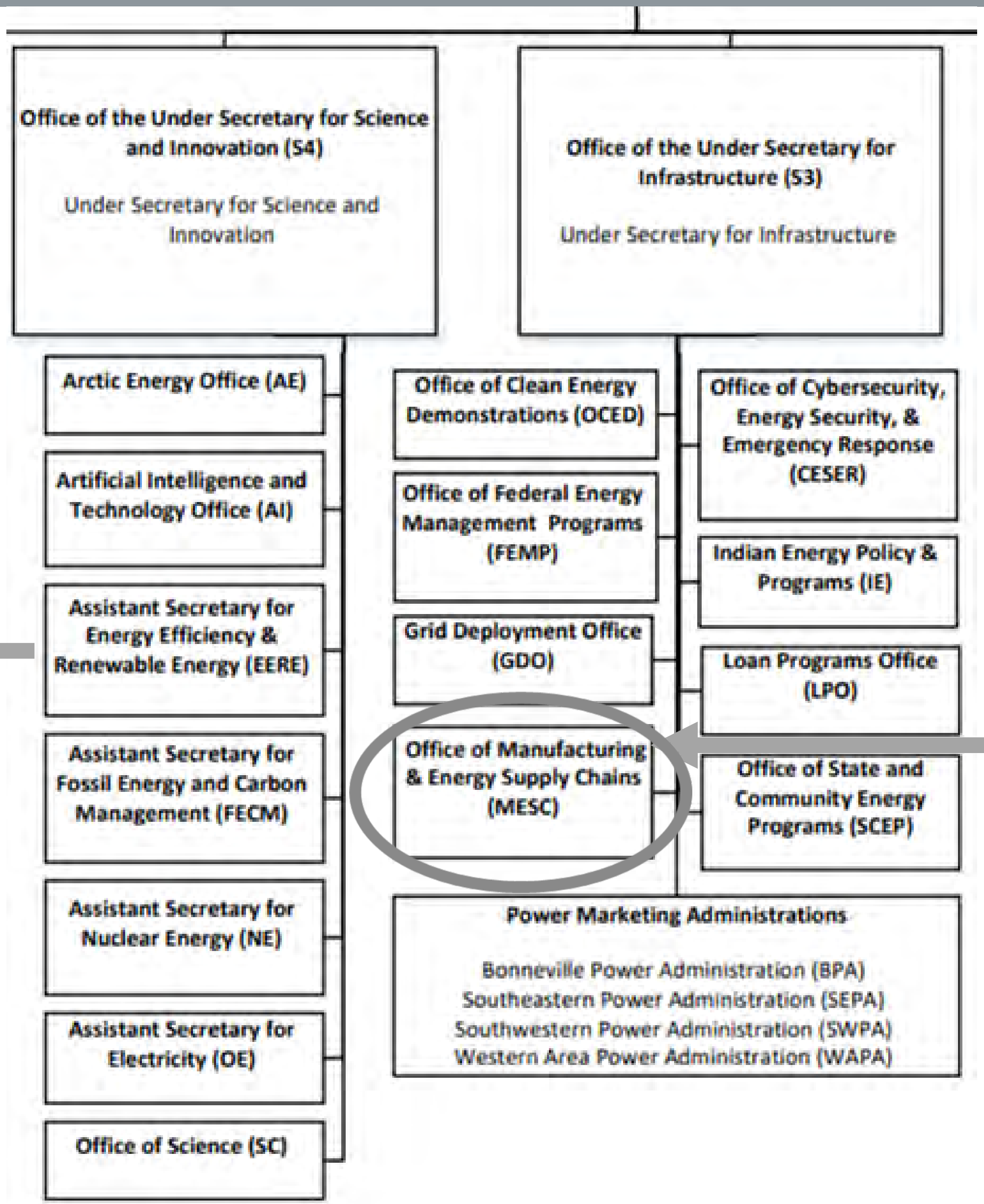

Sustainable Transportation & Fuels

- Vehicle Technologies
- Bioenergy Technologies
- Hydrogen and Fuel Cell Technologies
- The Joint Office of Energy and Transportation (established by BIL)

Joint Office of Energy and Transportation

Includes Battery/Critical Materials programs (BIL)

Vehicle Technologies Office Federal Staff

Director
Michael Berube (Acting)

Deputy Director
Vacant

Batteries R&D
Program Manager: Brian Cunningham

- **Technology Managers**
  - Tina Chen
  - Haiyan Croft
  - Thomas Do
  - Tien Duong
  - Nicolas Eidson
  - Jake Herb
  - Simon Thompson

Electrification R&D
Program Manager: Mike Weismiller

- **Technology Managers**
  - Susan Rogers
  - Fernando Salcedo
  - Lee Slezak

Materials Technology R&D
Program Manager: Sarah Ollila

- **Technology Managers**
  - Jerry Gibbs
  - Christopher Schooler
  - Felix Wu

Decarbonization of Offroad, Rail, Marine, and Aviation
Program Manager: Gurpreet Singh

- **Technology Managers**
  - Siddiq Khan
  - Kevin Stork

Energy Efficient Mobility Systems
Program Manager: Jake Ward* (Acting)

- **Technology Managers**
  - Erin Boyd
  - Melissa Rossi

Technology Integration
Program Manager: Mark Smith

- **Deployment Managers**
  - Alycia Gilde
  - Michael Laughlin
  - Margaret Smith

Operations
Operations Supervisor: Sarah Ollila (Acting)

- **Analysis**
  - Raphael Isaac
  - Patrick Walsh
- **Budget**
  - Vacant
- **Communications and Education**
  - Vacant
- **Office Administration**
  - Bernadette Jackson

Electrification R&D Program

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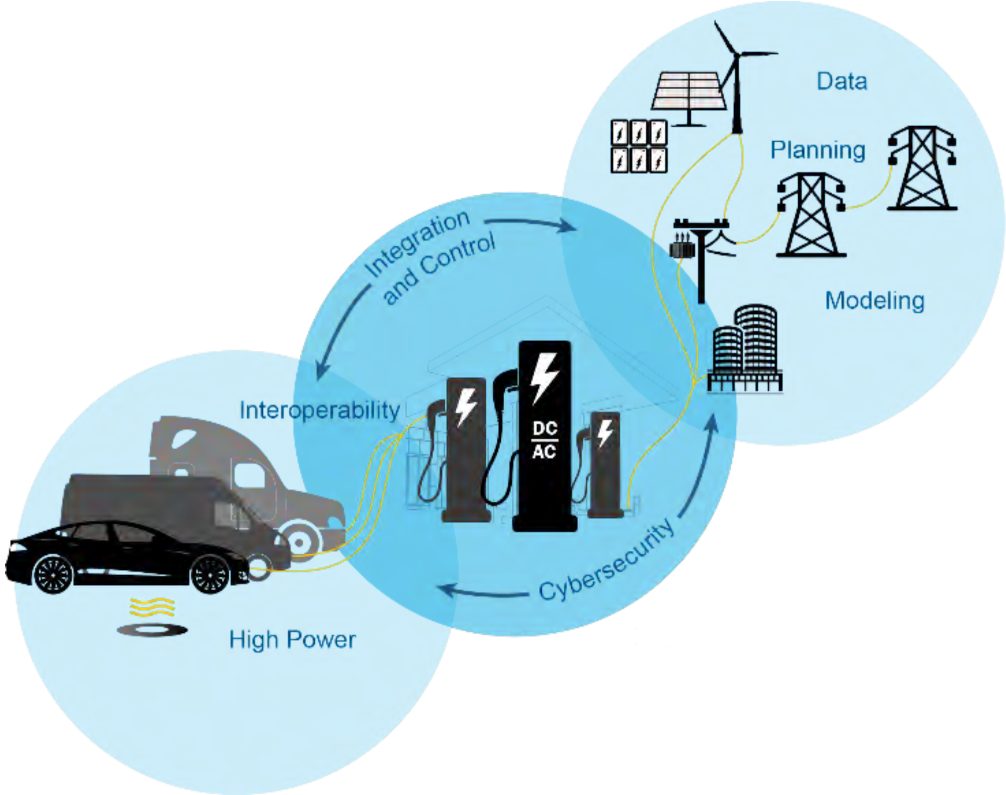
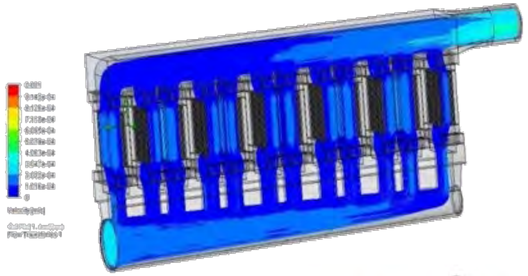
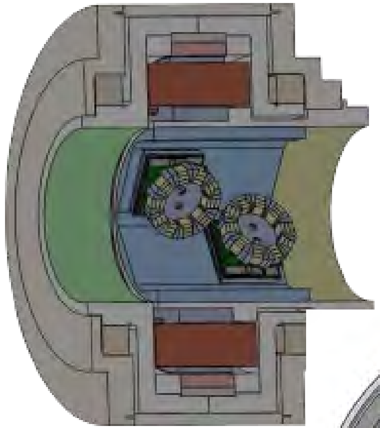
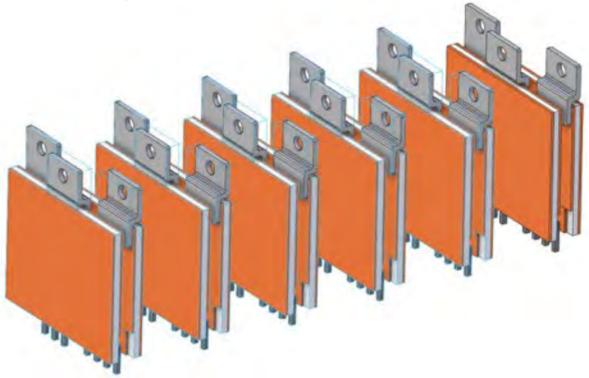
Enable a large market penetration of electric drive vehicles through innovative research and development:

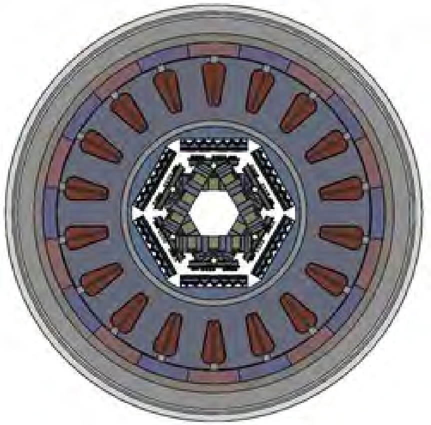
- Facilitate development and harmonization of a robust, interoperable, economically vibrant, resilient, cybersecure EV charging infrastructure that is integrated with a decarbonized modern grid
- Enable efficient, affordable, and high power density electric traction drive systems for vehicles











Stay Involved!

- **Active stakeholder engagement is critical to our mission**
  - Provides timely situation awareness of barriers and gaps that need to be addressed
  - Enlists participation in projects
  - Gathers stakeholder feedback on project relevance
  - Coordinates activities, resources, and information sharing
- **2023 VTO Annual Merit Review (AMR)**
  - AMR will be held as a virtual event on June 12-15, 2023 for updates on all ELT projects!
  - Currently enlisting project reviewers – email us if you are interested
  - Registration at https://www.energy.gov/eere/vehicles/2023-vto-annual-merit-review-registration
- **Funding Opportunities (eere-exchange.energy.gov)**
  - 2023 VTO Lab Call: AOI 1: Technology Commercialization Fund ($3.6M)
    - Call for proposals for national laboratories to team with private sector to commercialize technology (50% cost share required)
  - Notice of Intent to Publish 2023 VTO Program Wide FOA
    - List of potential topic areas
    - Teaming Partner List

… or Join Our Team!

Ready to start building our clean energy and transportation future?

- **VTO is Hiring for multiple positions, including on the Electrification R&D Team**
- **Visit: https://www.energy.gov/eere/vehicles/vehicle-technologies-office-careers or https://www.usajobs.gov/job/714784500**

ORISE

EERE Science, Technology and Policy (STP) Fellowships

Work with our team as a Fellow, ideal for those who are about to complete their requirements for a Master’s or PhD, or who have done so recently.

Please see our posted opportunity: https://www.zintellect.com/Opportunity/Details/DOE-EERE-STP-VTO-2023-1300 and apply through Zintellect

Thank You!

Mike Weismiller

michael.weismiller@ee.doe.gov

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Grid and Infrastructure

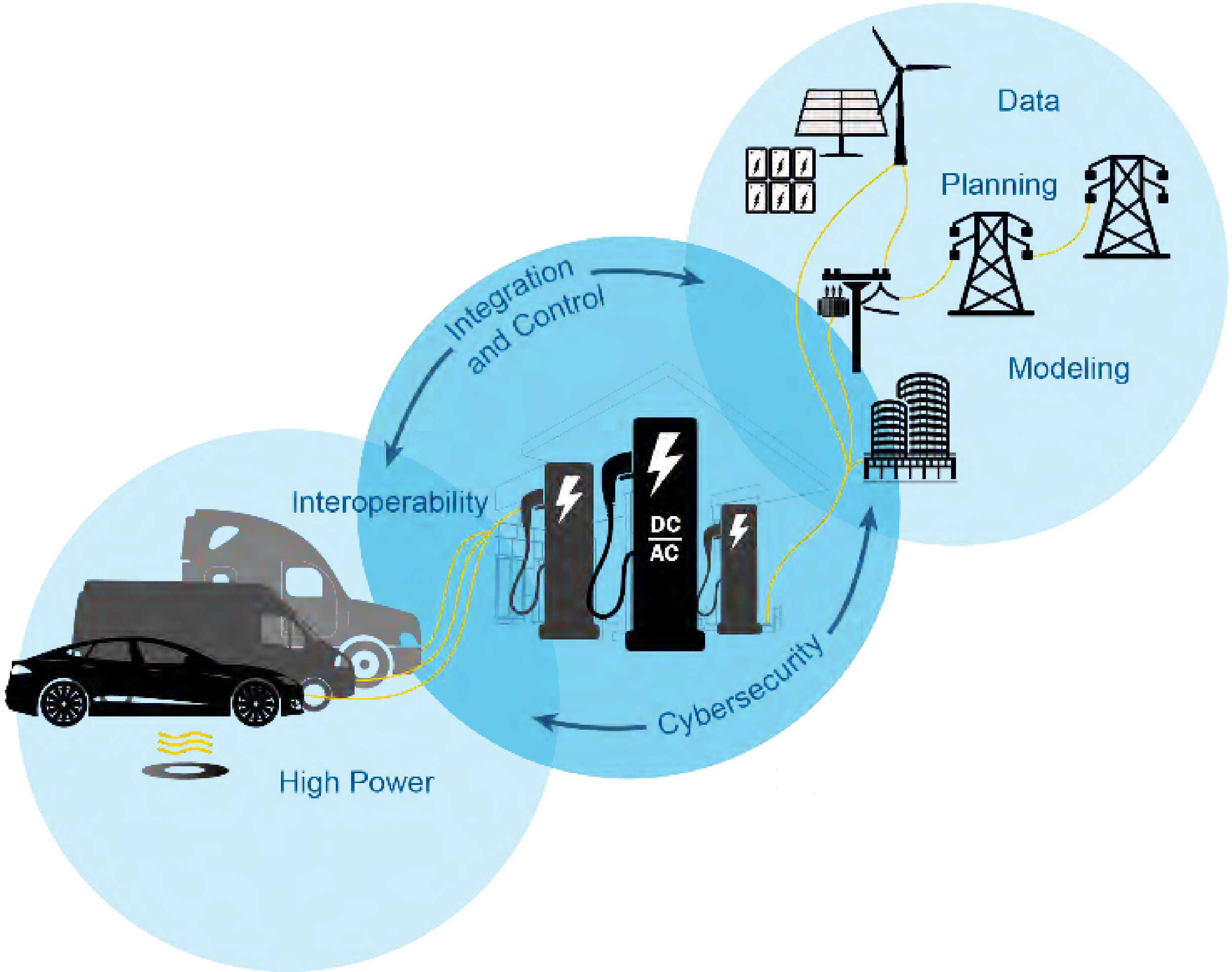
Lee Slezak

April 5, 2023

Grid and Infrastructure Activities

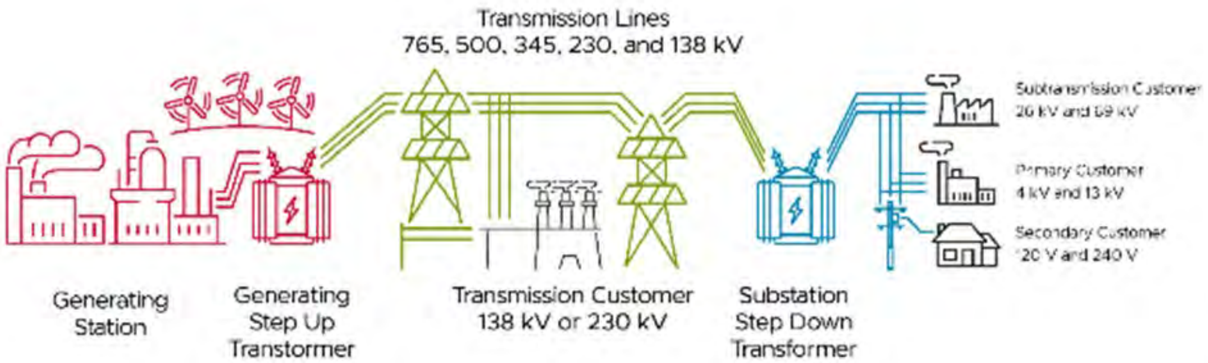
Enable a large market penetration of electric drive vehicles through innovative research and development:

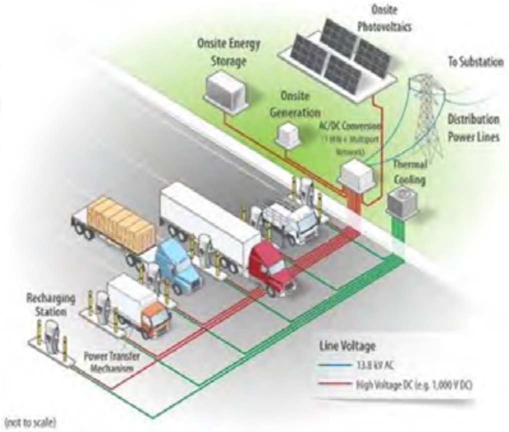
- Facilitate development and harmonization of a robust, interoperable, economically vibrant, resilient, cybersecure EV charging infrastructure that is integrated with a decarbonized modern grid

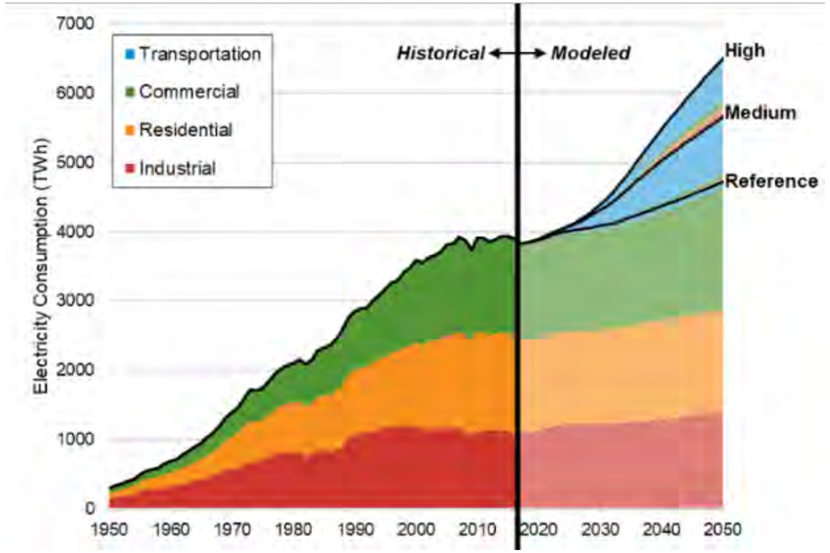


Integrating EVs with the Electric Grid

The transition to electric vehicles will require the coupling of the transportation and electric grid sectors







EV Vehicle Class, Charging Type, and Equivalent Loads

Level 1
AC

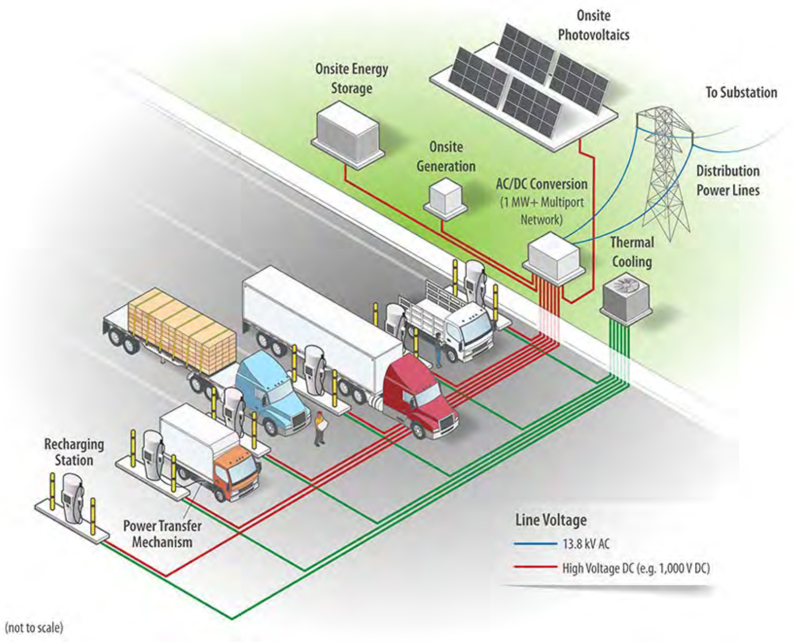
Level 2
AC

DCFC
and XFC

High
Power
Charging

MD/HD Charging Station and Equivalent Load

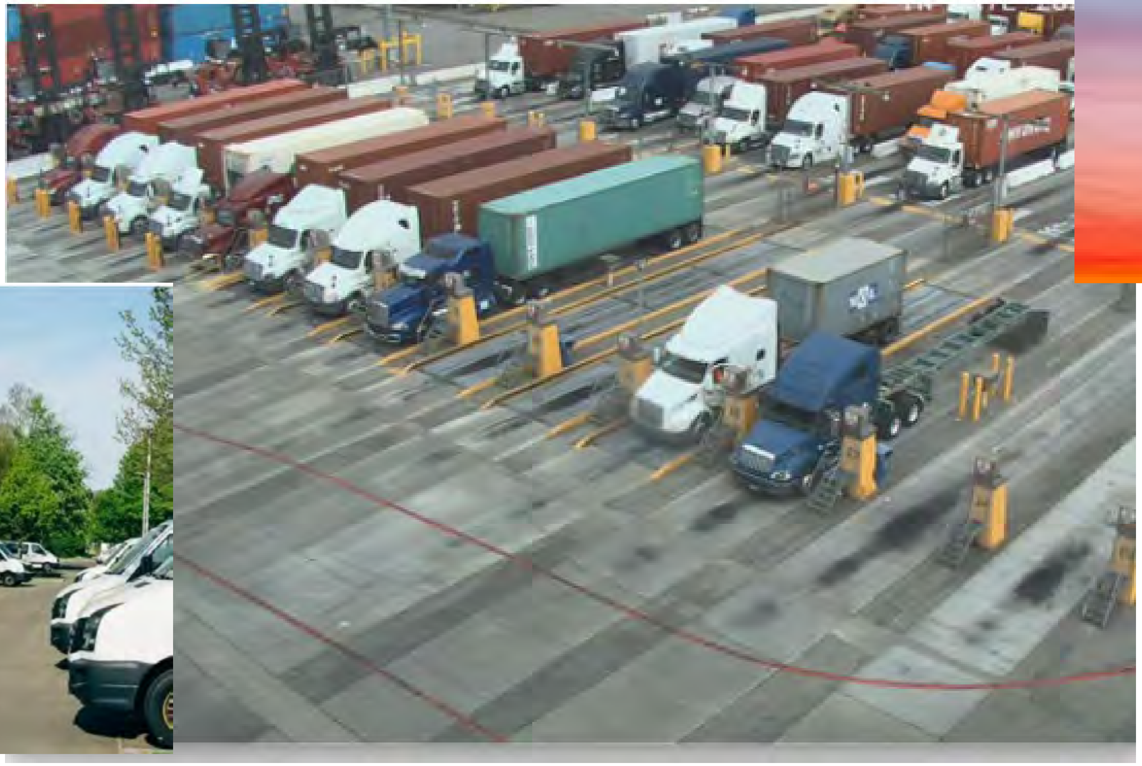
Peak Charging Loads: ~ 20 MW



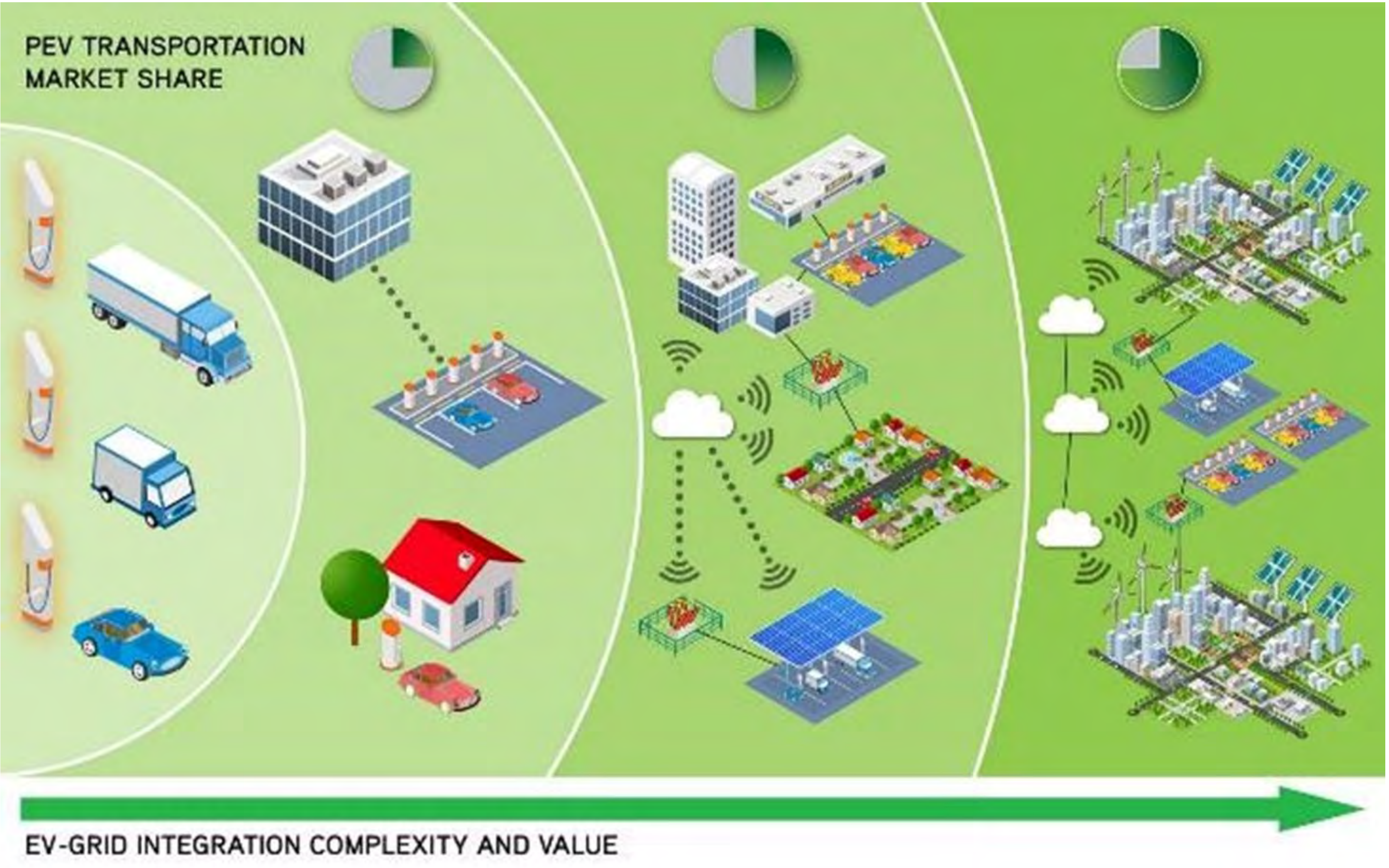
Sources: NREL, https://www.nrel.gov/transportation/medium-heavy-duty-vehicle-charging.html & lhttps://www.skyscrapercity.com

Challenging Environments

- Airports
- Fleet Depots
- Port Terminals
- Grid with Insufficient Capacity or Energy



The goal of VGI is to harmonize EV charging with the electric grid

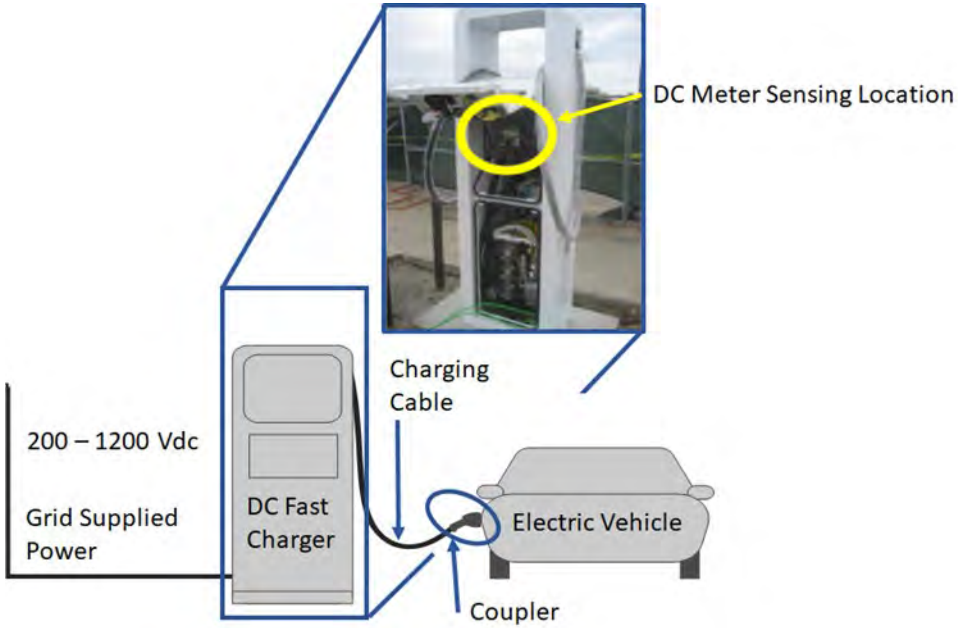


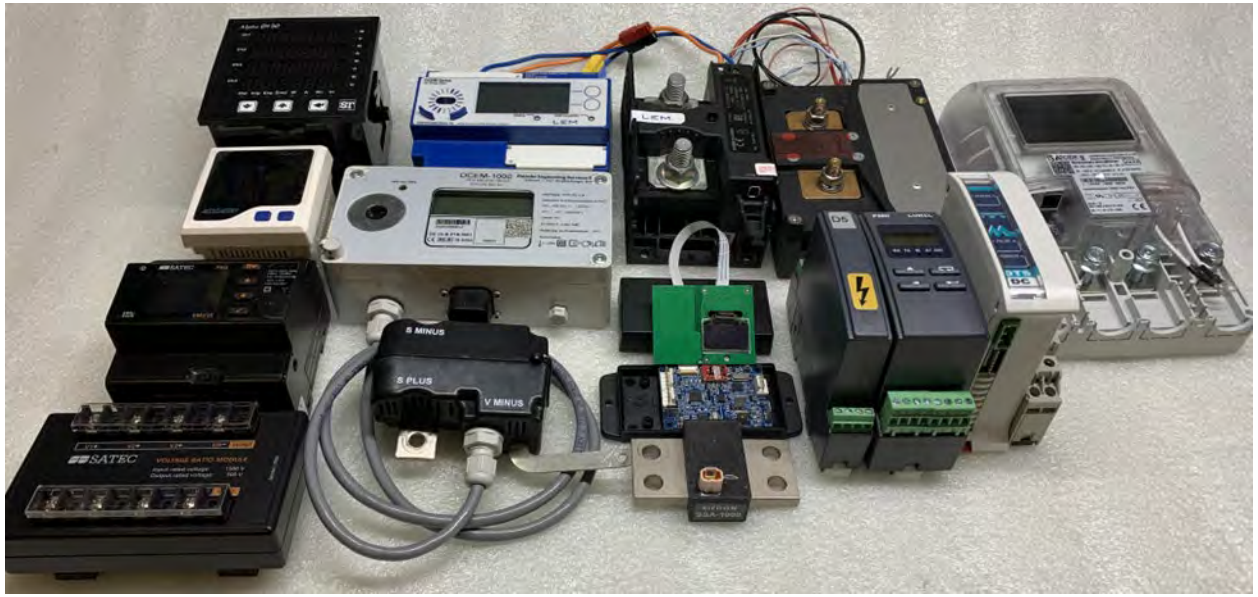
Cyber-Physical Security of Charging Infrastructure

Wireless Charging R&D

- Analyzing Use Cases
  - Drayage Operations
  - Autonomous Vehicles
  - Electrified Roadways
- Addressing Information Gaps

Codes and Standards





Thank You!

Lee Slezak

Lee.Slezak@ee.doe.gov

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Consortium Overview and Stakeholder Engagement

Andrew Meintz

April 5, 2023

EVs@Scale Lab Consortium

Objectives

- Adapt to rapidly evolving technology landscape
- Maximize multi-lab coordination
- Identify and prioritize long-and short-term RD&D
- Timely support to address urgent challenges
- Support Administration and IIJA (BIL) transportation electrification objectives

Consortium Features

- Six Labs – ANL, INL, NREL, ORNL, PNNL, SNL
- 5 R&D pillars aligned with G&I R&D pillars
- Stakeholder Engagement and Outreach

Scope

Precompetitive research, development, and demonstration to supports a nationwide network of electric vehicle charging that is harmonized with the grid

Consortium Structure

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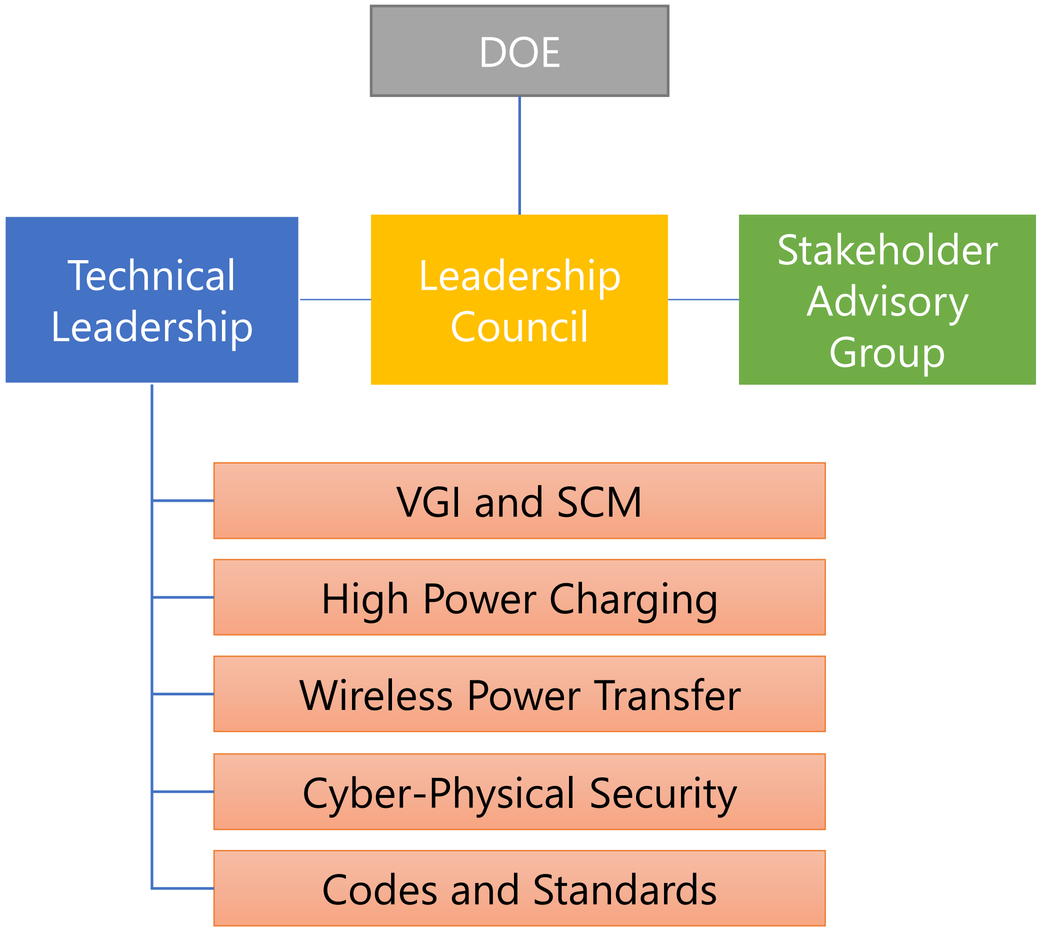
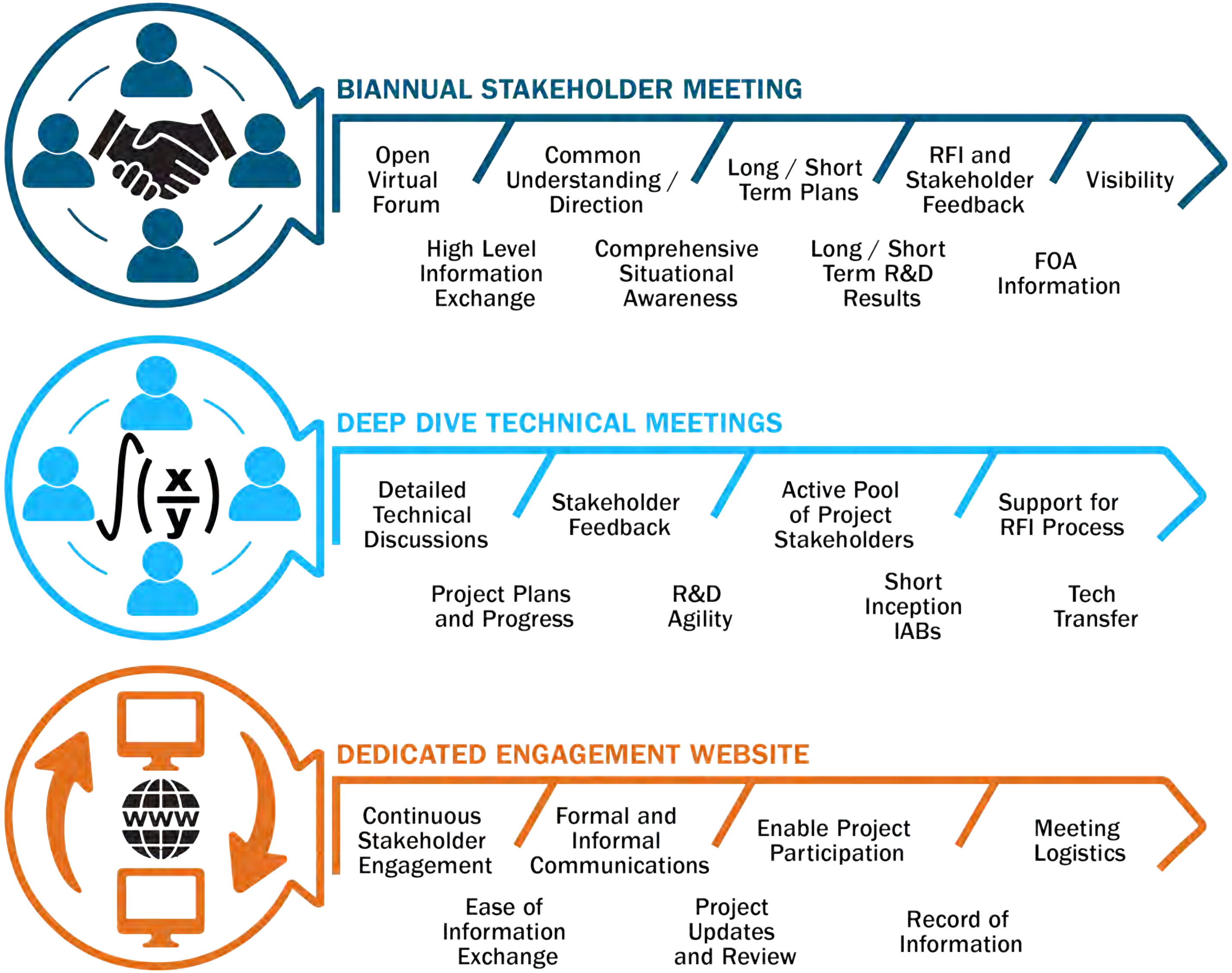
U.S. Department of Energy

- **Leadership Council**
  - Andrew Meintz (NREL, chair), Dan Dobrzynski (ANL, rotating co-chair), Burak Ozpineci (ORNL), Summer Ferreira (SNL), Rick Pratt (PNNL), Tim Pennington (INL)
- **Stakeholder Advisory Group**
  - Utilities, EVSE & Vehicle OEMs, CNOs, SDOs, Gov't, Infrastructure
- **Consortium Pillars and Technical Leadership**
  - Vehicle Grid Integration and Smart Charge Management (VGI/SCM): Jesse Bennett (NREL), Jason Harper (ANL)
  - High Power Charging (HPC): John Kisacikoglu (NREL)
  - Wireless Power Transfer (WPT): Veda Galigekere (ORNL)
  - Cyber-Physical Security (CPS): Richard "Barney" Carlson (INL), Jay Johnson (SNL)
  - Codes and Standards (CS): Ted Bohn (ANL)

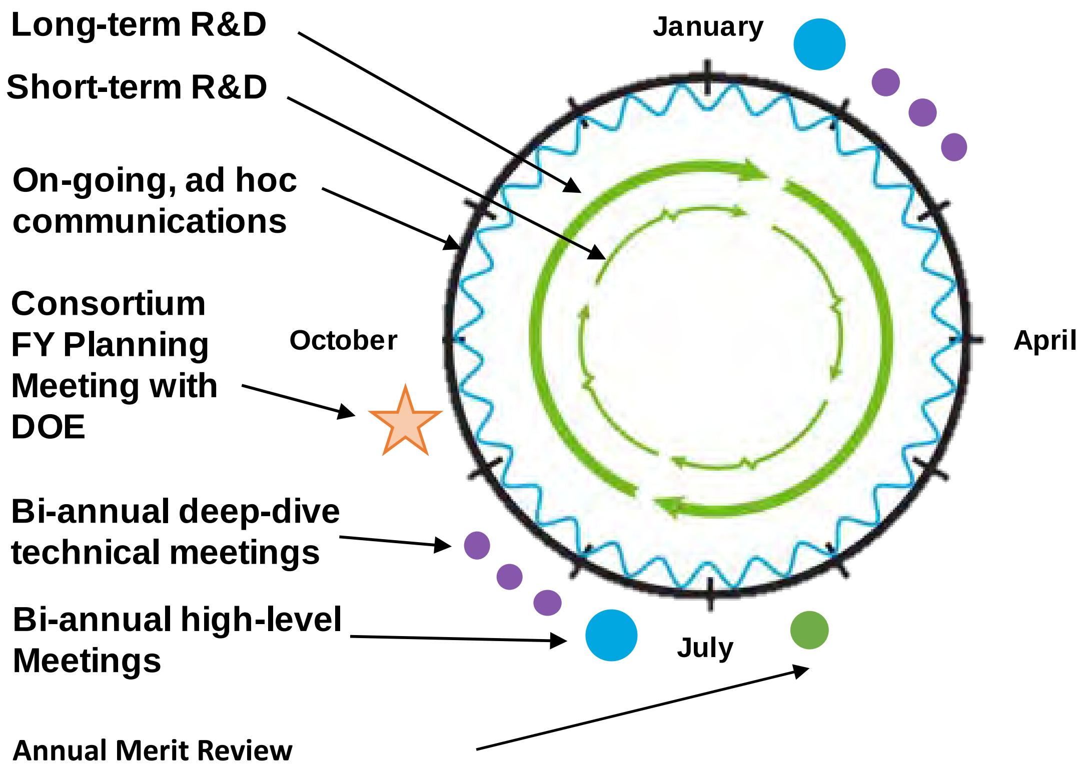


EVs@Scale Lab Consortium Stakeholder Engagement and Outreach

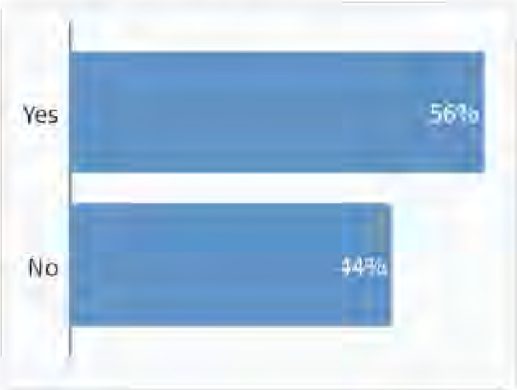


Collaboration and Coordination

- **Stakeholder Advisory Group**
  - Utilities, EVSE & Vehicle OEMs, CNOs, SDOs, Gov't, Infrastructure
- **Direct interaction for each pillar projects**
  - Utilities, EVSE & Vehicle OEMs, CNOs, SDOs, Gov't, Infrastructure
  - Webinars / Project discussions
- **Bi-annual high-level meetings**
  - Rotation among labs with discussion on all pillars
- **Bi-annual deep-dive technical meetings**
  - VGI/SCM, HPC & WPT, and CPS with C&S incorporated into all meetings



Is the EVs@Scale Lab Consortium sufficiently addressing high-level barriers to Vehicle-Grid Integration?



Response options	Count	Percentage
Yes	**9**	**56%**
No	7	44%

62%

Engagement

16

Responses

What should we address or discuss?

We asked if there are issues the Consortium had not addressed in the last bi-annual meeting and received the following top-three suggestions:

1. **Show how EVs@Scale projects/research have a pathway to commercial products/solutions that can quickly scale?**
    a) DOE’s Technology Commercialization Fund
    b) Direct stakeholder engagement with projects starting with deep-dives
2. **How does this lab community address the “need for speed” in order to gain experience, document lessons learned, AND publish standards and best practices?**
    a) Targeting C&S pillar activities
    b) Whitepapers, technical reports, journals
3. **User Interface standards so that terms, symbols, colors, etc. on charging equipment and on dashboards are consistent globally.**
    a) Joint Office of Energy and Transportation

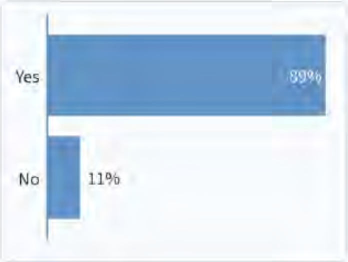
Other Pillars?

We asked if the Consortium should consider other pillars in the last bi-annual meeting and received the following top-three suggestions:

1. **Technology Transfer/ Commercialization**
   a) Technology Commercialization Fund
   b) Funding Opportunity Announcements
   c) This activity is focused on pre-competitive research, development, and demonstration
2. **Systems integration and demonstration of V2X (AC and DC)**
   a) Activities in eCHIP
3. **Resilience, maybe in Cyber**
   a) The eVision Project has joined the cyber pillar and activities for site-level in eCHIP under HPC
   b) Wide-scale efforts under consideration in other activities

Are the principal thrusts proposed within the pillars on target and appropriate for DOE to be pursuing?

- **Smart Charge Management and Vehicle Grid Integration**



Response options	Count	Percentage
Yes	**17**	**89%**
No	2	11%

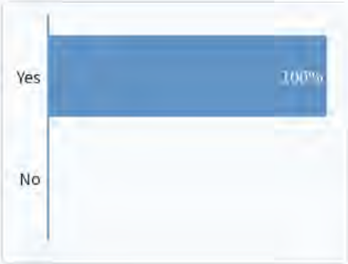
54%
Engagement

19
Responses

  - Make su
  - Much of this appears to be capabilities industry already has, is developing, and have commercial offerings.
  - Need to broaden the scope of what will be managed

Pillar Principals

- **High- Power Charging (HPC)**



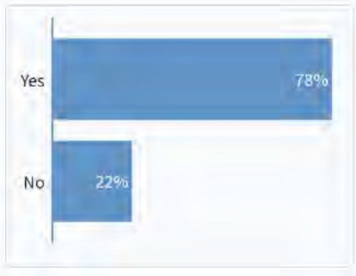
Response options	Count	Percentage
Yes	**10**	**100%**
No	0	0%

29%
Engagement

10
Responses

  – Add more on energy management and scheduling charging as well as microgrid management.

- **Dynamic Wireless Power Transfer (dWPT)**



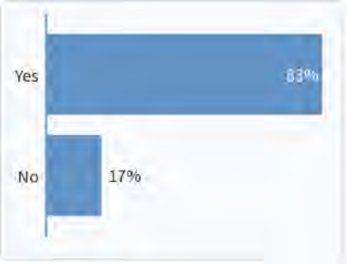
Response options	Count	Percentage
Yes	**7**	**78%**
No	2	22%

26%
Engagement

9
Responses

  - This pillar is probably the best to pursue autonomous connecting devices. Consider inclusion in the pillar.
  - Consider if there is any R&D worthwhile to pursue on Static WPT given lack of existing commercial adoption.
  - Need greater collaboration with industry and other organizations
  - Should this expand to include evaluation of alternative approaches to coil based dWPT?

- **Cyber-Physical Security (CPS)**



Response options	Count	Percentage
Yes	**10**	**83%**
No	2	17%

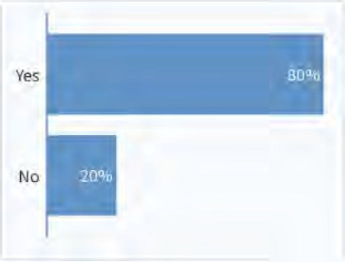
34%
Engagement

12
Responses

  - Not rapid enough
  - Standard/certification for EVSE: how do you explain to non-technical people what they need to be aware/concerned about?

Pillar Principals

- **Codes and Standards (C&S)**



Response options	Count	Percentage
Yes	**12**	**80%**
No	3	20%

43%
Engagement

15
Responses

  - Emphasize V2X
  - Identify highly dynamic pricing as the central mechanism for grid/DER coordination in general, for everything including EVs.
  - Timing is not on target. Missing coverage in standards for some topics.

Importance of Stakeholder Engagement

- **Our Bi-Annual Meetings and Deep-Dives are open to industry experts to help us better shape the R&D efforts for EVs@Scale.**
  - Deep-Dives: May 2023 Virtually
  - Next Bi-Annual Meeting: August 2023 @ Argonne

- **We need your input to identify:**
  - Partners for our R&D efforts to help with insight, data, and other resources.
  - Progress in our activities to ensure timely research is available to key stakeholders
  - Priorities for R&D that accelerates the transition to EVs at Scale.

Housekeeping for Today’s Discussion

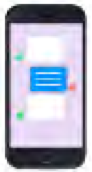
- **We are using PollEV to ask for your input**
  - Pillar Presentations
  - Panel Discussions
  - Roundtable Questions
- **Please be thinking during the discussions**
  - “Are the principal thrusts proposed within this pillar on target and appropriate for DOE to be pursuing?"
  - “Are there additional barriers / challenges within this pillar that DOE should be addressing?"

Audience Poll Questions

Join by Web

1. Go to **PollEv.com**
2. Enter **BURAKOZPINECI620**
3. Respond to activity

Join by Text



1. Text **BURAKOZPINECI620** to **22333**
2. Text in your message

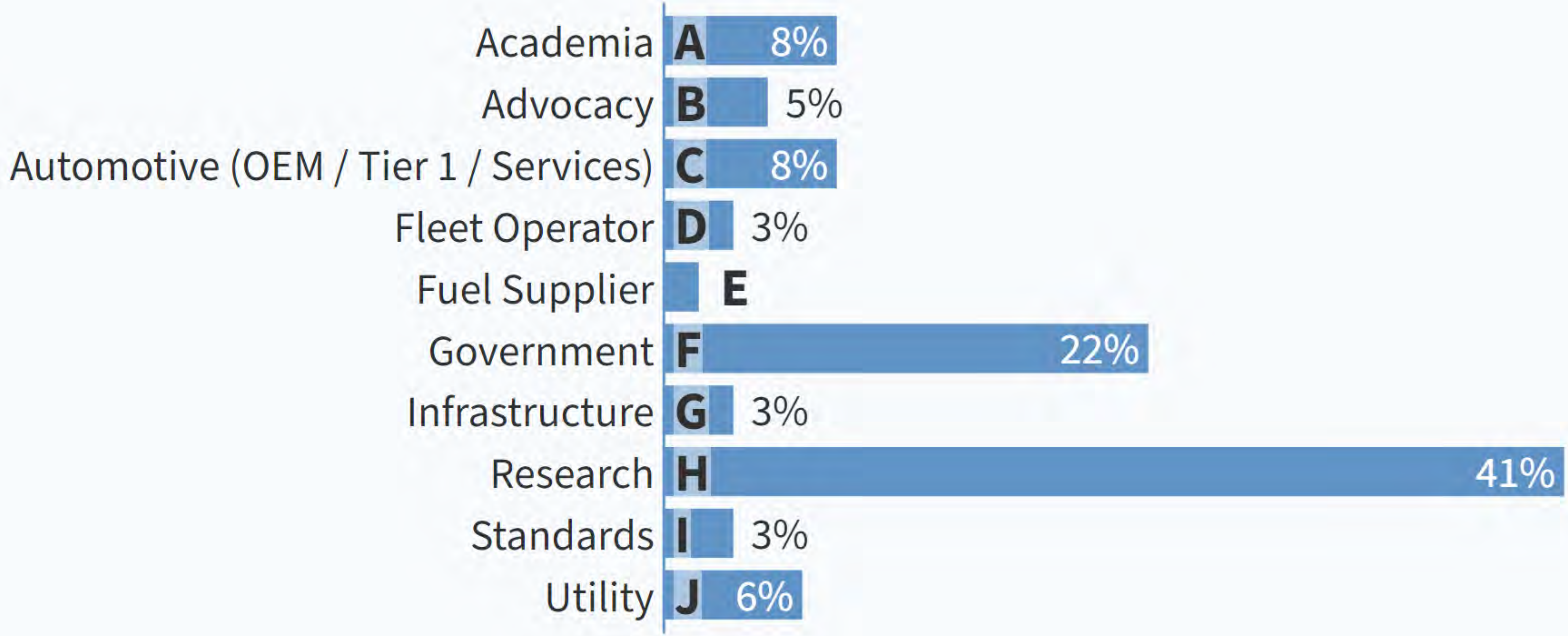
When poll is active, respond at **pollev.com/burakozpineci620**

Text **BURAKOZPINECI620** to **22333** once to join

Respond at **PollEv.com/burakozpineci620**

Text **BURAKOZPINECI620** to **22333** once to join, then **A, B, C, D, E...**

How would you characterize your organization/sector?



EVs@Scale

U.S. Department of Energy

Flexible charging to **U**nify the grid and transportation **S**ectors for **E**Vs at scale (FUSE)

Jesse Bennett

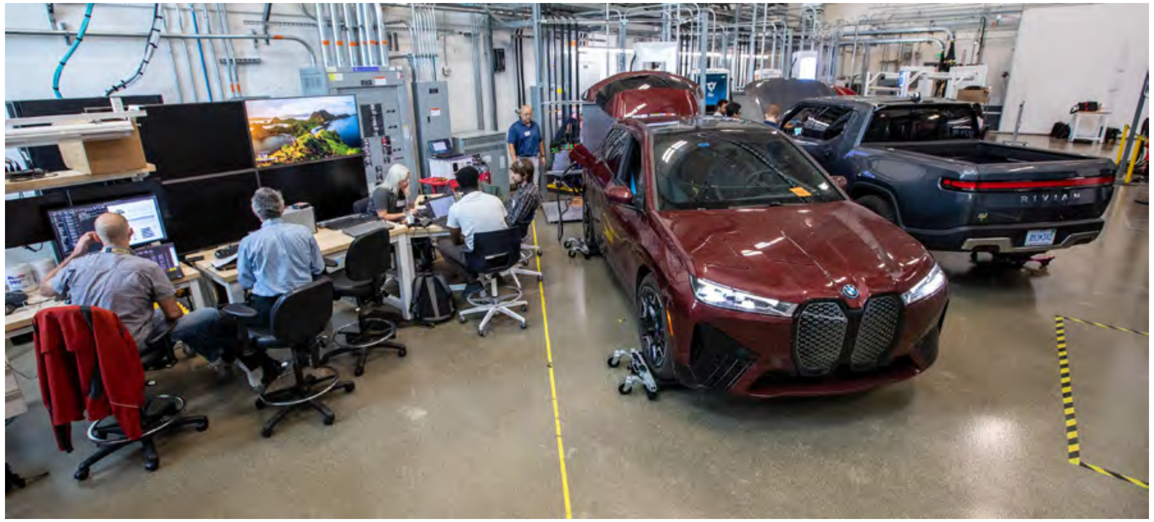
April 5, 2023

EVs@Scale FUSE - Overview

EVs@Scale
U.S. Department of Energy

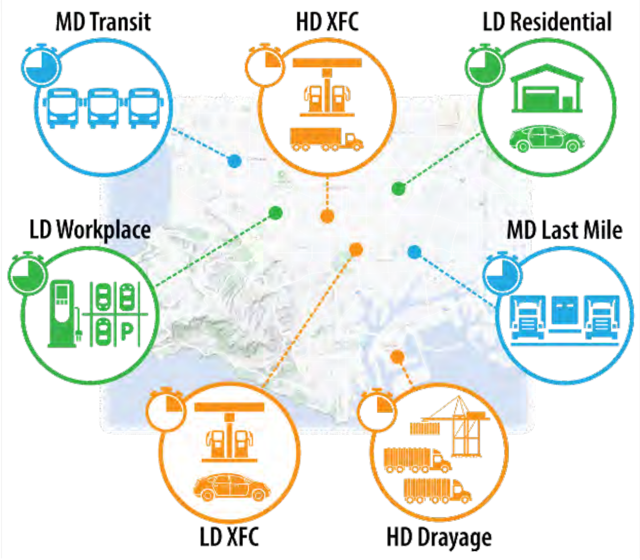
Objective:

- Develop an adaptive ecosystem of smart charge management (SCM) and vehicle grid integration (VGI) strategies and tools relevant to assess and reduce barriers to electrification throughout a wide geographic area and across numerous vocations



Outcomes:

- **Broadly identify limitations and gaps** in the existing VGI and SCM strategies to strategically shift PEV charging in time across a wide range of conditions
- **Develop enabling technologies** and demonstrate VGI approaches to reduce grid impacts throughout the entirety of the **LD, MD, and HD on-road electric fleet** while accounting for vehicle operational and energy requirements.
- **Determine SCM and VGI benefits** for consumers and utilities for EVs@Scale across the range of conditions (geographies and seasons) found in the US



EVs@Scale FUSE - Team and Partners

Team:

- **National Renewable Energy Laboratory (NREL)**
  - Vehicle Charging, Grid Impact Analysis, SCM/VGI Development and Demonstration
- **Argonne National Laboratory (ANL)**
  - SCM/VGI Development and Demonstration
- **Idaho National Laboratory (INL)**
  - Vehicle Charging Analysis, SCM/VGI Development
- **Sandia National Laboratories (Sandia)**
  - Grid impact Analysis

Industry Partners/Data Sources:

- **Electric Distribution Utilities**
  - Dominion Energy (100+ distribution feeder models throughout VA)
- **Vehicle Travel Data**
  - Wejo (~400 million trips throughout VA for Sept. ‘21 and Feb. ’22)

NREL Transforming ENERGY

Jesse Bennett
Matt Bruchon
Shibani Ghosh
Zhaocai Liu
Nadia Panossian
Priti Paudyal
Emin Ucer
Wenbo Wang
Mingzhi Zhang

Idaho National Laboratory

Manoj Sundarrajan
Steven Schmidt
Jean Chu
Tim Pennington

Argonne National Laboratory

Jason Harper
Bryan Nystrom
Dan Dobrzynski

Sandia National Laboratories

Andrea Mammoli
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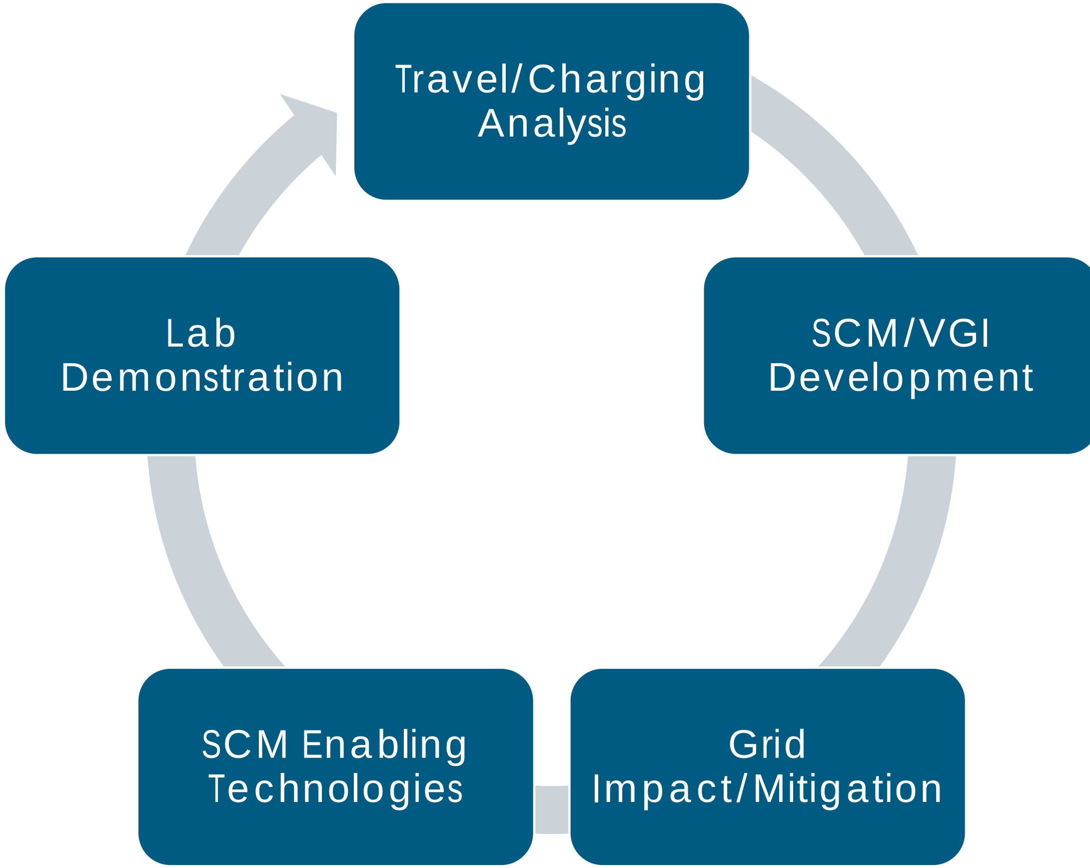
Matt Lave

EVs@Scale FUSE - Approach and Outcomes

- **This project will analyze and demonstrate SCM and VGI approaches to reduce grid impacts from EVs@Scale as a result of the charging needs of the LD, MD, and HD on-road electrified fleet.**

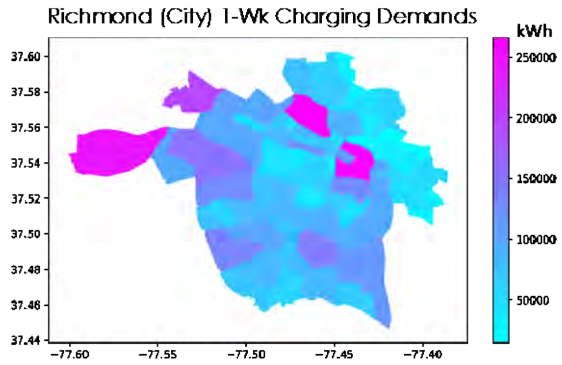
- **SCM/VGI Analysis**
  - Assess the potential charging demand for EVs@Scale and determine the uncontrolled charging grid impacts.
  - Develop and analyze the effectiveness of various VGI and SCM strategies at mitigating the grid impacts of charging EVs@Scale

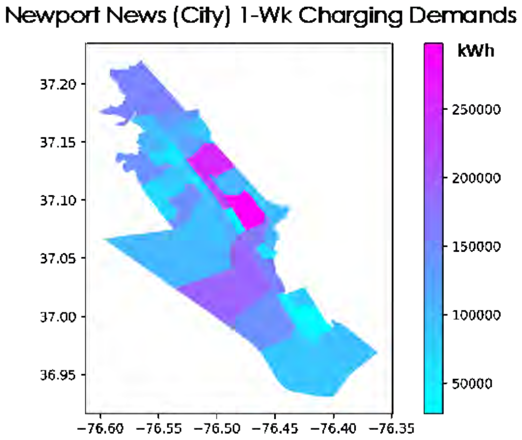
- **SCM/VGI Demonstration**
  - Expand on existing SCM/VGI strategies to adapt to the evolving needs EVs@Scale throughout a wide range of vehicles and vocations.
  - Develop enabling technologies to demonstrate the potential for new and existing SCM and VGI in a laboratory and real-world environment.
  - Coordinate with Codes and Standards Pillar to determine the potential of existing technologies and need for future developments.

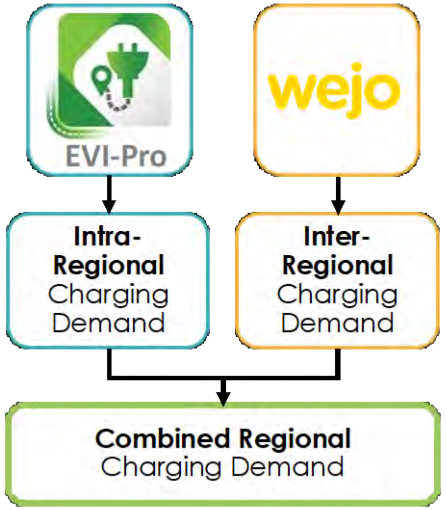


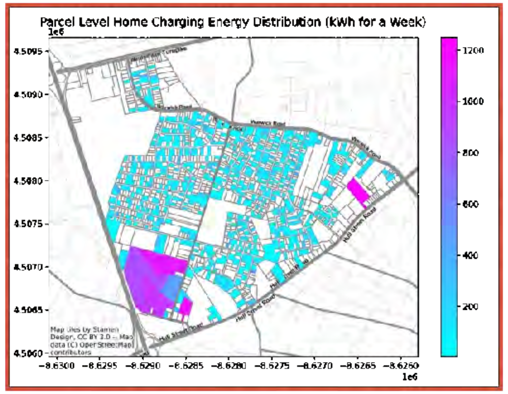
Vehicle Travel and Energy Analysis (FY22 Review)

- Trip data acquisition and preprocessing:
  - Wejo trip events data was purchased for September 2021 and February 2022 for the state of Virginia
  - Wejo trip events data cleaned and analyzed. 8 counties were selected to conduct trip itinerary and EV charging analysis
- EV adoption modeling:
  - County level LDV stock projection prepared using NREL's TEMPO
  - EV prediction was disaggregated to census tract level and DirectXFC vehicles
- Synthesize travel itineraries:
  - Unlinked Wejo trips were chained together to generate synthetic travel itineraries
  - Synthetic travel itineraries were validated against 2017 NHTS vehicle trip distributions
- EV charging simulation:
  - NREL's EVI-Pro was used to simulate EV charging behaviors, energy demands, and infrastructure requirements
- Generate location-specific load profiles:
  - On-going work to assign charging demands to specific locations (e.g., land parcels) by location type









Vehicle Travel and Energy Analysis (FY23 Update)

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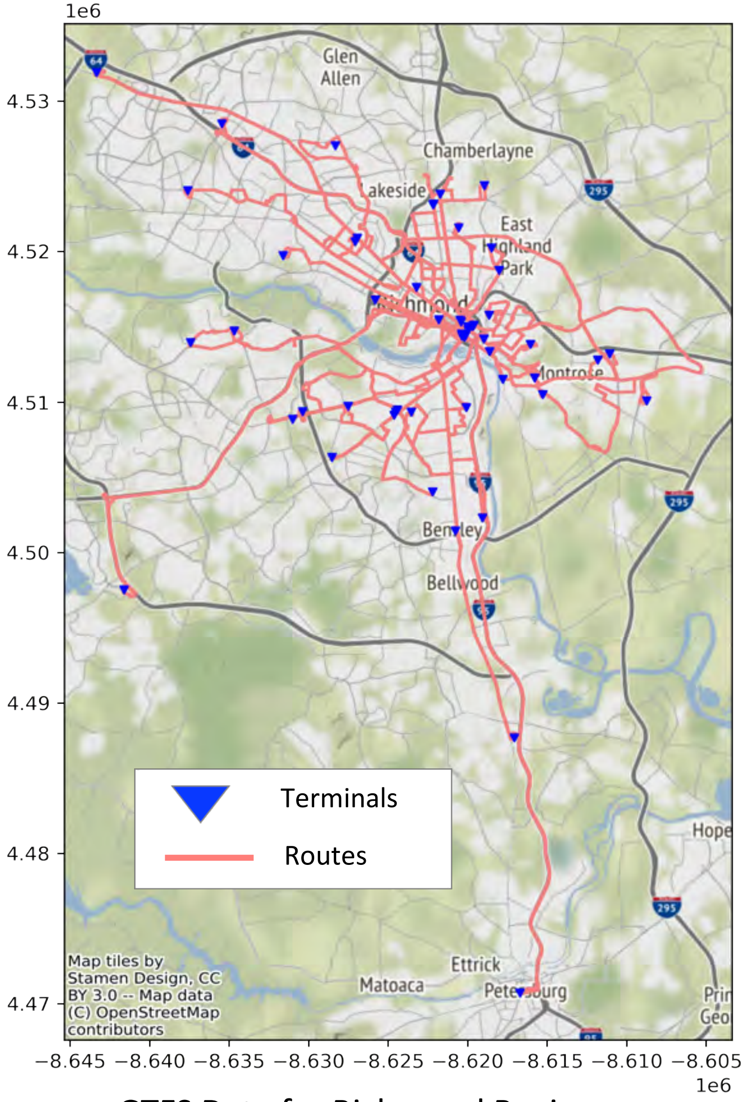
- **M/HD EV Analysis:**
  - National-level M/HD stock projection prepared; FUSE region stock projection modeling plan determined and projections under development
  - Finalizing contract with Geotab, a provider of M/HD trip data to be used to estimate travel and dwell patterns
    - In discussions with another M/HD trip data provider, StreetLight Data, regarding potential complementary data
  - Obtained GTFS transit system data for the Richmond region, working on charging demand analysis for transit buses.
- **LD EV Analysis:**
  - Facilitating use of passenger EV charging data sets for feeder selection
  - Working on updating the simulation to add more stochasticity to charging events
  - Working with the grid team to finalize the LD EV charging data sets
  - LD EV study to be presented at the 2023 INL DICE conference



GTFS Data for Richmond Region

Concentrated EVSE for an Equitable, Sustainable Future

EVs@Scale
U.S. Department of Energy

- **Existing EVSE cannot support full-scale adoption of EVs**
- **New EVSE is required – but where to invest optimally?**
- **EVSE “Deserts”**
  - Limited or no access to EVSE discourages adoption
  - Investment in infrastructure typically follows demand
  - Vicious cycle distorts real potential for a just adoption
- **EVSE “Oases” could reverse the problem**
  - Promote EV adoption via improved access and visibility
  - Provide opportunities for evaluating incentives
  - Speed of charge / cost / technical feasibility / access must be well-understood to avoid costly failures

Photo by Jordan Allen Walters on Unsplash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Location Selection Methodology for Concentrated Charging

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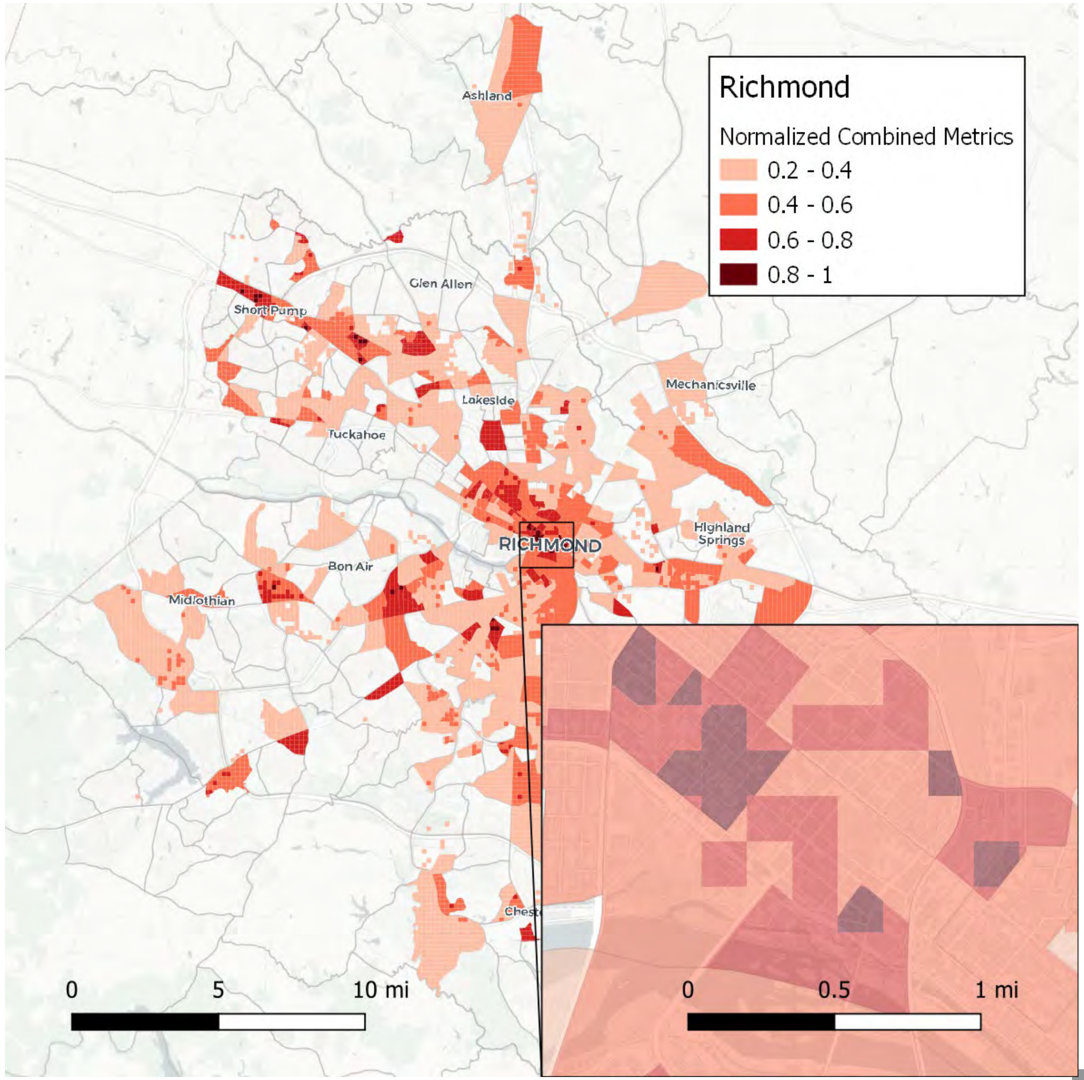
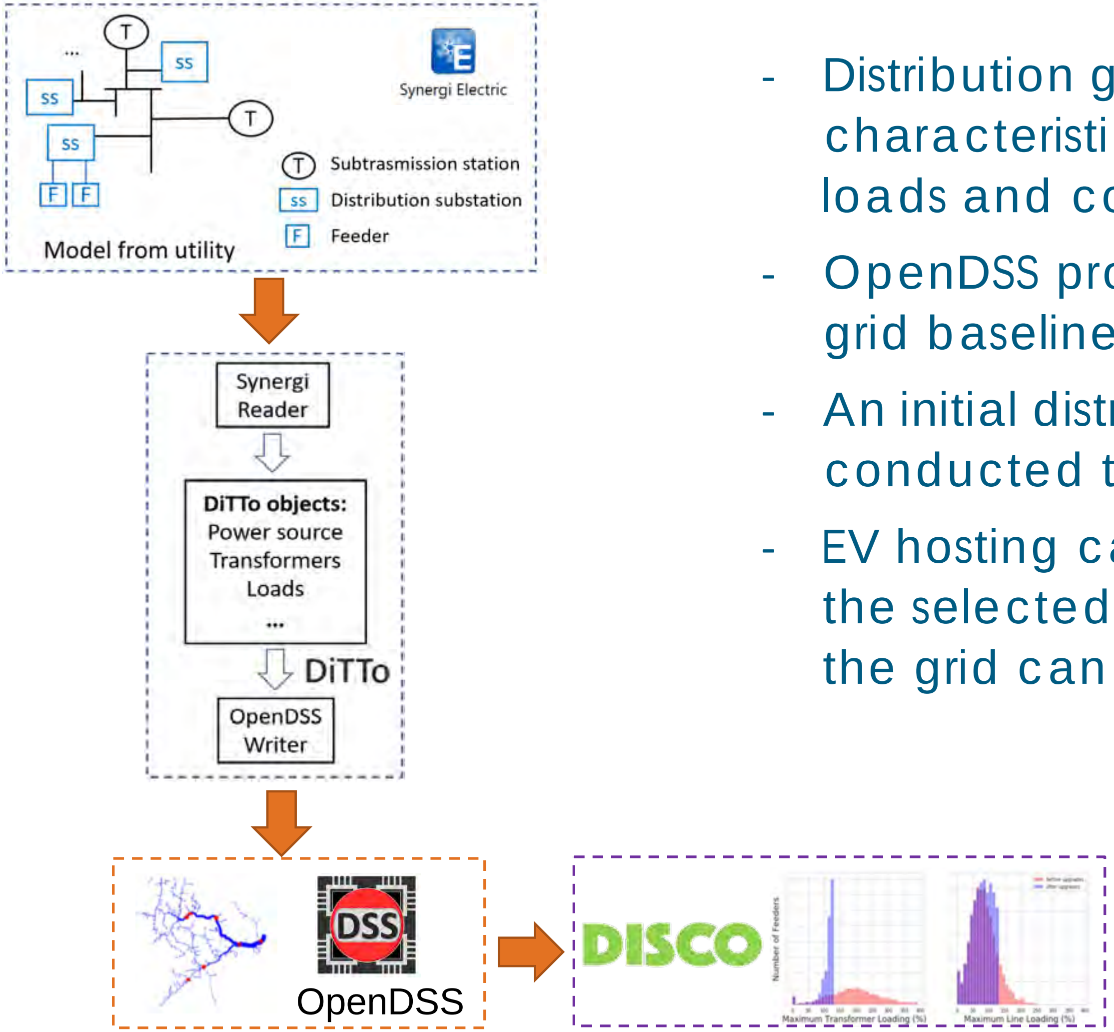
- **Newport News and Richmond (VA) considered**
- **Geographic Data used**
  - Census: Multi-unit housing population, renter population, cars owned by renters
  - Open Street Map: Parking lot location and size
  - Wejo vehicle Travel Data: Dwell time at location
- **Geographic resolution**
  - Census block groups overlayed with 250x250 m grid (~ 15.4 acre, ~12 American Football Fields)
- **Weighted combinations for specific scenarios**
  - Census and OSM data only (No Wejo data considered)
  - Long Dwell (over 5 hours – suitable for L2 charging)
  - Short Dwell (L3 Charging preferred)



NREL Grid Update

- **Grid model conversion process through NREL-DiTTo**



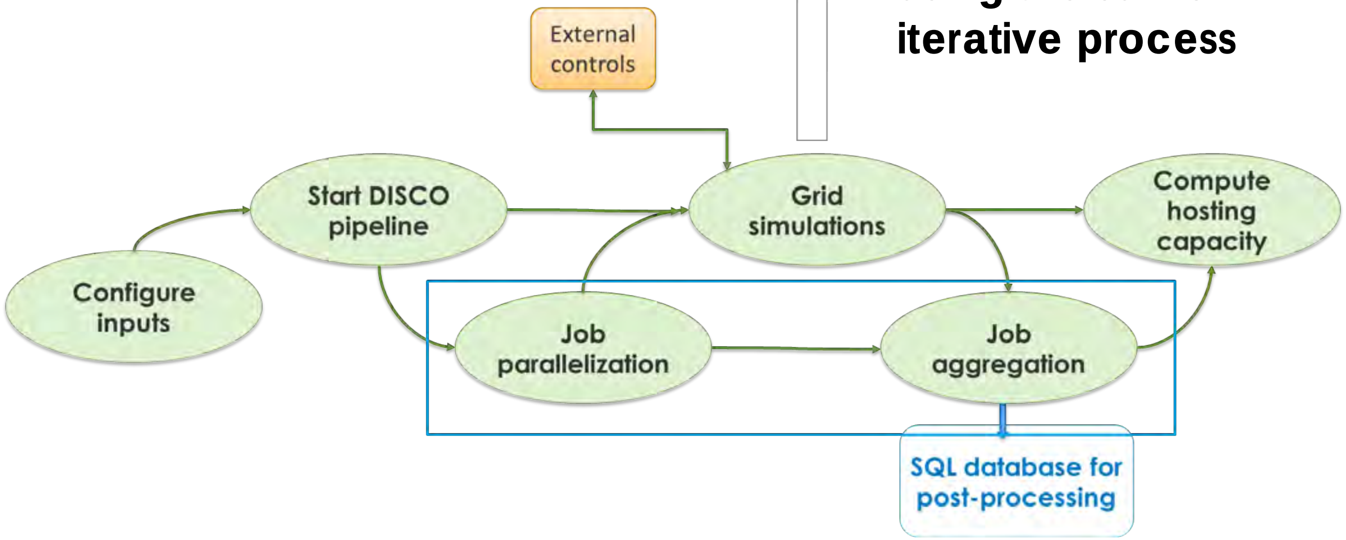
- Distribution grid models include topological and electrical characteristics of existing assets such as lines, transformers, loads and control devices
- OpenDSS provides an open-source platform to model a grid baseline based on data received from utility partner
- An initial distribution upgrade analysis for baseline can be conducted through an in-house tool, DISCO
- EV hosting capacity and placement will be evaluated for the selected feeders, revealing how much additional load the grid can accommodate in terms of EVSE loads

• Computing hosting capacity at scale

DISCO

- Provides a modular framework for distribution systems analysis
- Open-source Python application
- Can work on Laptop, standalone server, or HPC cluster to scale up number of simulations

Conducts EV hosting capacity for N number of feeders using the same iterative process



Performance Parameters
- Voltage and thermal limitation
- Thresholds can be customized depending on use cases

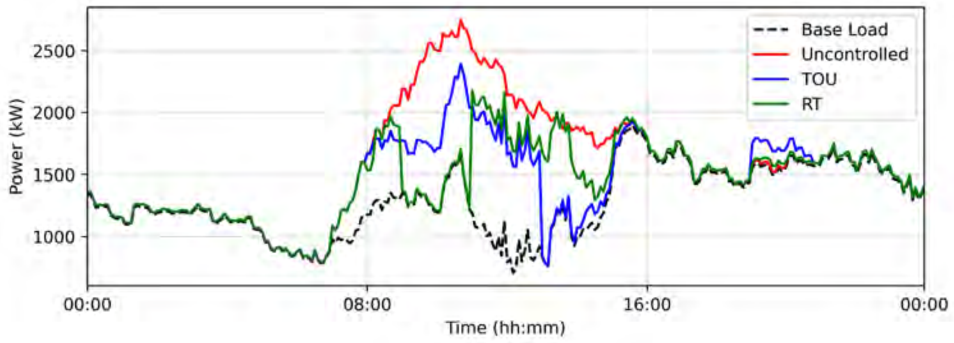
Feeder Data/Models
- Planning models can be used with worst case load representations
- Account for some uncertainties and assumptions

EV Hosting Capacity
- Nodal/feeder section hosting capacity
- EV scenarios can be reflected in hosting capacity levels for circuit maps

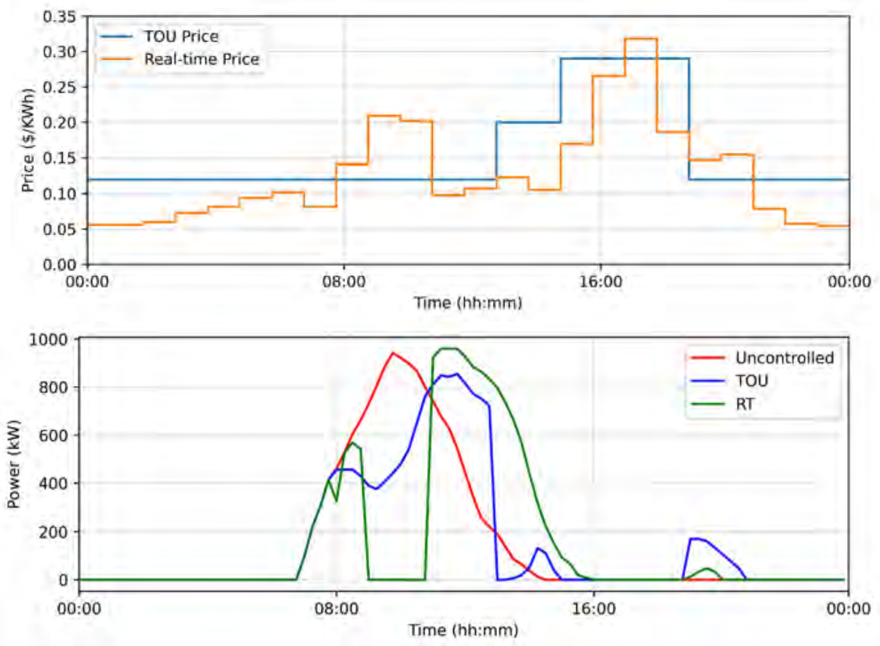
SCM Control Development (NREL)

Real-time Pricing Based Smart Charging Control

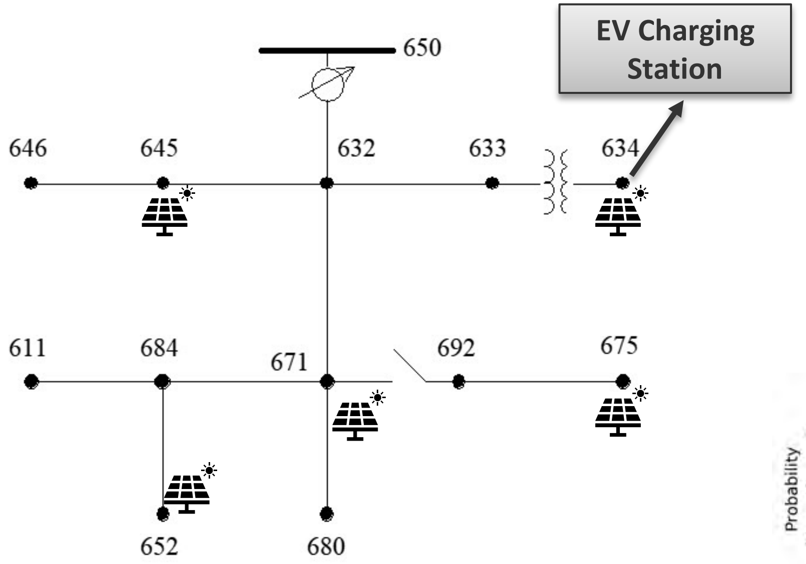
- Meet the energy needs of EVs prior departure and minimize the total charging cost under the time-of-use (TOU) and real-time (RT) pricing scheme.
- EV charging loads have great temporal flexibility and dynamic pricing scheme can effectively shift the EV charging loads to less-demanding periods.
- The real-time (RT) pricing scheme is updated daily to better reflect short-term power supply and demand conditions than the seasonal variated time-of-use (TOU) scheme.



Feeder power variations during the day

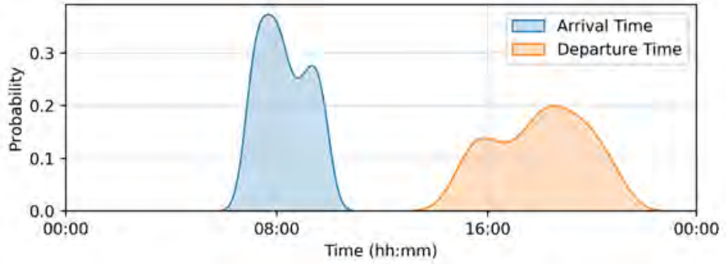


Total EV charging power during the day



Case setup:

- Workplace charging: 100 EVs with different arrival and departure time.
- Each EV has a random initial SOC (20%-60%).
- EV battery size: 60 KWh.
- Maximum charging power: 9.6 KW.
- Total PV installment capacity: 1000 KW.



Arrival/departure distributions of EVs

Regional EV charging and SCM analysis (INL)

EVs@Scale
U.S. Department of Energy

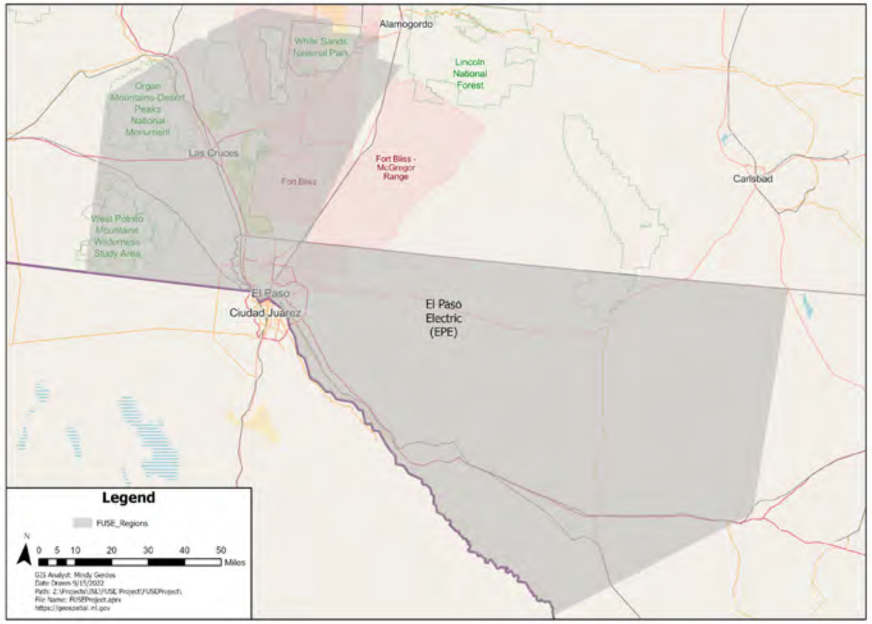
Objective: Address the limitations of existing SCM strategies at a regional level in a range of geographic and seasonal conditions in EVs-at-Scale scenario.

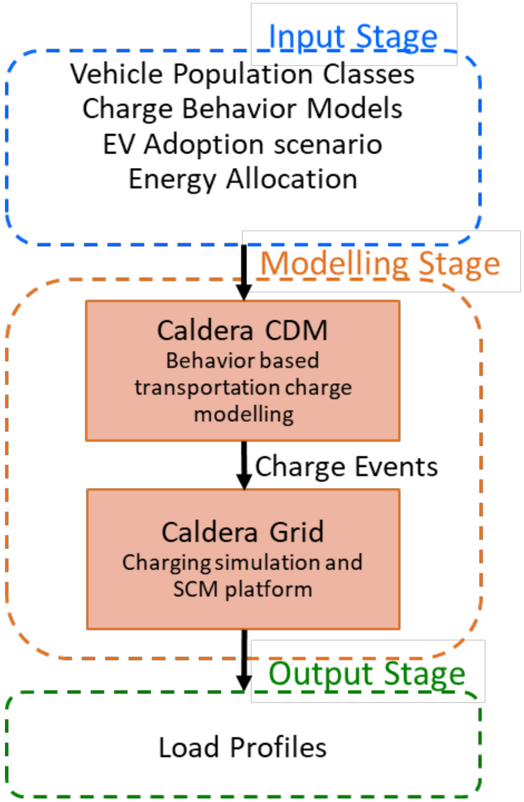
Methodology: The charging behavior of a population of EVs in a region is derived using collected trip itinerary data. The Caldera CDM software tool using stochastic modelling generates charge events from the charging behavior models. SCM strategies are applied on the charge events and generate power profiles using the Caldera Grid tool to study and address the limitations of the strategies.

Case Study:

- El Paso Electric (EPE) service territory.
  - high solar potential
- 384,363 LD EVs for the year 2040 with 50% adoption rate from TEMPO.
- WEJO trip data in Virginia state is used to derive the charging behavior for the EVs.
- Two energy allocation scenarios.
  - home dominant (H:60, W:10, P:30)
  - work dominant (H:20, W:50, P:30)
- Renewable following SCM strategies were studied to take advantage of excess solar generation.
  - Time-of-use (TOU) random during solar
  - Centralized aggregator optimized for solar

El Paso Electric (EPE) Region





Regional EV charging and SCM analysis contd. (INL)

Results:

Home-dominant controlled:

- Both solar TOU random and solar centralized aggregator strategies struggled to shift charging towards the solar period due to the majority of cars only charging at home at night.

Work-dominant uncontrolled:

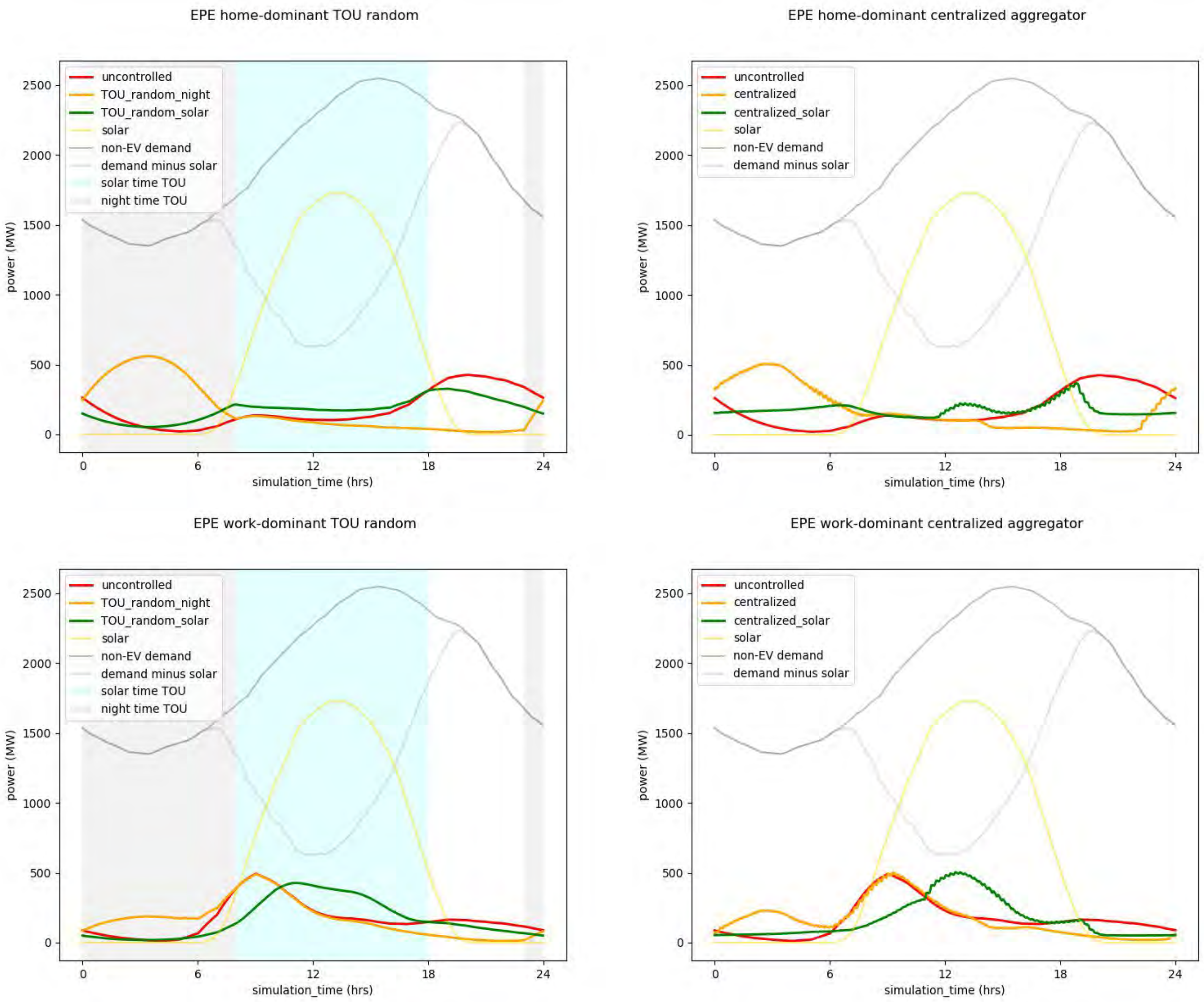
- A significant amount of charging shifted from nighttime to daytime due to EVs charging at work but the charging peak does not coincide with the solar peak.

Work-dominant controlled:

- Both solar TOU random and solar centralized aggregator strategies we able to shift charging towards the solar peak.

Future Work:

- Simulations on four other geographic regions and different seasons are in progress.
- MHDV charging behaviors will be added to the charging behavior models.
- Agent-based simulations will be studied to understand the impacts of charge scheduling and stationary energy storage (SES).



SCM Demonstration/OCPP Characterization (NREL)

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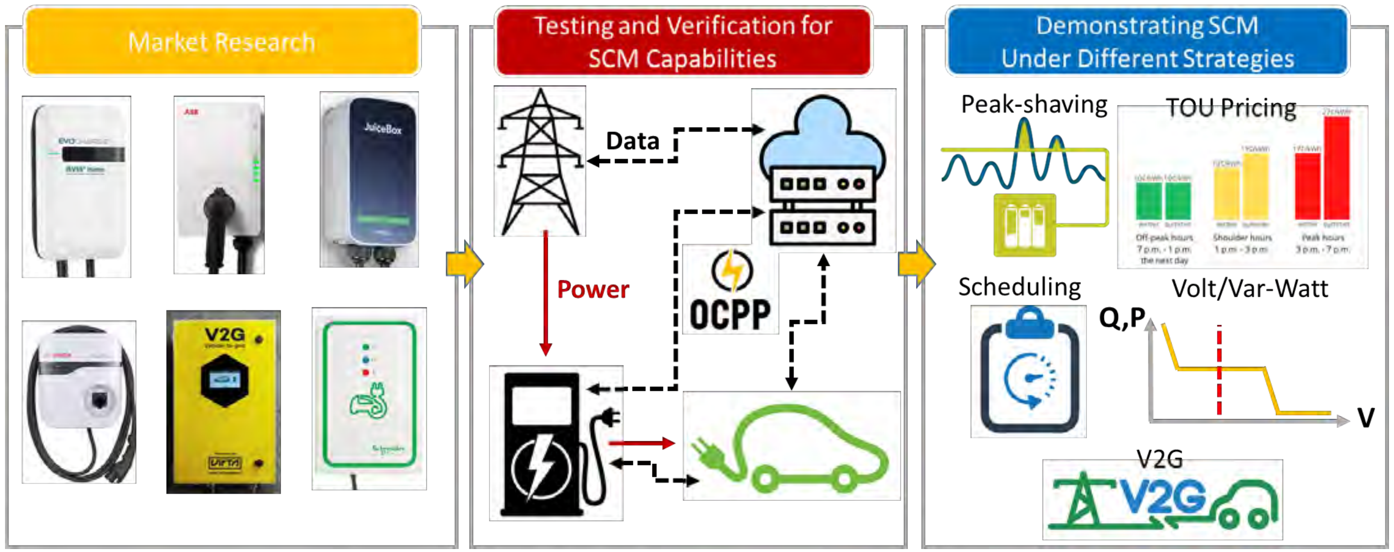

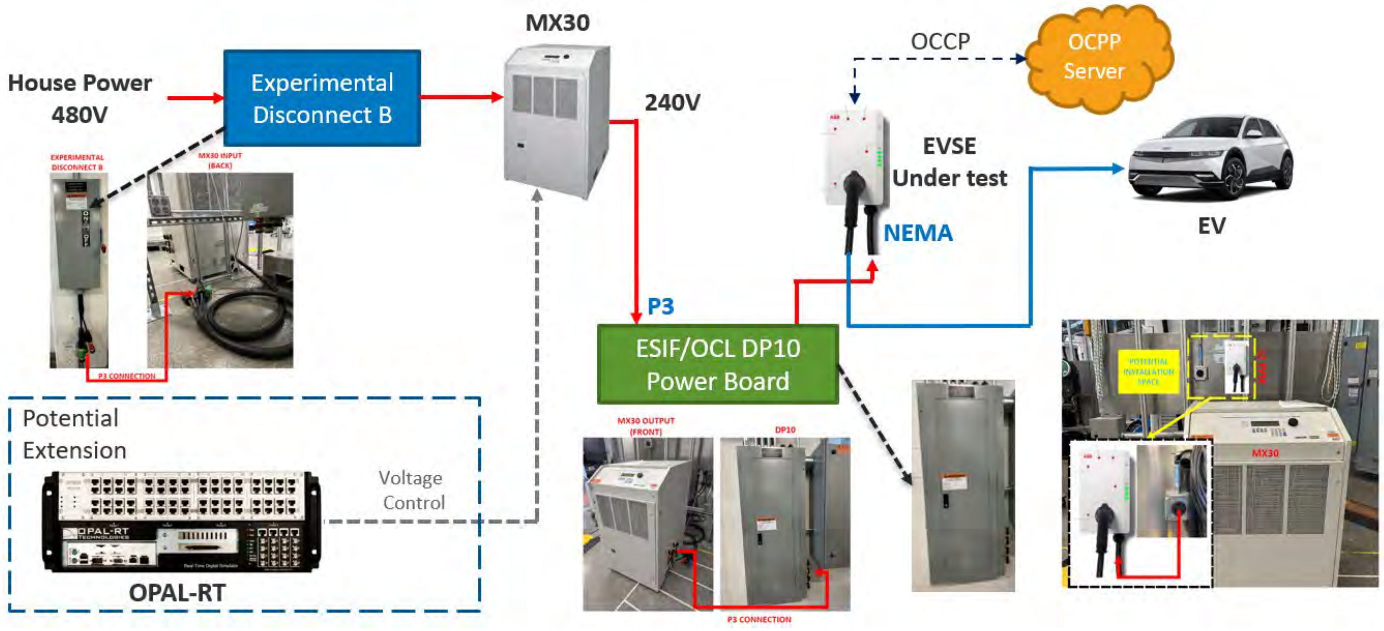

- ✓ EVaS FUSE will characterize the performance of SCM controls with current market offerings of EVSE
  - Test the response and precision of OCPP 1.6J
  - Test the improvements and differences in OCPP 2.0.1
- ✓ Characterization and testing of SCM performance will:
  - Better inform FUSE analysis to reflect real-world SCM performance under a wide range of conditions
  - Identify current SCM capabilities and gaps under existing standards and protocols
- ✓ Plan for long-term goals of CHIL/PHIL testing with Dominion Feeders and representative charging needs

Potential testing plans

- OCCP server response time
- Vehicle response time
- Testing and verification of SCM capabilities
- EVSE response to communication failure
- Vehicle response to power outage
- EVSE and vehicle response to voltage sags and drops
- EVSE and vehicle response to harmonic distortion (optional)
- Volt/watt control (if possible)
- OCPP voltage measurement

Research Development and Demonstration (ANL)

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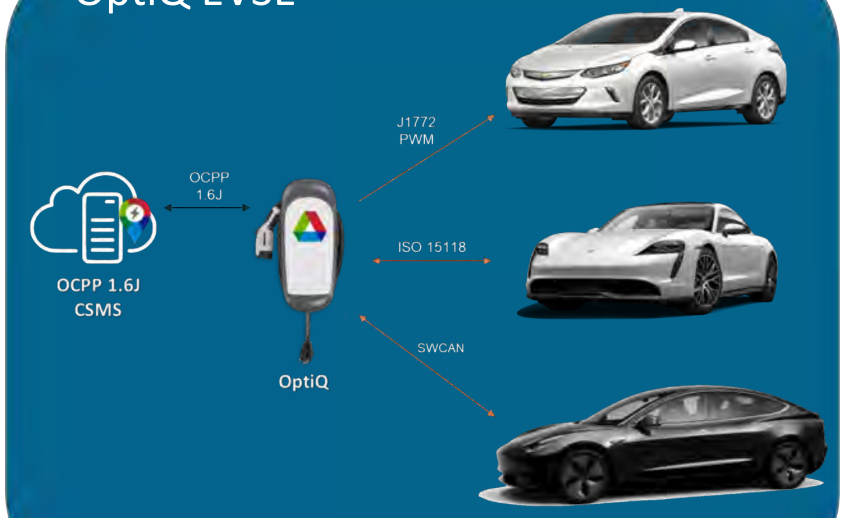
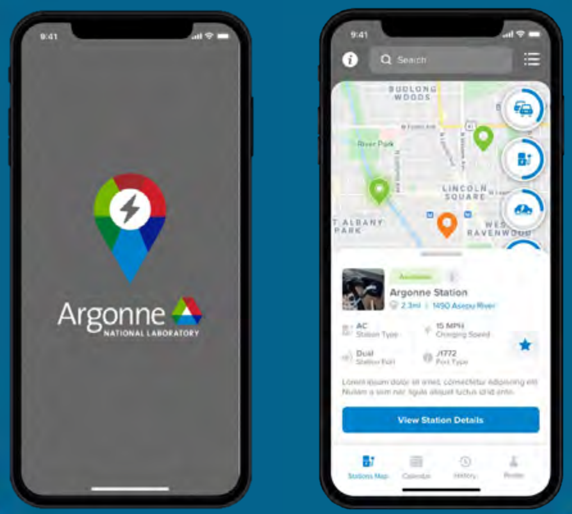
OptiQ EVSE



- Smart EVSE Capable of 3 "versions" of AC Charging
  - Analog (J1772 PWM)
  - Digital (ISO 15118-2)
  - Digital (Tesla SWCAN)
- Currently Working Integrating Tesla SWCAN into Application
- 2 Proof of Concept Stations Deployed at Argonne for Employee Use
- Recently Demonstrated ISO-15118-2 Charging

EVrest



- EV Charge Reservation Mobile App
- Allows EV Drivers the Ability to Reserve a Specific Port/Station for Future Use
- Integrates with ANL's OCPP CSMS Platform to Enable Future Smart Charging Algorithm Development and EV Charging Behavior Research
- Finishing up testing and will deploy Q3 FY23 at Argonne

Charge Scheduler Bridge

- Application that Integrates into EVrest to Schedule EV Charging on Behalf of non-ISO 15118 EV/EVSE
- EV Agent Deployed on Behalf of the EV to ensure Energy Requirements are Met by Departure Time
- Demonstrated Q2 FY23

Review

- LDV Charging Analysis
- Grid Modeling and Concentrated Charging
- SCM Control Development
- Developing Enabling Technologies/OCPP Testing

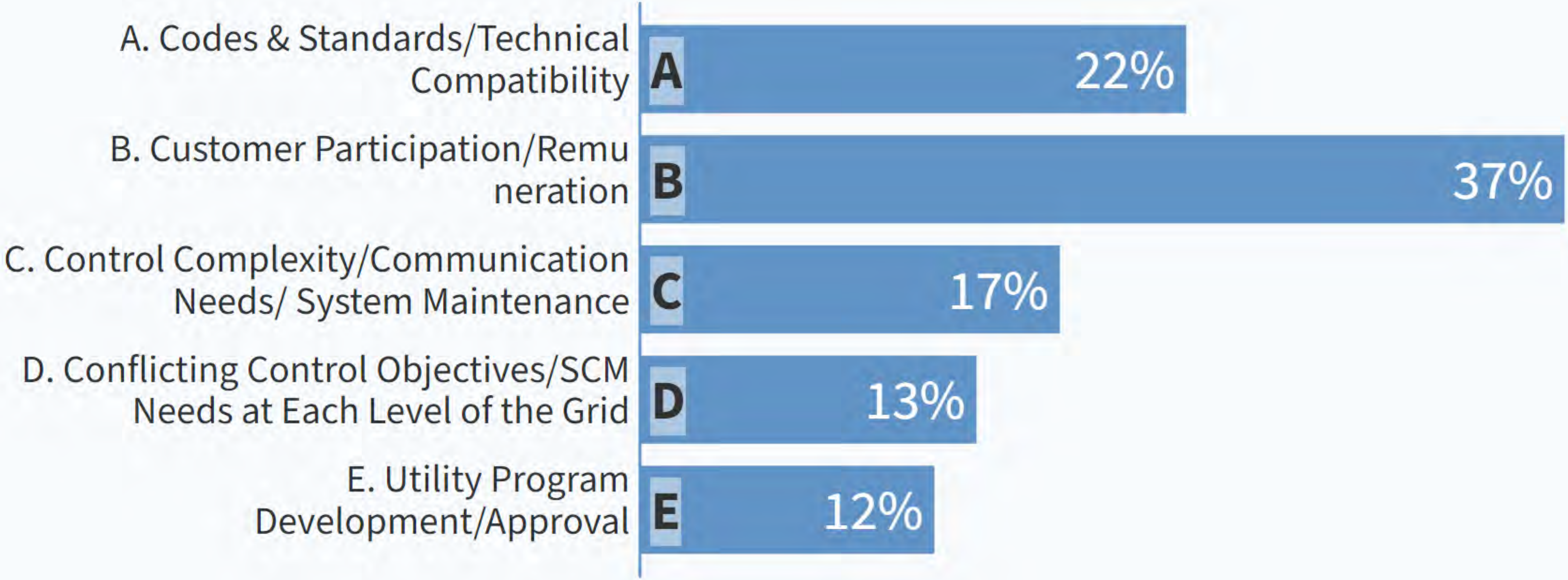
Next Steps

- MHDV Charging Analysis
- Co-simulation uncontrolled/controlled grid impact analysis
- Demonstration of SCM Enabling Technologies

Respond at **PollEv.com/burakozpineci620**

Text **BURAKOZPINECI620** to **22333** once to join, then **A, B, C, D, or E**

What do you think will be the toughest barrier to SCM implementation?



EVs@Scale

U.S. Department of Energy

Thank You

Join us for the
SCM/VGI Deep Dive

Thursday May 18th 2:00-5:00 pm EDT

EVs@ Scale
U.S. Department of Energy

High-Power Electric Vehicle Charging Hub Integration Platform (eCHIP)

John Kisacikoglu, NREL

April 5, 2023

Outline

- **Project Overview**
- **Status Review for High-Power Charging Technology Based on “DC Hub” Approach**
- **DC Charging Hub Hardware Development**
- **DC-DC Charger Power Electronics Development and Controller Integration**
- **Site Energy Management System**
- **Charging Test Results**
- **Conclusion and Next Steps**

Project Overview

Objective: Develop plug-and-play solution allowing charging site to organically grow with additional chargers and distributed energy resources through predefined compatibility with standards that will ensure interoperability and reduce upfront engineering expense

Outcomes:

– Develop and demonstrate solutions for efficient, low-cost, and **high-power-density DC/DC** for kW- and MW-scale charging
– **Broadly identify limitations and gaps** in DC distribution and protection systems that allow for modular HPC systems
– Determine interoperable hardware, communication, and control architectures for high-power charging facilities that support **seamless grid integration and resilient operation**

- John Kisacikoglu (PI)
- Shafquat Khan
- Rasel Mahmud
- Alastair Thurlbeck
- Emin Ucer
- Ed Watt
- Mingzhi Zhang

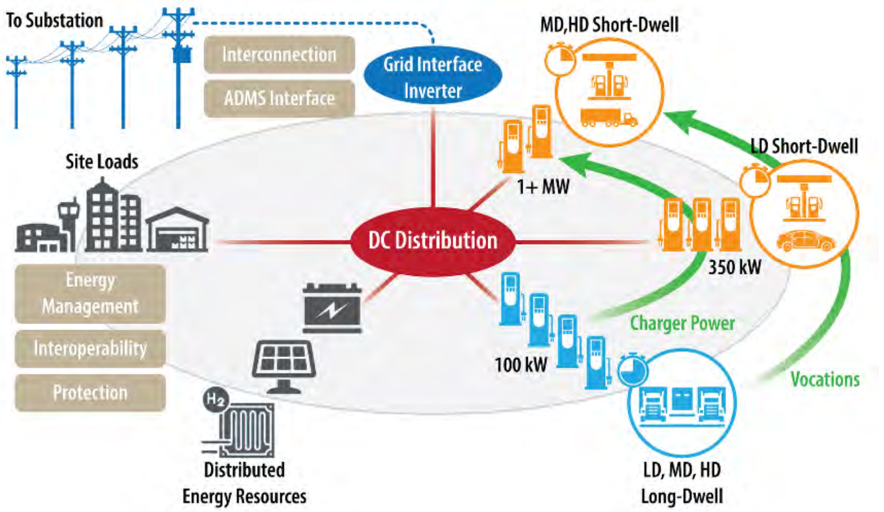
NREL

- Jason Harper
- Akram Ali
- Bryan Nystrom

Argonne National Laboratory

- Prasad Kandula
- Steven Campbell
- Madhu Chinthavali

Oak Ridge National Laboratory



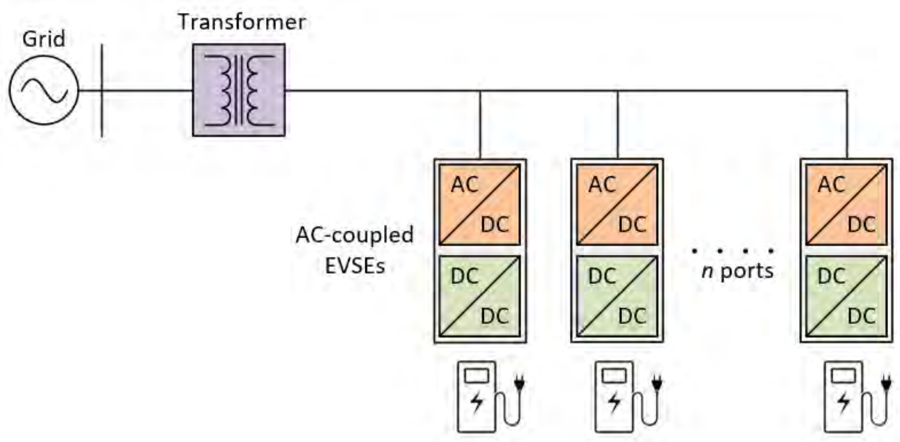
Overview of DC Hub Approach

Why a DC hub?

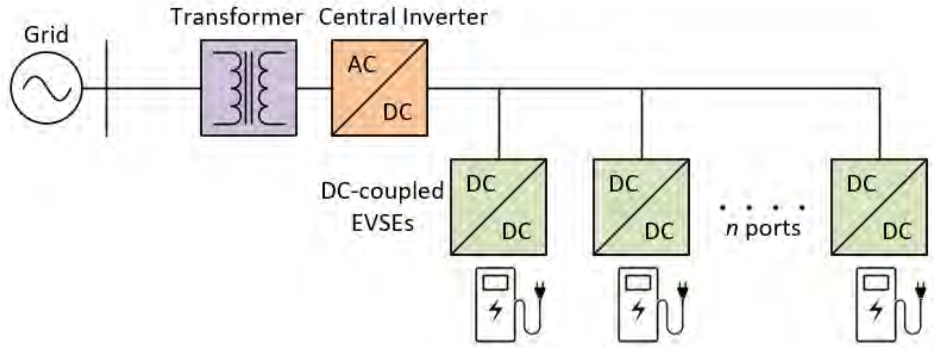
- Higher inverter utilization
- More natural and flexible interface with EV, PV, and ESS
  - Fewer conversion stages
  - Higher efficiency
  - Reduced size and cost of components
  - Simplified controls (no AC sync., no Q-control)
  - Easier scalability
- No reactive power flow in system

Issues with DC Hub:

- More complex protection
- Product immaturity
- Lack of standardization



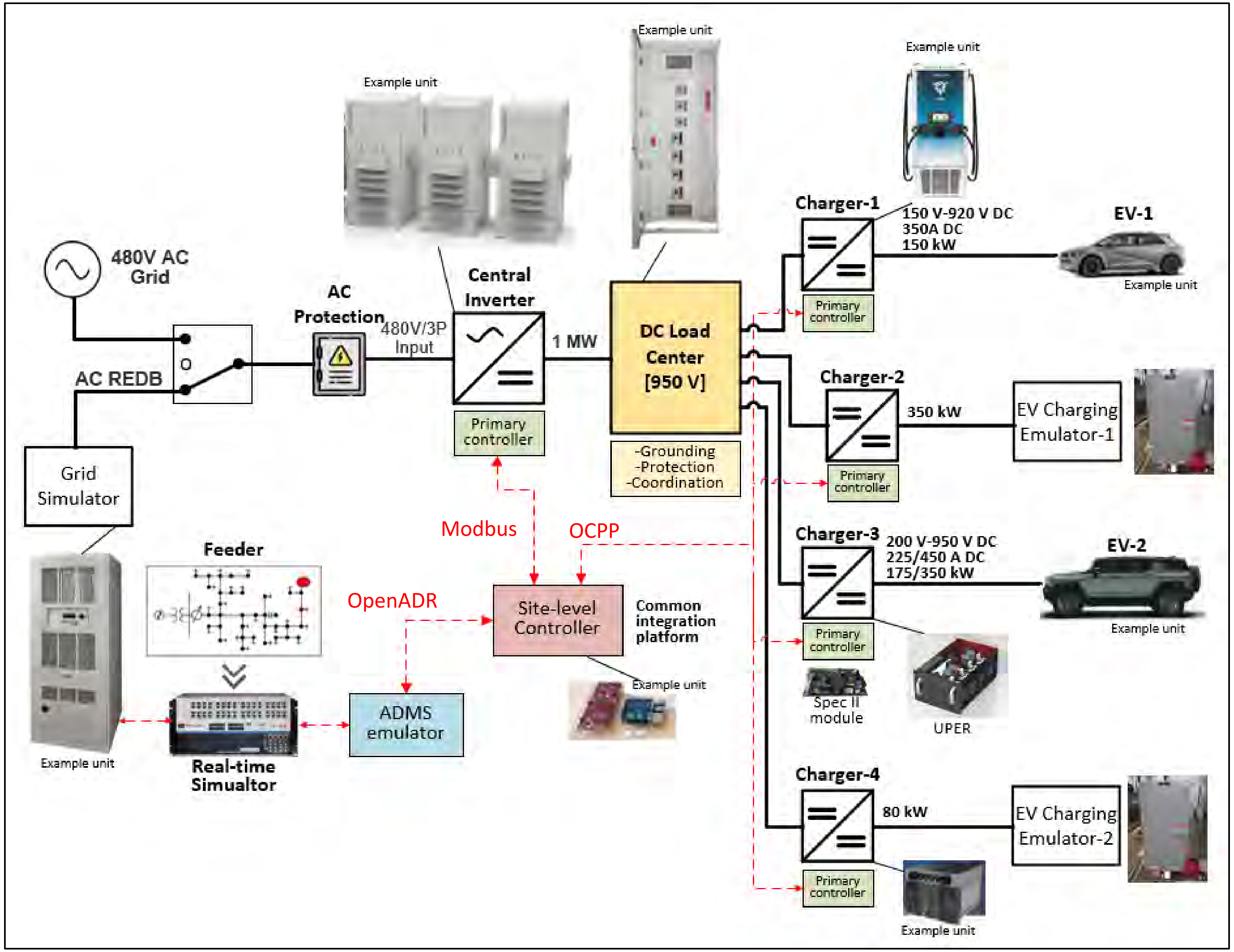
AC-Hub option



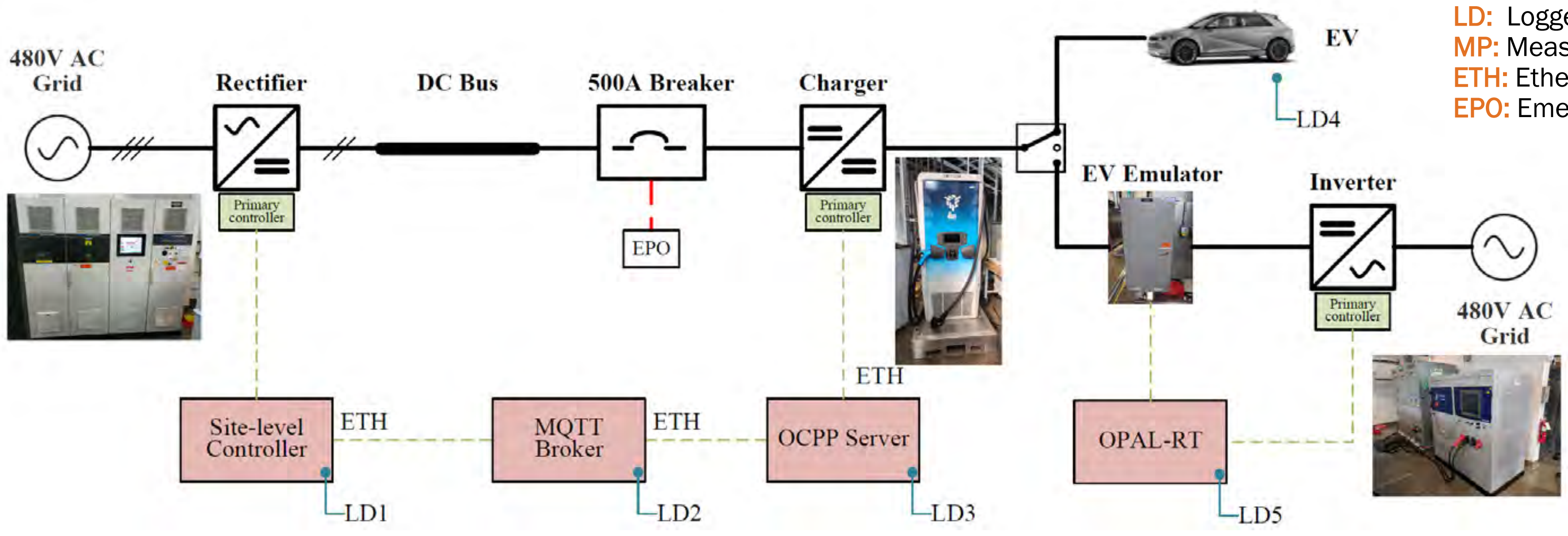
DC-Hub option

Overview of DC-Hub HPC Station Architecture

- Representative power and communication architecture for DC-hub chargers
- Three research topics are investigated:
  - Power architecture development
  - Site energy management (SEM)
  - Grid integration and standardization



Current Setup Overview and Specifications



LD: Logged data
MP: Measurement point
ETH: Ethernet
EPO: Emergency power off

Component Type	Voltage Rating	Current/Power Rating
Inverter/Rectifier	265-1000 VDC	660 kW
DC Bus	1000 VDC	500 A
DC Breaker	1000 VDC	500 A
DC-DC Charger	Input: 950V DC	150 kW
	Output: 150-920 VDC	
EV Battery	800 VDC	235 kW

DC-DC Charger Development

EVs@Scale
U.S. Department of Energy

A 1000 V class 175/350 kW charger and 1500 V class 350 kW charger are being built.

Multi-Dimensional Improvement v/s SOA

High power Building block
Enable MW+ Charging
350 KW instead of 125-150 kW

Power density
Frequency > 20 kHz, η > 99%
Enable two men carry < 80 Lbs

Higher Working voltages
Distribution DC voltage increased to 2 kV
Vehicle voltage increased to 1500 V

Bidirectional Power (V2X)
Controls to enable
bidirectional power transfer
while maintaining low loss

UPER: Universal Power Electronics Regulator

1700 V, 280 A/560 A, SiC

1000 V class 175 kW/350 kW charger	
Vin	800-1200 V
Vout	200-950 V
Imax	225 A/ 450 A
Eff	>98.5%
Temp	-30°C to 50°C
Comms	CAN
Powerflow	Bidirectional

3300 V, 500 A, SiC

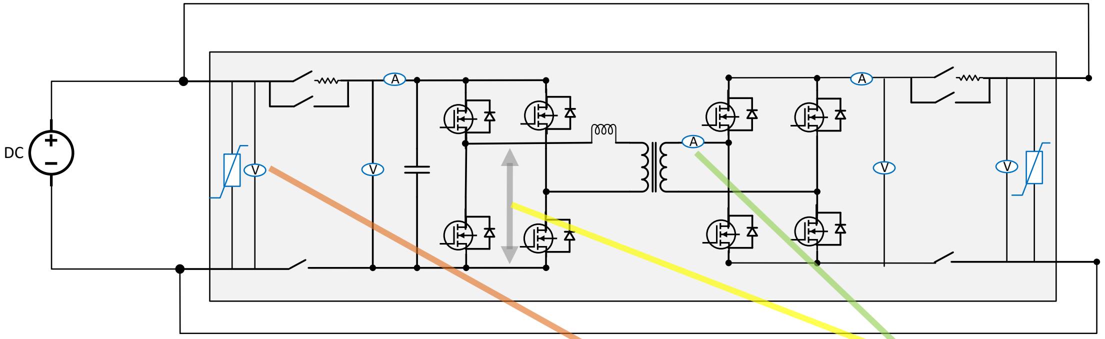
1500 V class 350 kW charger	
Vin	1500-2000 V
Vout	500-1500 V
Imax	250 A
Eff	>99%
Temp	-30°C to 50°C
Comms	CAN
Powerflow	Bidirectional

Specifications of charger under development

Initial 1000V Class Charger Test Results

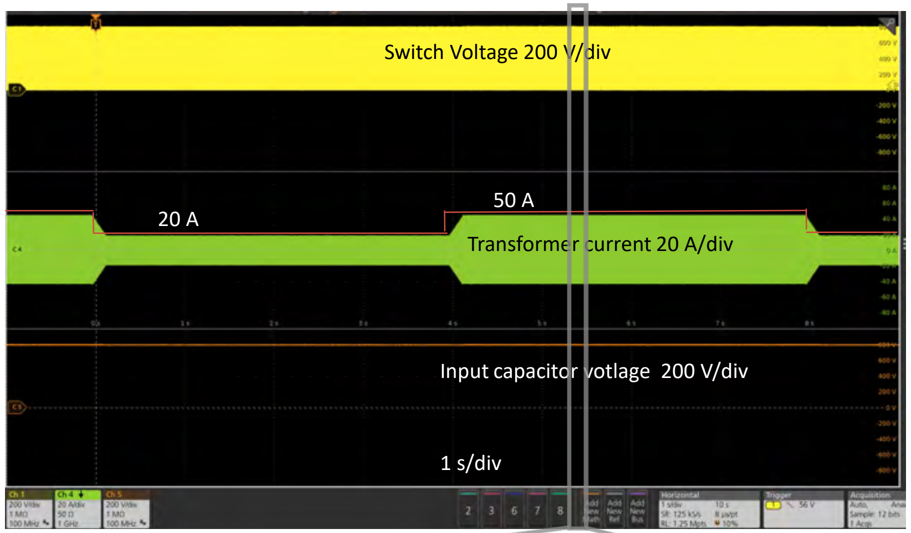
1000 V, 175 kW Dual-Active-Bridge based charger was built and tested.

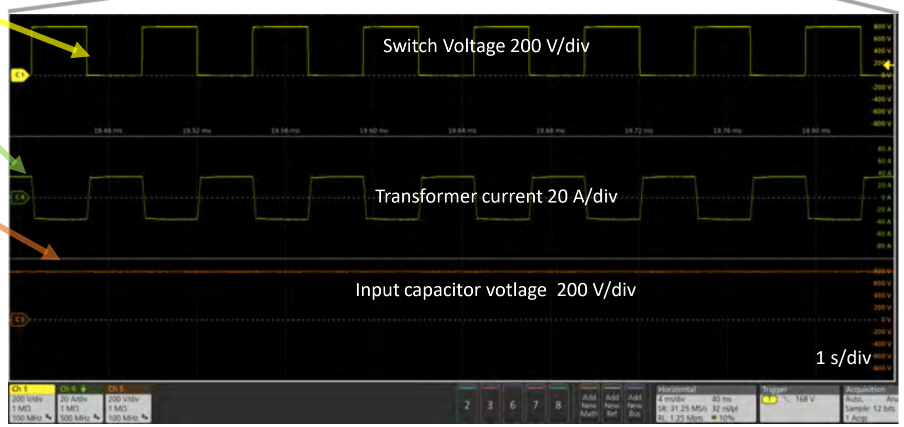
1000 V, 0.5/1 MW Charger



1000 V, 175 kW, 20 kHz DC/DC Charger

Initial Results at 800 V and 50 A

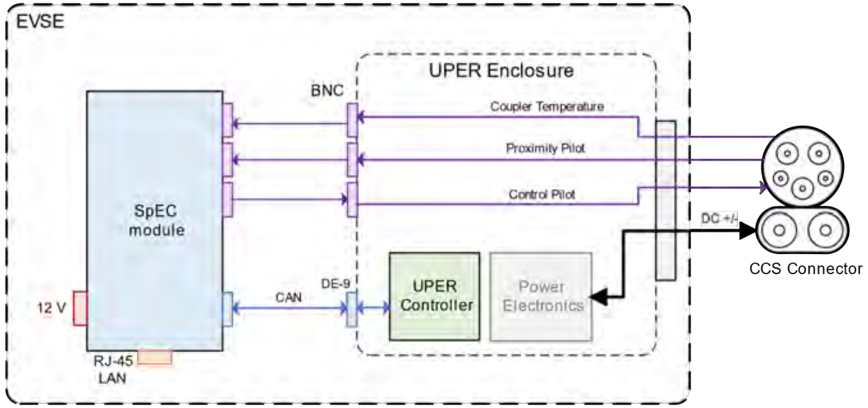




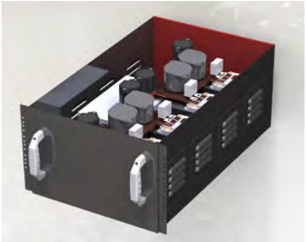
UPER- SpEC II Integration Update

Development of hardware and software integration specifications between SpEC and UPER

- Communication protocol and specifications
- CAN interface messages descriptions
- Physical wiring specifications and interface
- Software implementation and testing



SpEC II module (ANL)

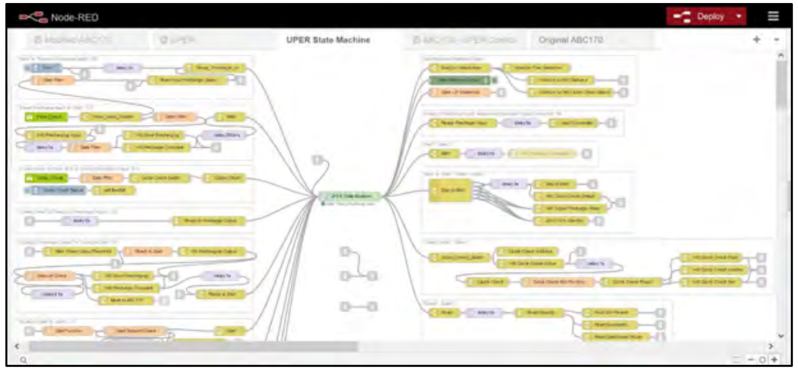


UPER – DC/DC converter (ORNL)

Development of UPER Emulator for testing

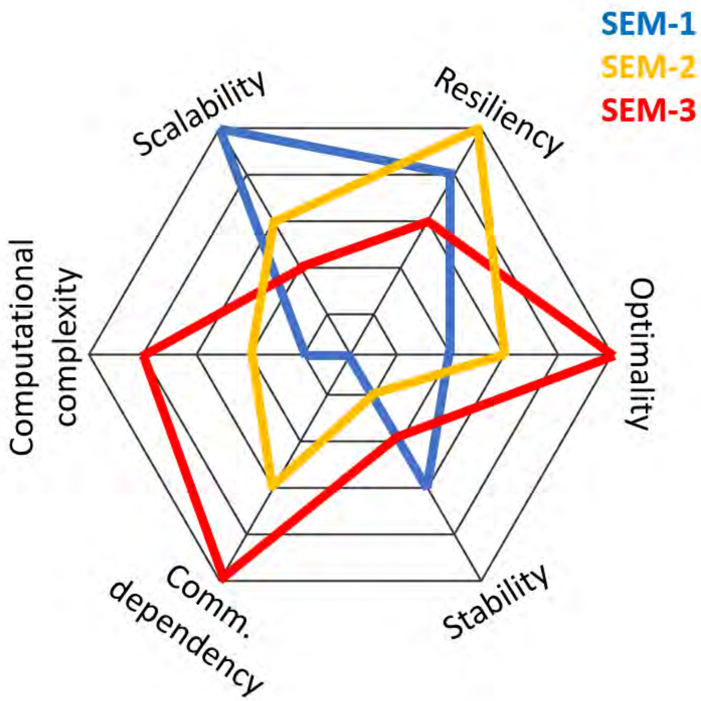
- Built on Node-RED
- Running on Raspberry Pi
- Dual CAN interfaces
- Custom flow to simulate UPER state machine
- Dashboard to provide easy access to read and control UPER settings
- All CAN messages compiled into a CAN database (.dbc) file for testing and simulation

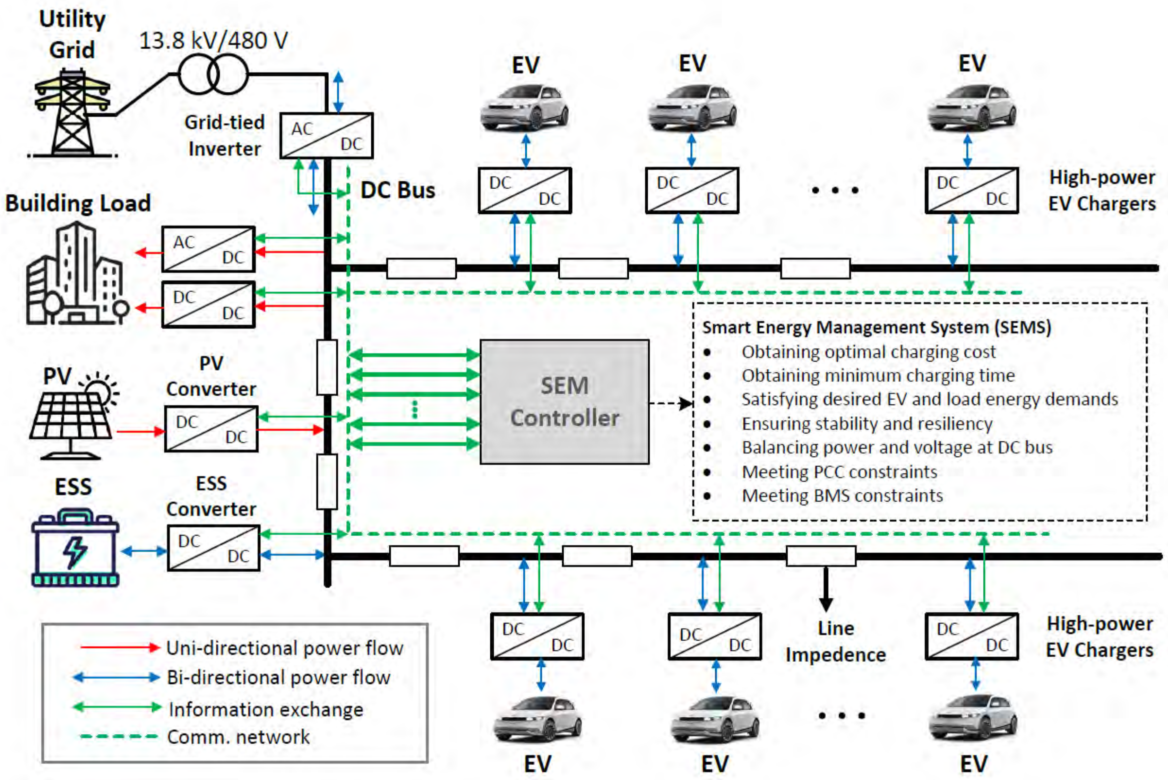
UPER Emulator (ANL)



Site Energy Management System (SEMS) Development

- Extension of DC hub components and modeling complexity
- Development, testing, and comparison of different SEMS strategies
- Development of testing use-cases
- Specifying SEMS requirements





Site Energy Management System Implementation

Choice of Commercial vs Open-Source Software (OSS)

OSS Advantages:

- Potential for cost savings due to free or low-cost open-source software
- High customizability and ability to tailor software to specific needs
- Potential for collaboration and innovation with a community of contributors

OSS Disadvantages:

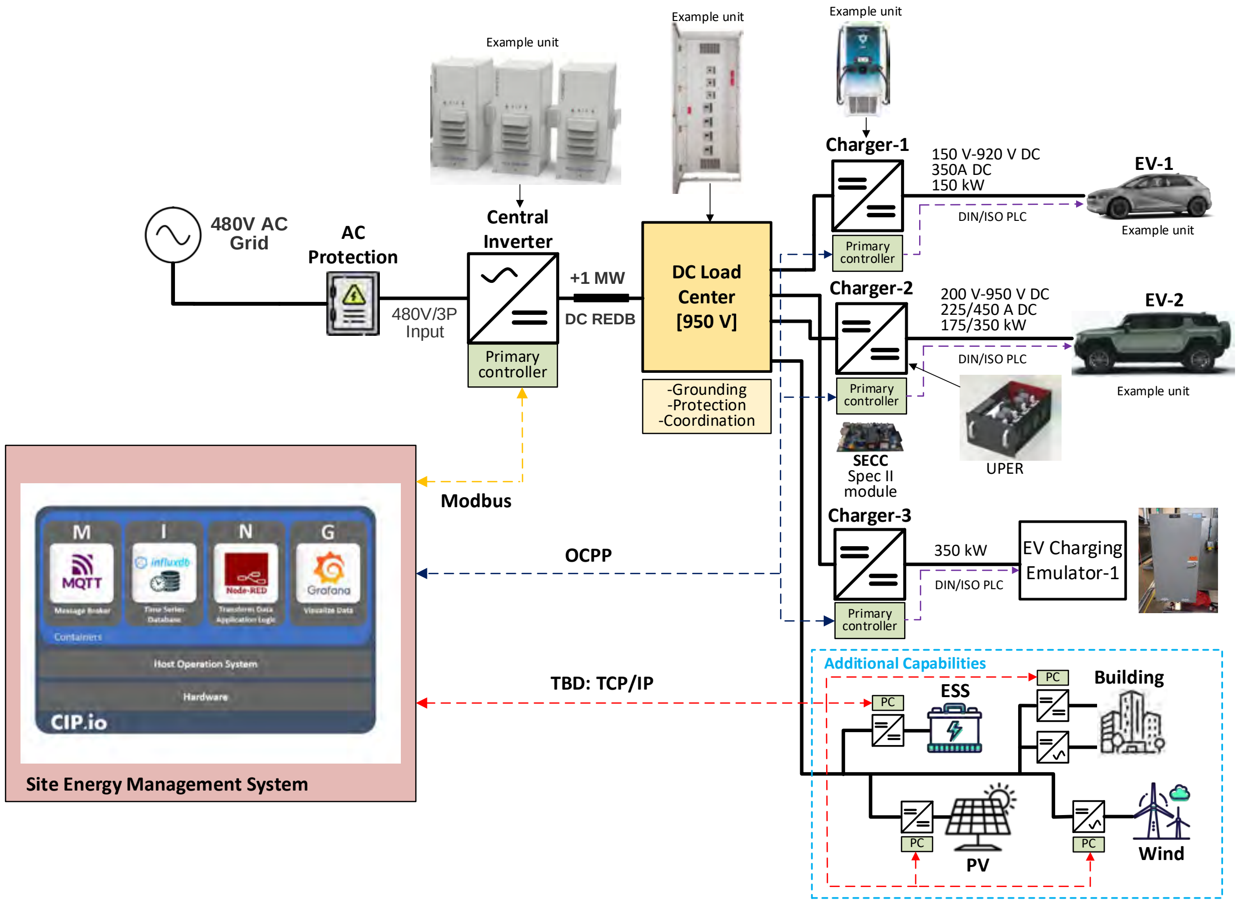
- Lack of vendor support and reliance on community forums and documentation for troubleshooting
- Limitations in integration with proprietary software, reducing functionality in certain situation

Decision

- Chose to first explore OSS
- Leverage existing OSS platform deployed at ANL Smart Energy Plaza (CIP.io) and modify as needed for eCHIP
- Opportunity to explore other options in upcoming years

The CIP.io Platform Leverages the "MING" Stack

- MQTT: Communication broker to facilitate communication between applications
- Infuxdb: Time-series database
- Node-RED: Application logic and bridge between comm. protocols
- Grafana: Create plots and quickly visualize data



Test Cases and Results-1

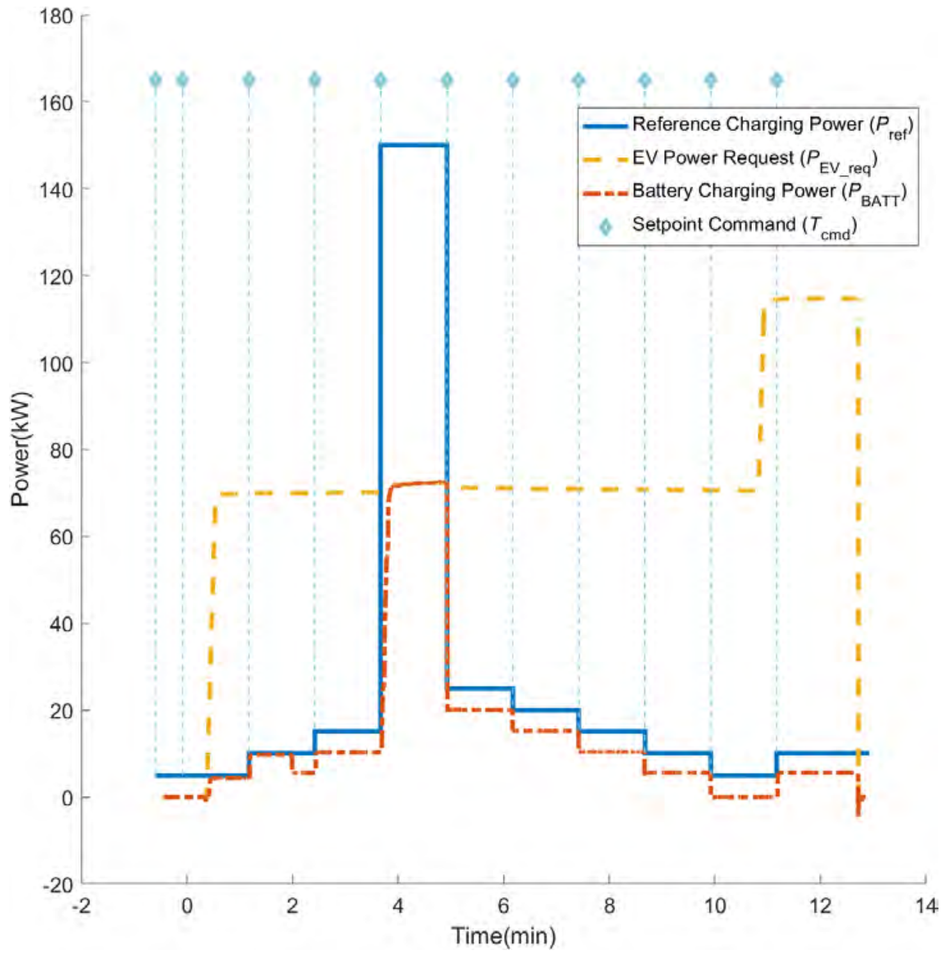
SEM provides power references for EVSE units with dynamically variable power reference.

Photo Credit: NREL

Highlights:

- Power reference (P_{ref}) is updated throughout session at instances of time T_{cmd} which is 1 min.
- Though EV requests more power (P_{EV_req}), power is limited to varying dynamic power limit.

Dynamic power control of Ioniq5 charge session showing power curves with setpoint command using OCPP1.6-J.



Test Cases and Results-2

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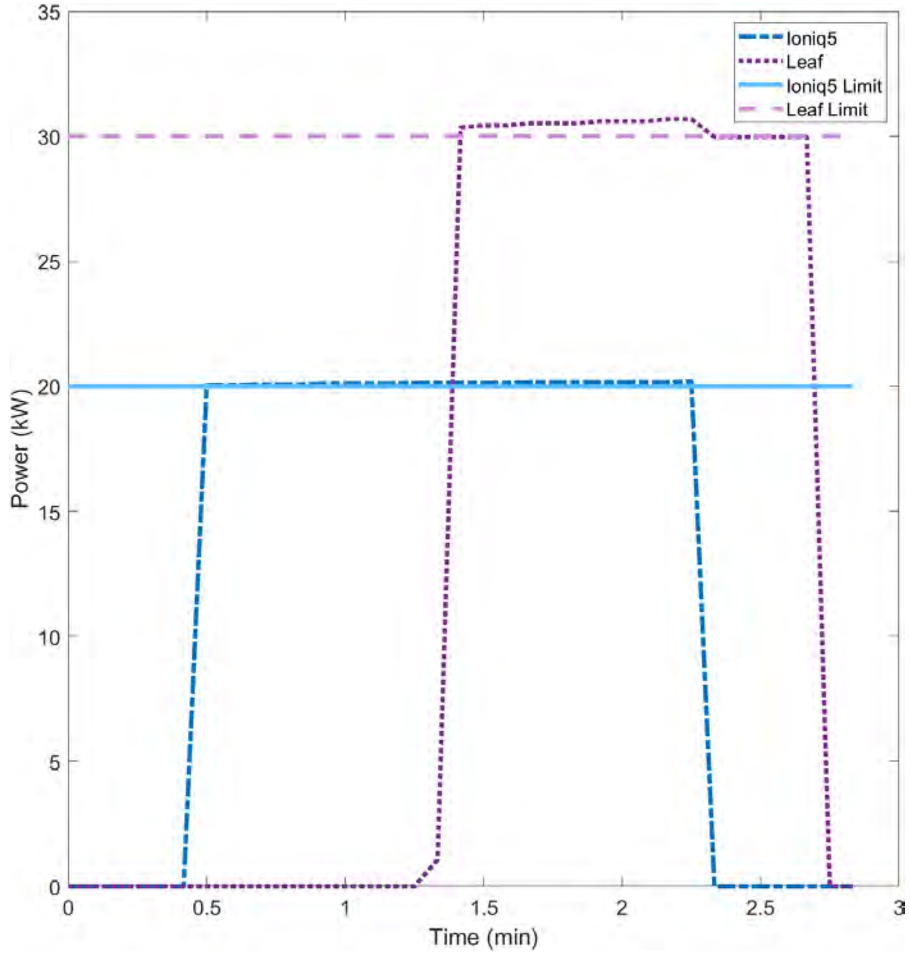
SEM provides power references for two EVSE units with dynamically variable power reference.

Highlights:

- Two EVs can be independently controlled without exceeding power limits.
- Ability to connect and control more than one EV to the DC hub.

Power limit control of Ioniq5 and Leaf charge sessions showing input power to each vehicle.



Conclusion and Next Steps

Review

- Technology Status on DC Charging Hub
- DC Charging Hub Hardware Development
- Power Electronics and Controller Integration
- Testing with Hyundai Ioniq-5 and Nissan Leaf

Next steps

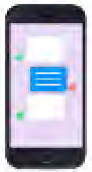
- Testing with energy storage system and improving grid integration
- Evaluation and comparison of various SEMS control algorithms
- Testing Spec-II module integration with UPER
- Integration of 1000 V Class Charger with DC Hub
- Development of 1500 V Class Charger

Audience Poll Questions

Join by Web

1. Go to **PollEv.com**
2. Enter **BURAKOZPINECI620**
3. Respond to activity

Join by Text



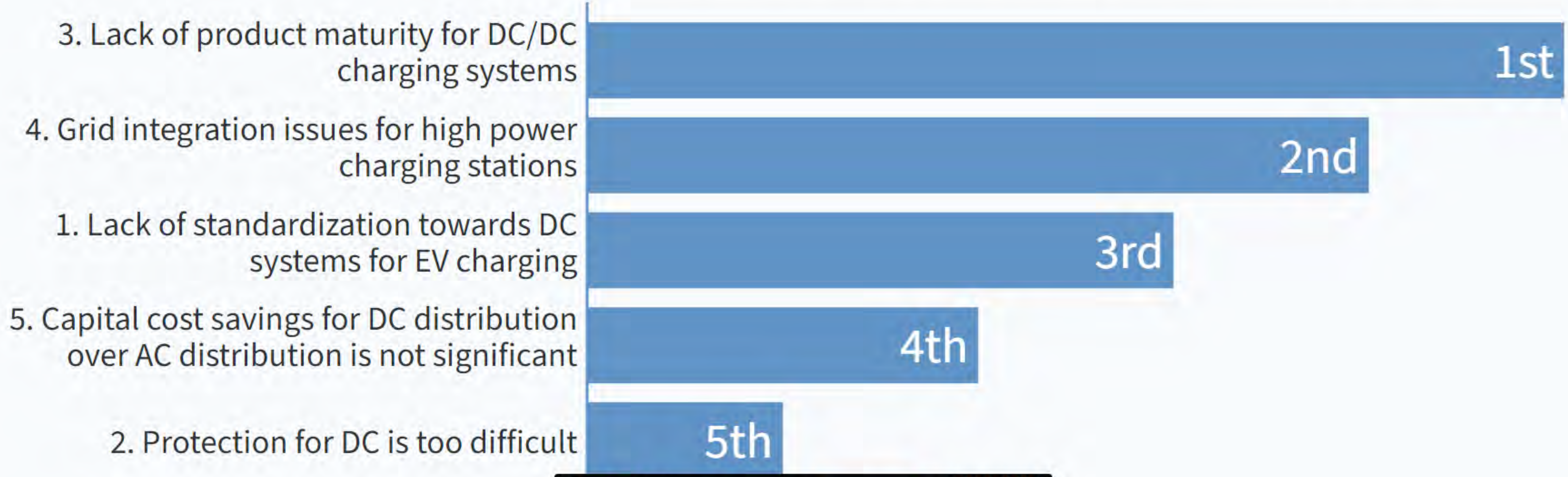
1. Text **BURAKOZPINECI620** to **22333**
2. Text in your message

When poll is active, respond at **pollev.com/burakozpineci620**

Text **BURAKOZPINECI620** to **22333** once to join

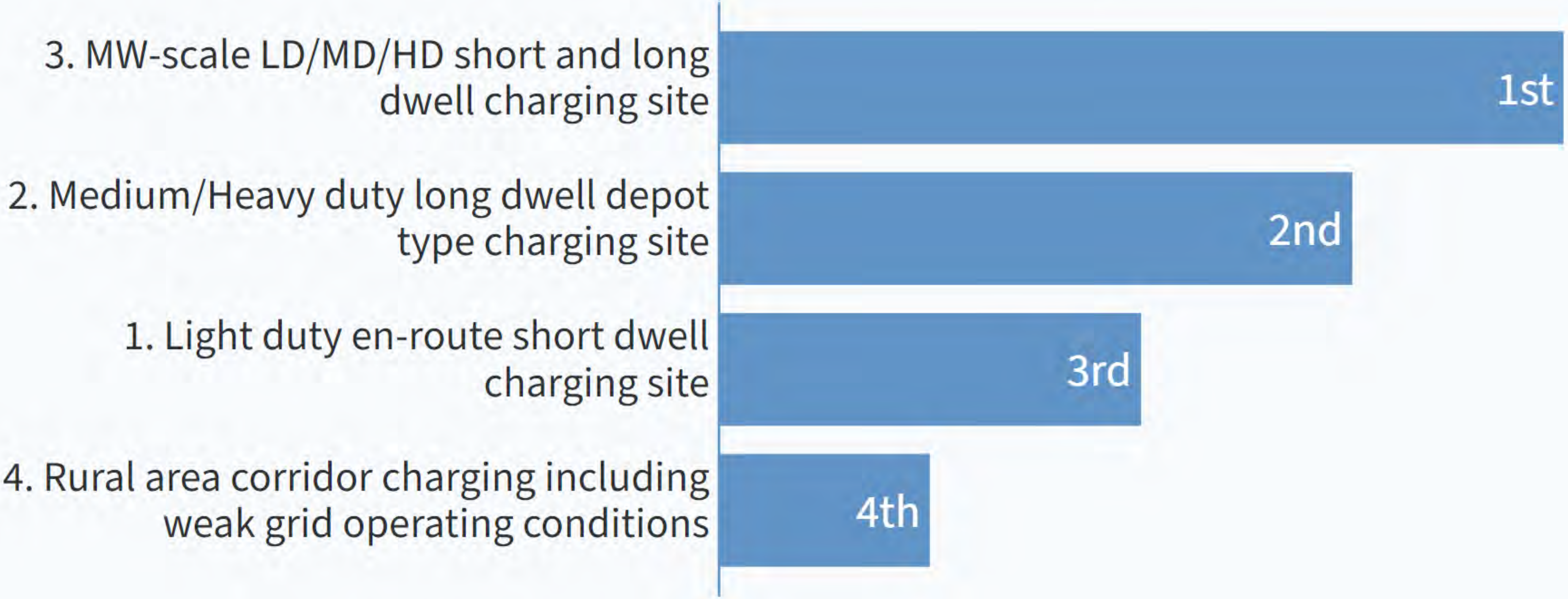
Respond at **PollEv.com/burakozpineci620**

Q1: What are the potential barriers that need to be resolved to implement DC Charging Hub approach for high power charging? Please rank from 1-5, 1 being the highest rank.



Respond at **PollEv.com/burakozpineci620**

Q2. Which application area do you think DC Charging Hub should be prioritized for? Please rank from 1-4, 1 being the highest rank.



Thank You!

Join us for the

HPC Deep Dive on May 2

John.Kisacikoglu@nrel.gov

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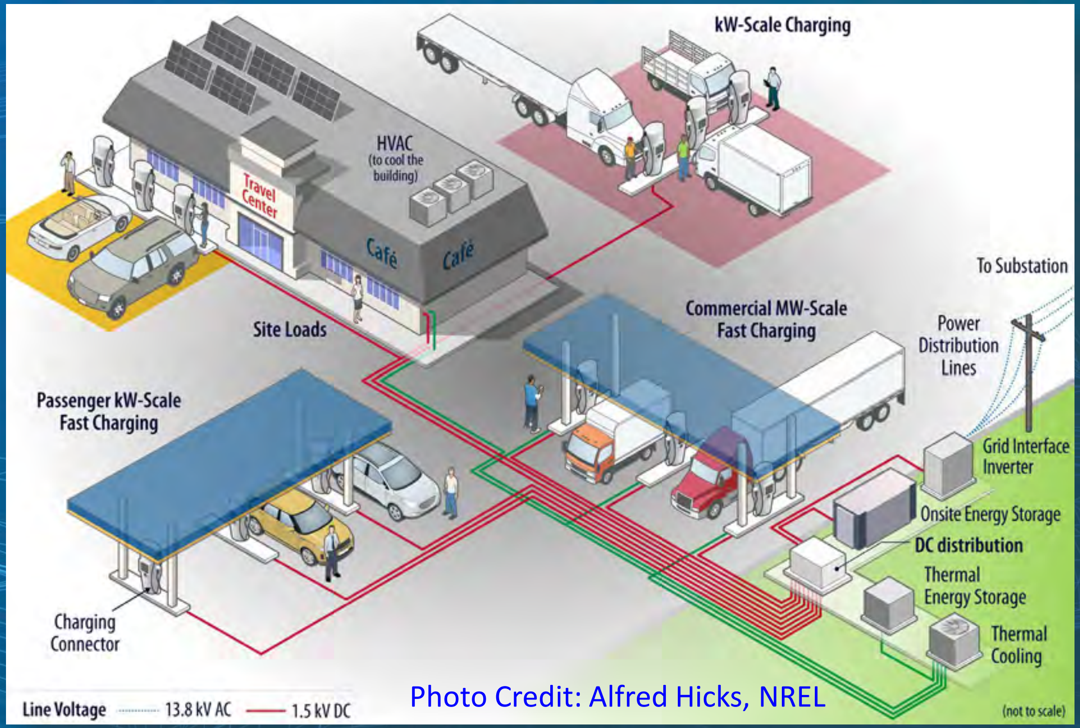

Photo Credit: Alfred Hicks, NREL

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U.S. Department of Energy

NextGen Profiles

Dan Dobrzynski

Barney Carlson

Keith Davidson

Omer Onar

April 5, 2023

EV Charging Advancements

Key technological breakthroughs have led to higher charging performances:

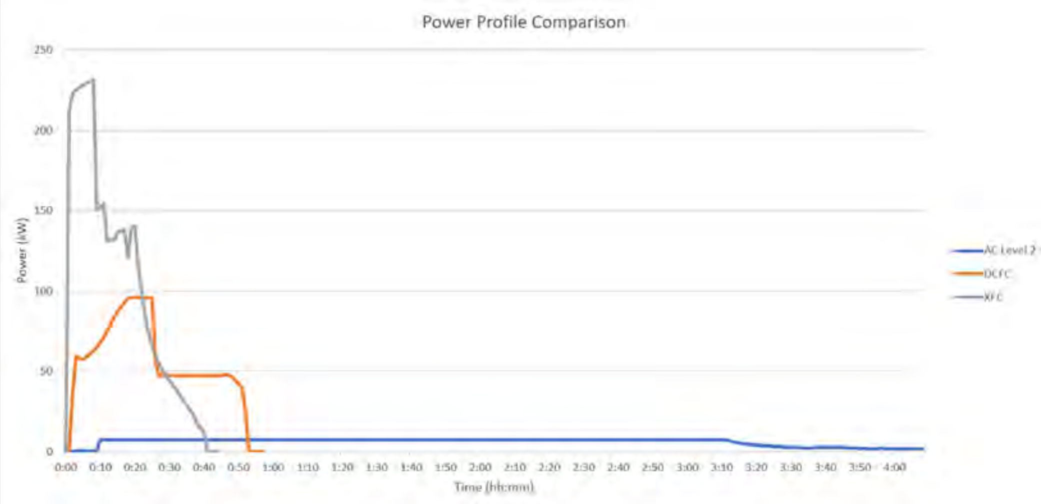
- Higher voltage battery configurations
- Liquid-cooled charger cabling
- Advanced charging connectors and topologies

Advanced charging performances give rise to **deeper discussion topics**:

- How do we quantify EV charge performance?
- What are the DC Fast Charger capabilities and limitations?
- How are EV fleets utilizing fast charging?

Opportunity to develop a **knowledge base** towards:

- Grid planning efforts
- Charging depot site sizing
- DER/Storage Integration
- HPC charge management strategies



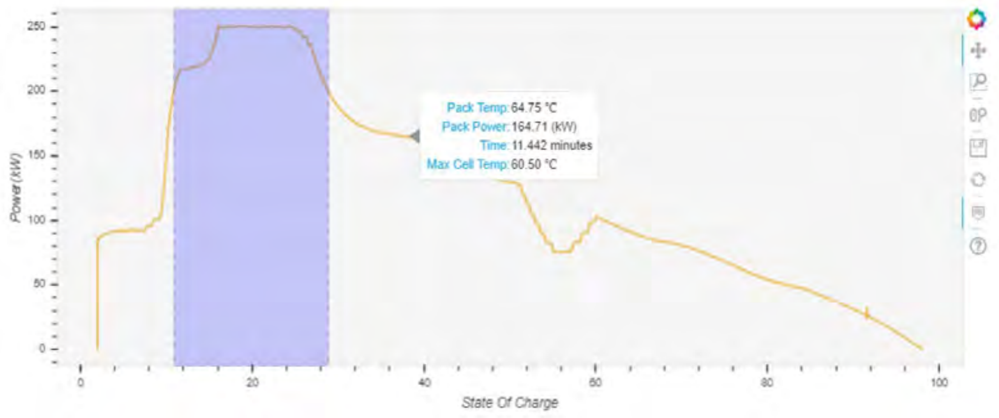
Project Overview

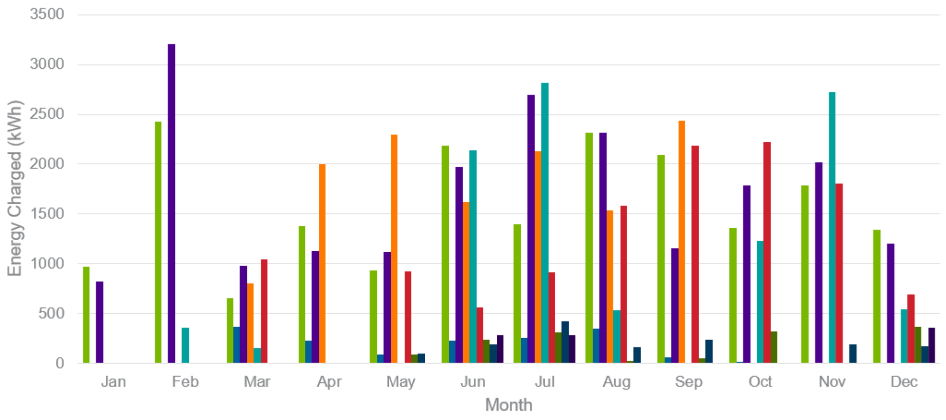
Argonne NATIONAL LABORATORY
INL Idaho National Laboratory
NREL NATIONAL RENEWABLE ENERGY LABORATORY
OAK RIDGE National Laboratory

Objective: Assess the likely portfolio of EV and EVSE that are expected to utilize High Power Charing. (>200kW)

Sub-objectives:

- Perform charging system assessments at baseline and modified boundary conditions
- Perform charging system (wireless and conductive) responses to grid disturbances and charging management
- Perform long duration fleet utilization analysis
- Collaborate with OEMs, manufactures, and industry stakeholder for:
  - Process and procedure collaboration
  - Short-term rental of testing assets





Project Timeline

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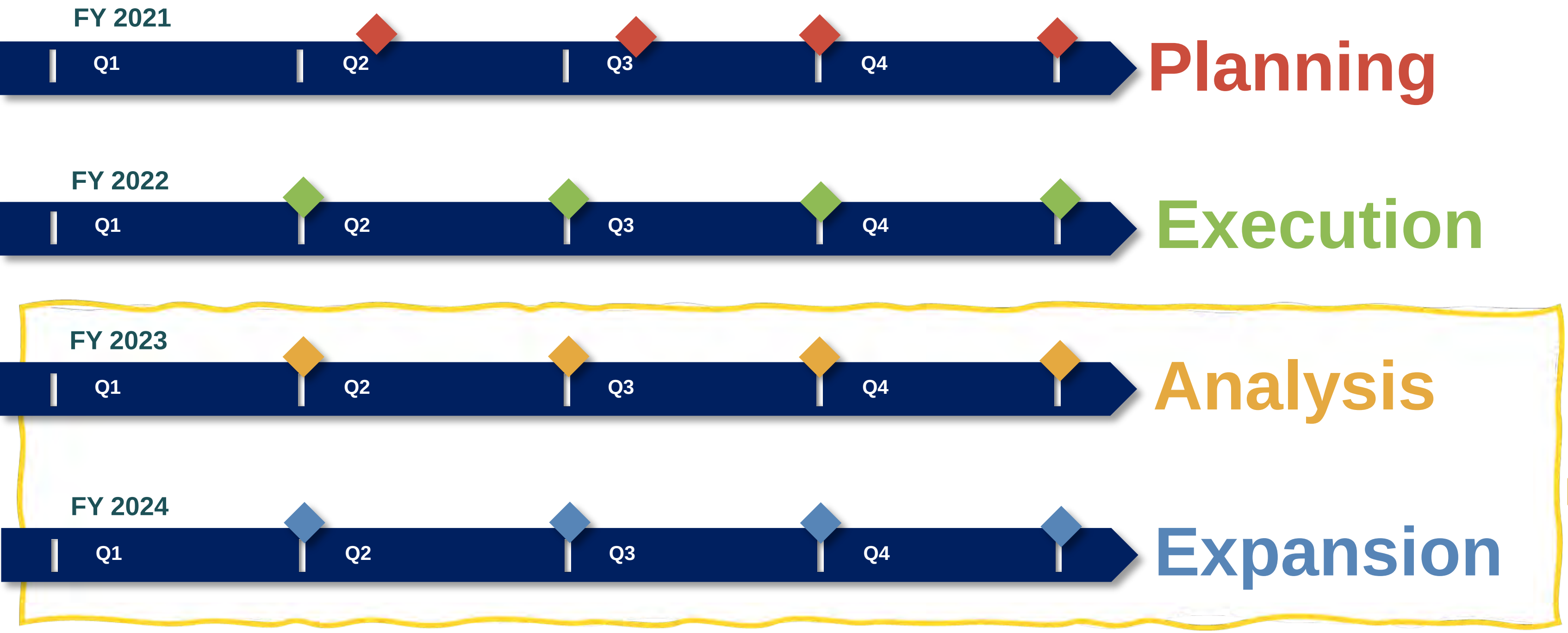

Integrated into
EVs@Scale HPC Pillar

- Completed
- Ongoing
- Future Work

Year 1 Milestones

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

Year 2 Milestones

- Fleet data collection review (Completed)
- Capture conductive profile sets (Completed)
- Complete EVSE characterization (Ongoing)
- Capture non-conductive profiles sets (Ongoing)

Year 3 Milestones

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

Year 4 Milestones

- Refine testing procedures (Future Work)
- Acquire new test assets (Future Work)
- Conduct characterizations (Future Work)
- Amend analysis and reports (Future Work)

Technical Workload

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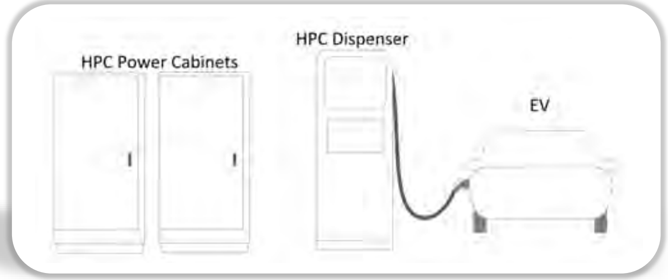
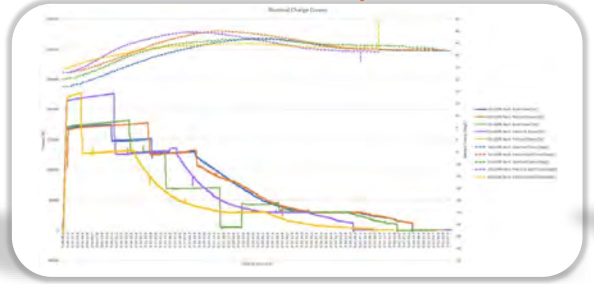
EV Profile Capture

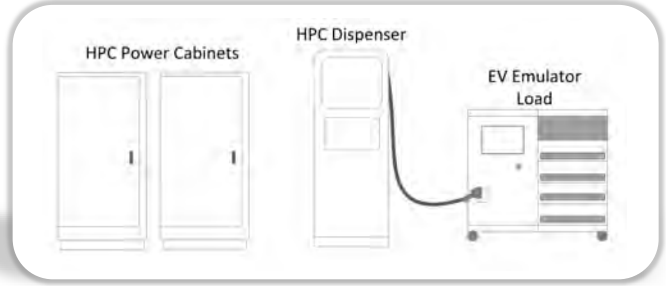


Single Vehicle Boundary Condition Analysis

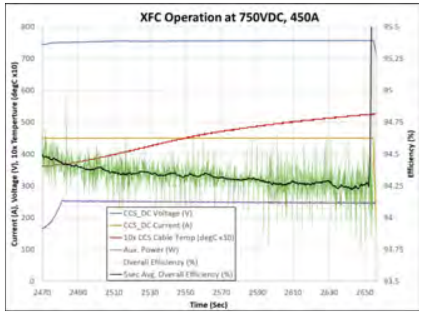


EV Charge Profile Comparison

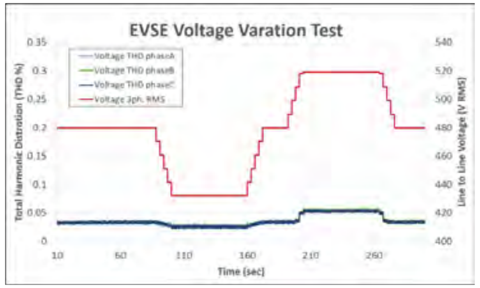
EVSE Characterization



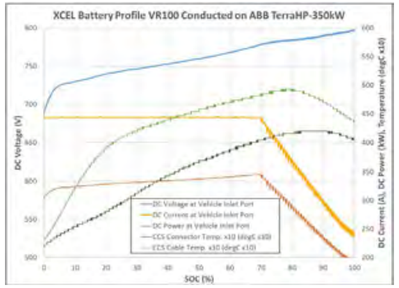
Quasi-steady state Performance Analysis



Grid Disturbance Analysis

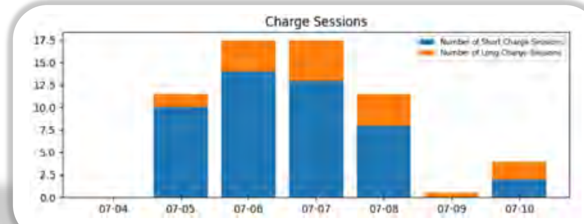


Advanced Profile Analysis



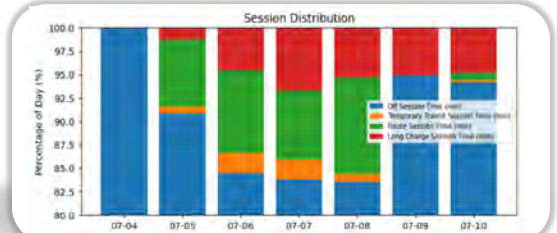
Fleet Utilization Analysis

Fleet Session Analysis



Fleet Route Analysis

Temporal Use Analysis



EV Profile Capture Accomplishments

Charging Types: **CCS**, **Pantograph**, **Tesla**, **WPT**

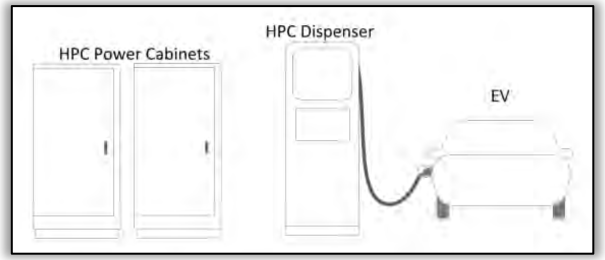
Testing Conditions:

- Starting Battery Temp: Hot (40°C), Nominal (23°C), Cold (-7°C)
- Starting SOC: 10-100%, 25-100%, 50-100%
- State of Vehicle: Pre-Driven, Temperature Soaked

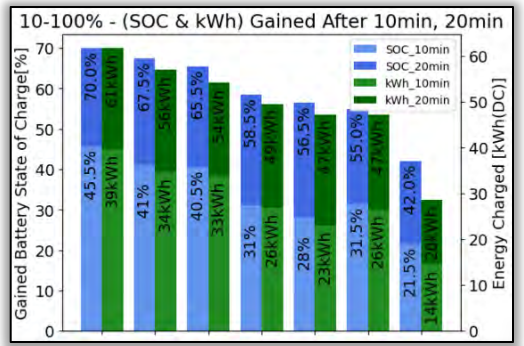
70 Profiles Captured

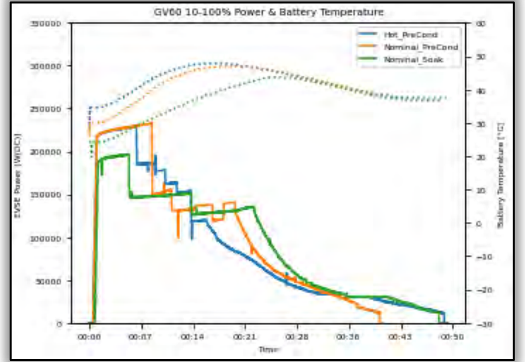
- Results are aggregated between the labs with time-series formatting for uniform comparison and plotting.

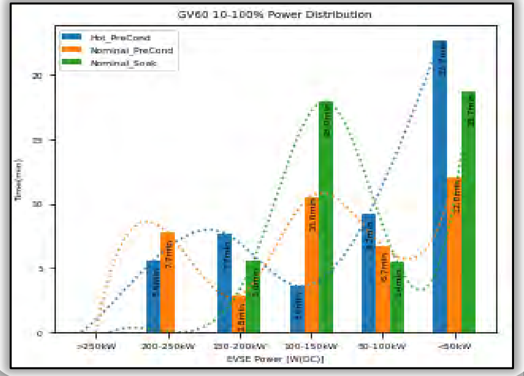
EV Capture Setup



EV Capture Initial Results







EVSE Characterization Accomplishments

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Power Transfer Characterization

- Quasi-steady state performance characteristics of the HPC by testing wide voltage and current operating ranges
- System efficiency, current ramp up/down, voltage sag/sweep, curtailment responsiveness, thermal readings, etc.

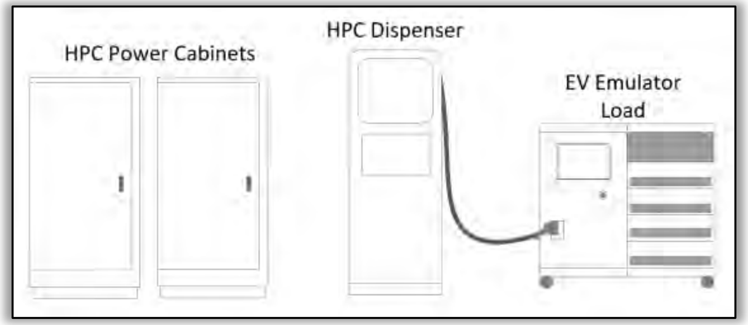
High Utilization Tests

- Run multiple HPC sessions in succession with limited temporal gaps

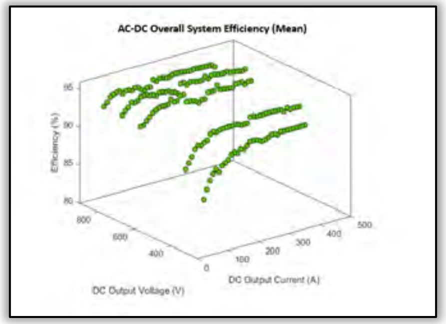
XCEL Scaled Profile Tests

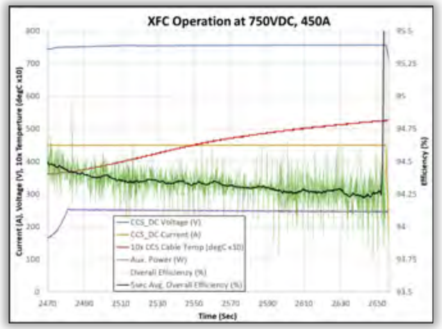
- Administer battery charging profiles based on scaled high performance battery cell research
- 50kWh pack (192 series cells) ~750VDC
- Equivalent to charging 150 mi. equivalent range in 10 minutes

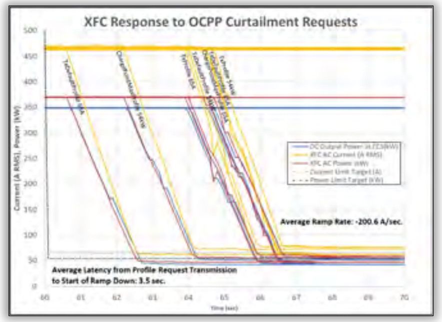
EVSE Characterization Setup



EVSE Characterization Results







Fleet Utilization Analysis

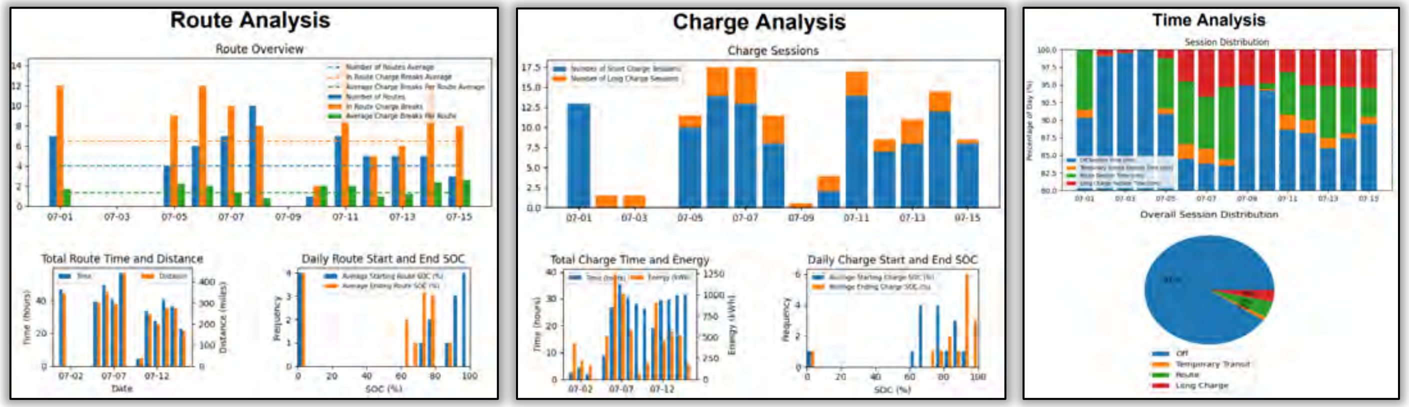
Long duration fleet data data sharing

- NGP currently examining 4-5 fleet networks

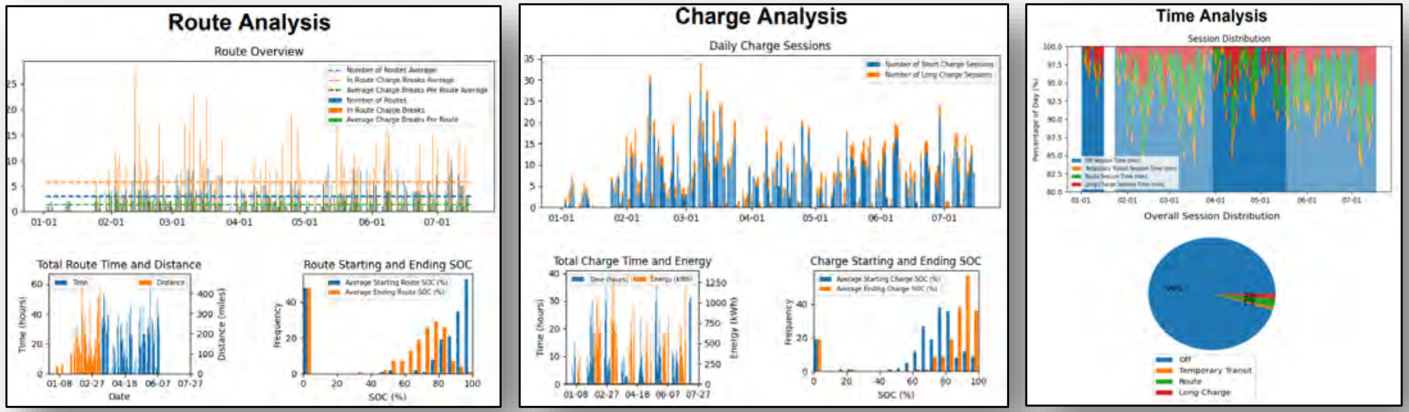
Example:

- US Transit Fleet of 23 Proterra EV Buses
- Data is characterized based on routes, charging, and temporal utilization
- Can be modified for weekly, monthly, quarterly, etc. reporting

1 Week of EV Fleet Analysis



6 Months of EV Fleet Analysis



Programmatic Accomplishments

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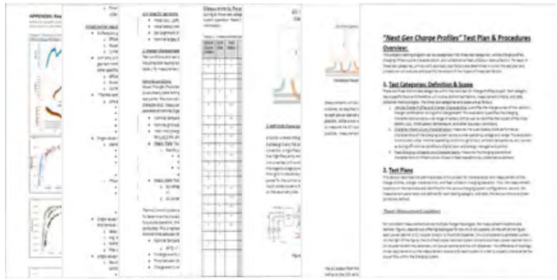
Procedure Development

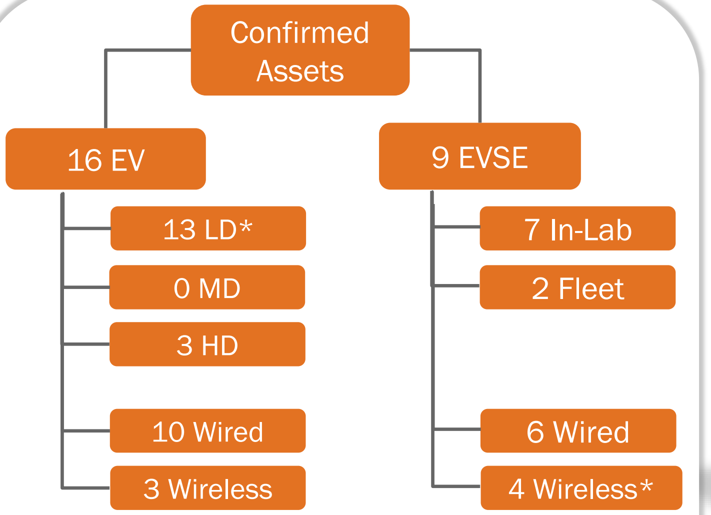


Commenting Source	Comment Count
DOE and National Laboratories	32
US Research Institutes	12
EVSE OEMs	10
EV OEMs	6
Foreign Research Institutes	26
Total	**86**

Development Outline

- Draft document completed 08/20/2021
- 2 Month open review period – 86 industry comments
- Resolution of Comments – completed 11/30/2021

Securing Testing Assets



* - Includes some assets without 200kW capabilities

Setbacks

- Delays and lack of assets availability
- Lack of interest by some OEMs
- Acceptance of assets capable of less than 200kW charging

Developing Dissemination Policy

Public
High-level publicly available report

Project Partner Group
Anonymized time-series results

Project Partner
Full time-series results to specific partner

Balancing incentives and impact

- Aim to maximize collaboration and participation
- How do we get key data available to stakeholders without de-incentivizing participation?

Conclusion and Next Steps

Review

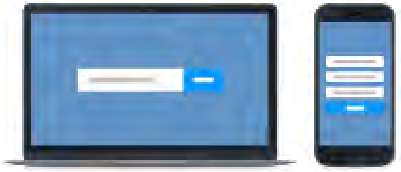
- High Power Charging is a new area of research that is moving extremely quickly.
- This project takes key steps to define, capture, and analyze performance metrics charging systems.
- It is important to have consensus on a process to gather the data and disseminate properly.
- Challenges include ensuring representative data quality and collaborative follow-through.

Next steps

- Continued test execution and data gathering
- Develop impactful analysis that can guide performance standards and inform industry.
- Delivery of a full 3-year project report and findings – Expected in Winter of 2023.
- Continue to garner stakeholder interest in performance definitions, process, and access as qualifying assets come to market

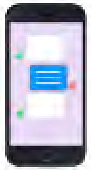
Audience Poll Questions

Join by Web



1. Go to **PollEv.com**
2. Enter BURAKOZPINECI620
3. Respond to activity

Join by Text



1. Text BURAKOZPINECI620 to 22333
2. Text in your message

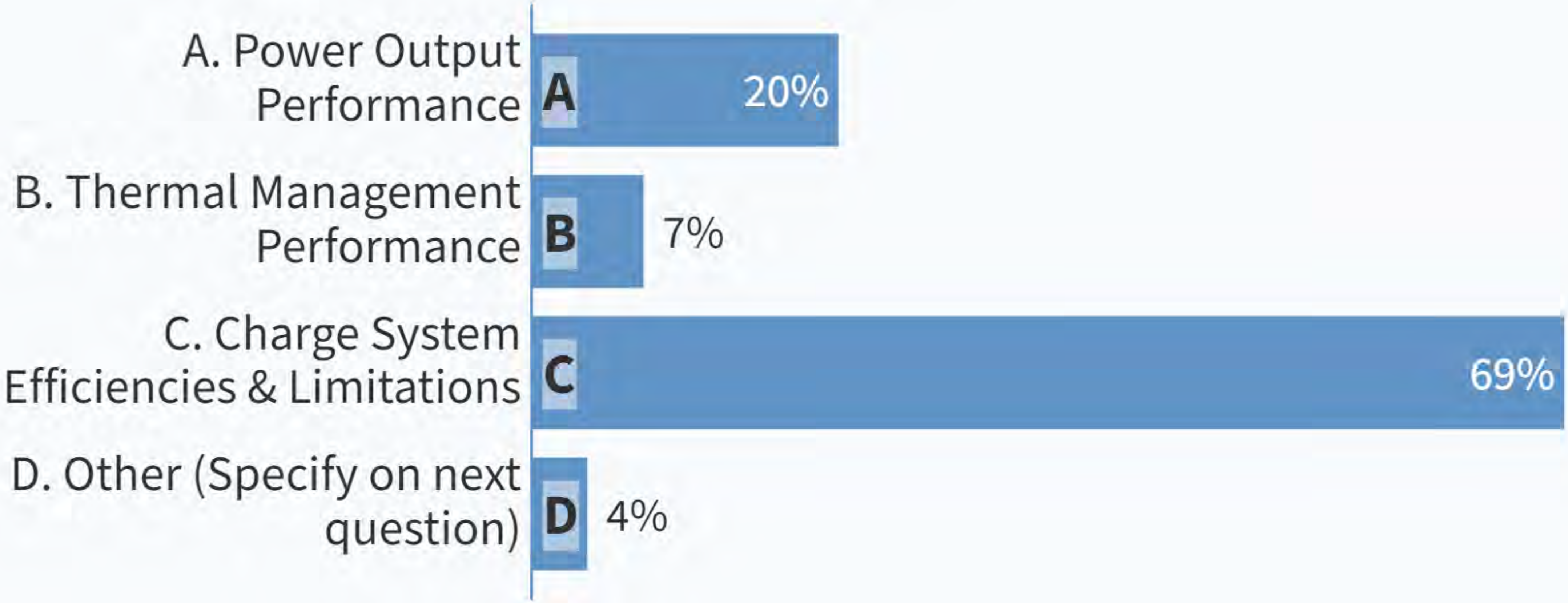
When poll is active, respond at **pollev.com/burakozpineci620**

Text **BURAKOZPINECI620** to **22333** once to join

Respond at **PollEv.com/burakozpineci620**

Text **BURAKOZPINECI620** to **22333** once to join, then **A, B, C, or D**

What technical analysis would be most beneficial in a publicly available report?



Respond at **PollEv.com/burakozpineci620**

Text **BURAKOZPINECI620** to **22333** once to join, then text your message

What technical analysis would be most beneficial in a publicly available report? - ONLY for those who responded "Other" : Please Specify

“ Na ”

“ time and consistency of the charge event for user experience ”

“ Other ”

Open-Feedback

- NextGen Profiles provides OEM collaborators with unbiased performance data, detailed edge-case testing, anonymized competitor time-series data, and comparative analysis; however, participation is low. What additional project features (test cases, project outputs…etc.) would incentivize OEMs to participate in the project? (open-ended)

What additional project features (test cases, project outputs...etc.) would incentivize OEMs to participate in the project? (open-ended)

"Payment for participation"

"Talk to fleet providers who use the OEMs you're interested in working with"

"Load profiles for energy cost modeling"

"What would improve reliability of EVSE's"

"NTEP Requirement"

"Emulated vehicles – test at EVSE limitations"

"Data that could potentially lead a partner towards specific areas impacting charge speed, which they might not have considered."

"Future proofing their vehicle systems"

"EVSE behavior under/over frequencies conditions. Also over/under-voltage conditions."

"Reliability improvements"

"Useable data"

Thank You!

Join us for the

HPC Deep Dive on May 2

ddobrzynski@anl.gov

EVs@ Scale

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EVs @ Scale

U.S. Department of Energy

Working Lunch:
11:30am – 12:30pm

Respond at **PollEv.com/burakozpineci620**

Text **BURAKOZPINECI620** to **22333** once to join, then text your message

Do you have any additional questions or feedback regarding this morning's pillar session? (Anonymous)

“ Will slides be made available? ”

“ Thanks for the great overview this morning ”

“ Data that OEMs could use (evse / vehicle) to support V2G development ”

EVs@ Scale

U.S. Department of Energy

Wireless Power Transfer Pillar: High Power and Dynamic Wireless Charging

Veda Galigekere

April 05, 2023

Overview of High Power and Dynamic Wireless Charging

- **Objective:** Develop and validate technologies and solutions to transition high-power dynamic wireless (HPDW) charging of electric vehicles (EVs) from an early-stage proof-of-concept system to a practical roadway-integrated dynamic wireless power transfer (DWPT) system suitable for deployment at-scale.

- **Partners:** Actively seeking collaborators (FHWA, DOT, fleet operators, OEMs, and technology developers)
  - National Labs:
    - Oak Ridge National Laboratory
    - Idaho National Laboratory
    - National Renewable Energy Laboratory
  - External:
    - Virginia Tech Transportation Institute
    - American Center for Mobility
    - Hyundai-Kia Technical Center and Stellantis

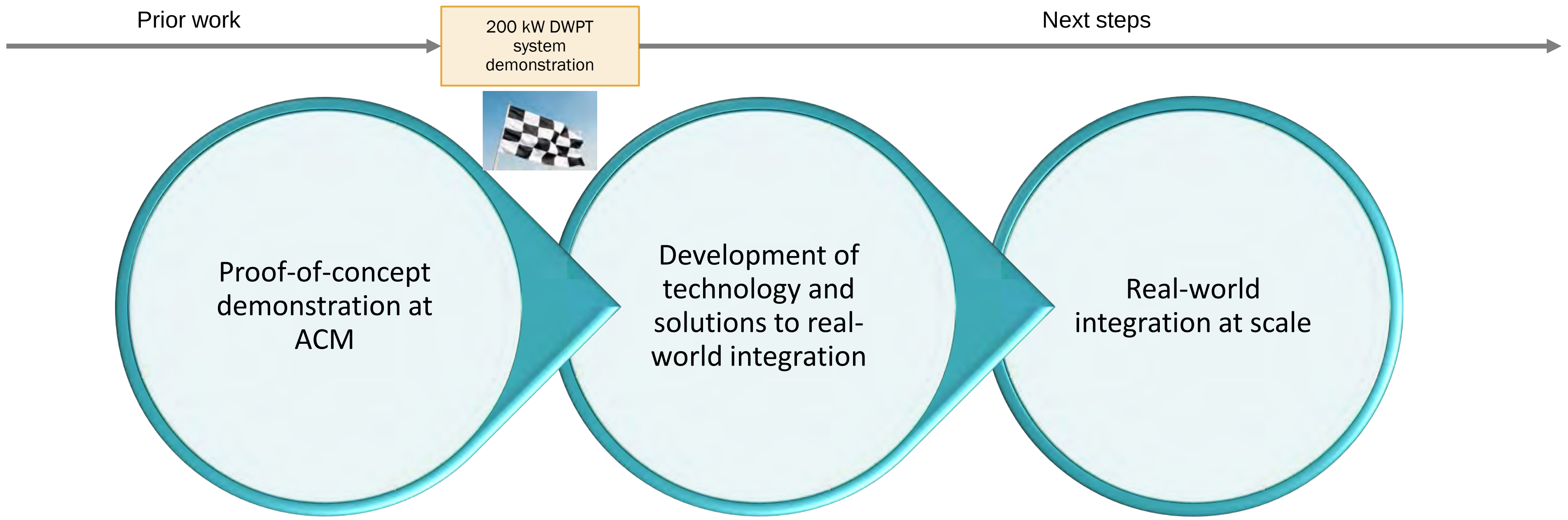
High-power DWPT system developed and suitable for deployment

- **Outcomes:**
  - Evaluation of comprehensive data from dynamic wireless charging system
  - Life-cycle and accelerated aging impact on coupler and roadways using heavy-vehicle simulator
  - Solutions to system- and component-level barriers for real-world deployment of HPDW systems
  - Validated HPDW coil architectures and embedding techniques suitable for different roadways, environmental conditions, use cases, and system life-cycle.

Overall Approach

Prior work: Focused on developing proof-of-concept 200 kW DWPT system demonstration at ACM and generation of baseline data

Next steps: Demonstration, comprehensive characterization, and integration of DWPT into real-world



- High-level cost and feasibility studies
- System design and development
- Laboratory and field validation

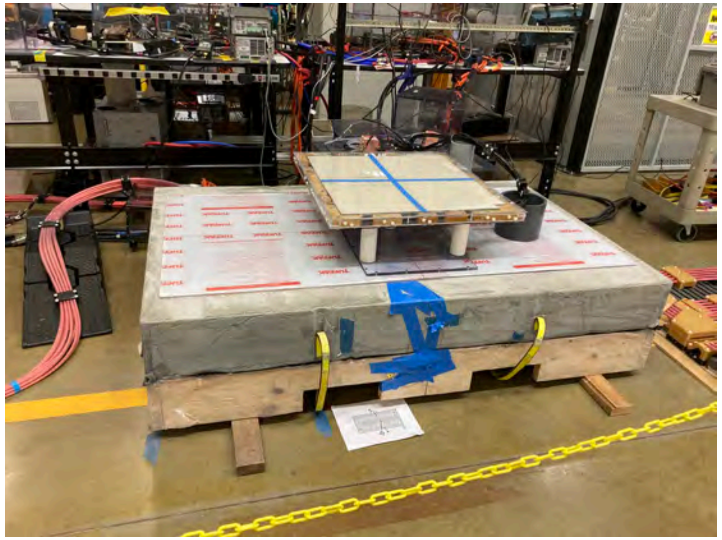
- Accelerated aging tests
- Durability and performance of roadway and DWPT system

- Integration with the roadway
- Integration with the Grid
- Interoperability

Status of High-Power DWPT System Validation in the Laboratory: Stationary Mode (1/2)

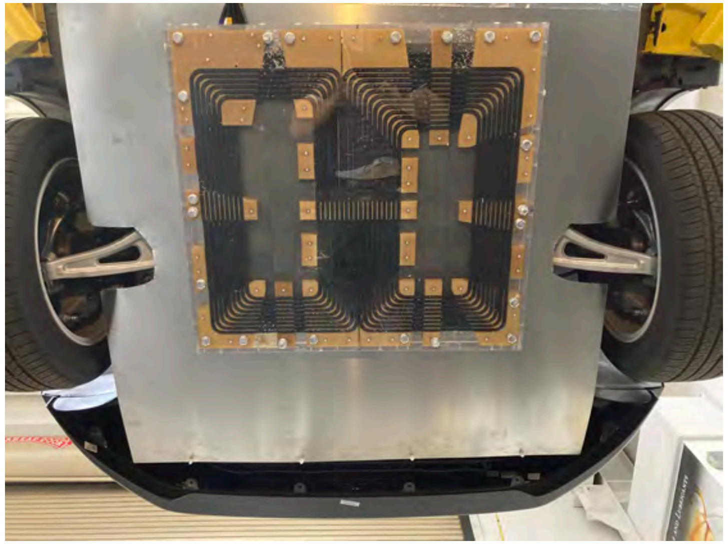
Validated power transfer capability and thermal performance with embedded transmitter and vehicle mounted coupler

- Embedded transmitter with MasterFlow 648 Epoxy Resin Grout (5000 psi)
- Mounted vehicle coil with aluminum shielding
- Minimal or no variation in electrical performance



Thermal image of receiver and transmitter taken after 10 min of operation. Transmitter not set in precast

200 kW DWPT system with the receiver coil mounted on Hyundai Kona

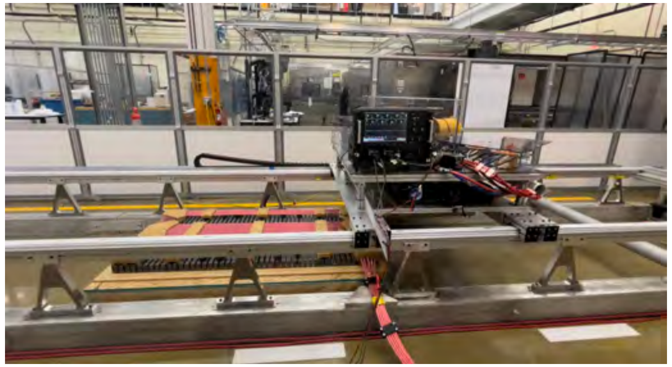


200 kW DWPT system with the receiver coil mounted on Hyundai Kona

Status of High-Power DWPT System Validation in the Laboratory: Stationary Mode (2/2)

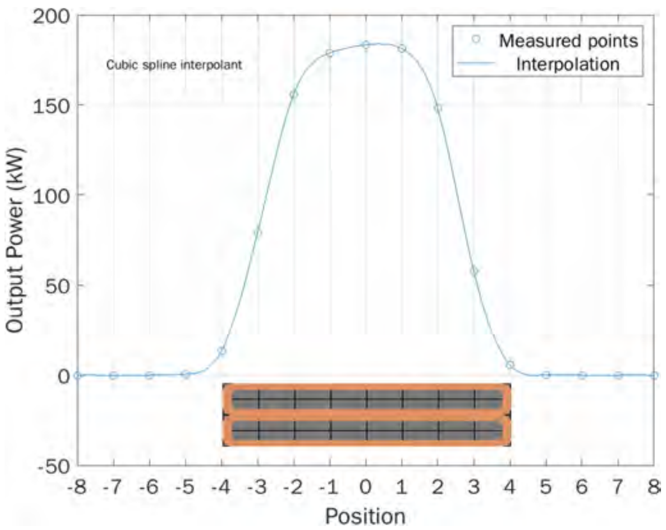
Validated dynamic power transfer capability in laboratory

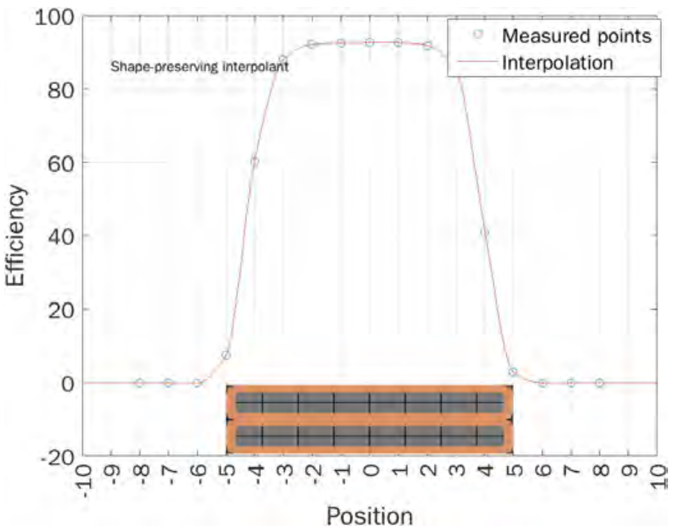
- Stationary mode along the length of the track at discrete steps – baseline profile
- Effect of lead inductance noted



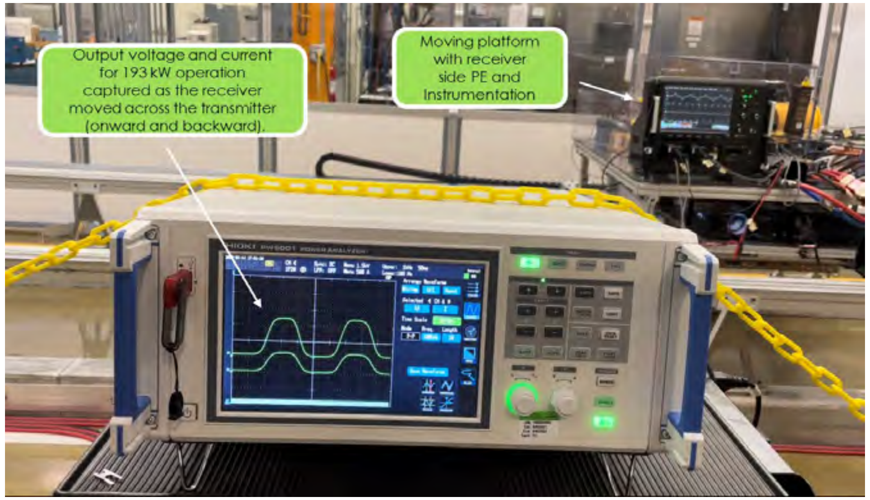
Dynamic inductive charging setup in the laboratory

- Track length: 18 m
- Payload capability: 100 Kg
- Speed: ~9 m/s (20 mph)
- X, y, and z coil misalignment capability
- Automated and programable
- Capability with hardware-in-the-loop software





Profile of measured output power and efficiency of 200 kW dynamic charging system measured along the length of the transmitter at discrete points

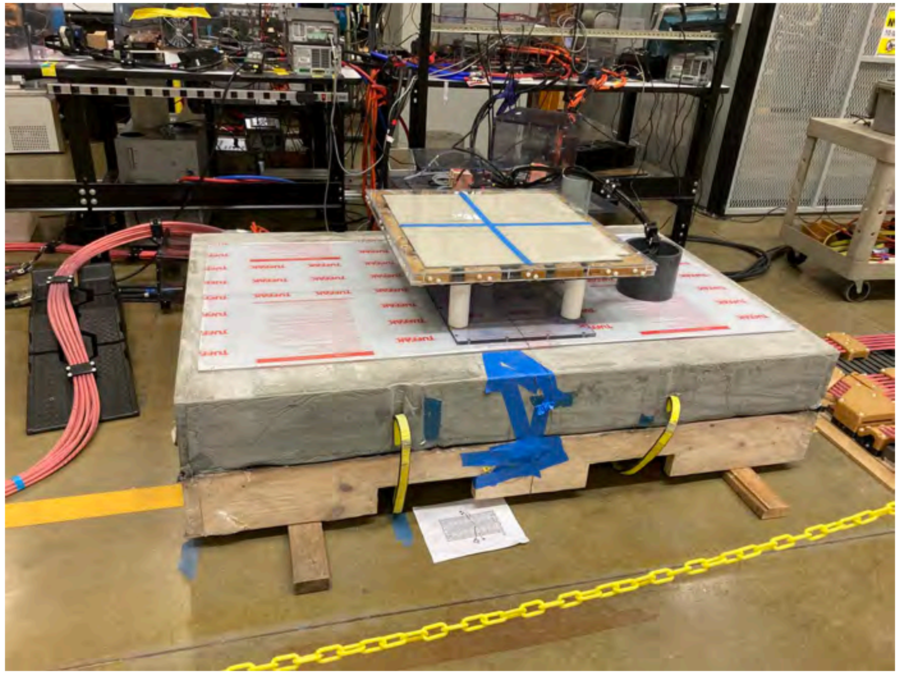


Experimentally measured output voltage and current corresponding to 193 kW operation

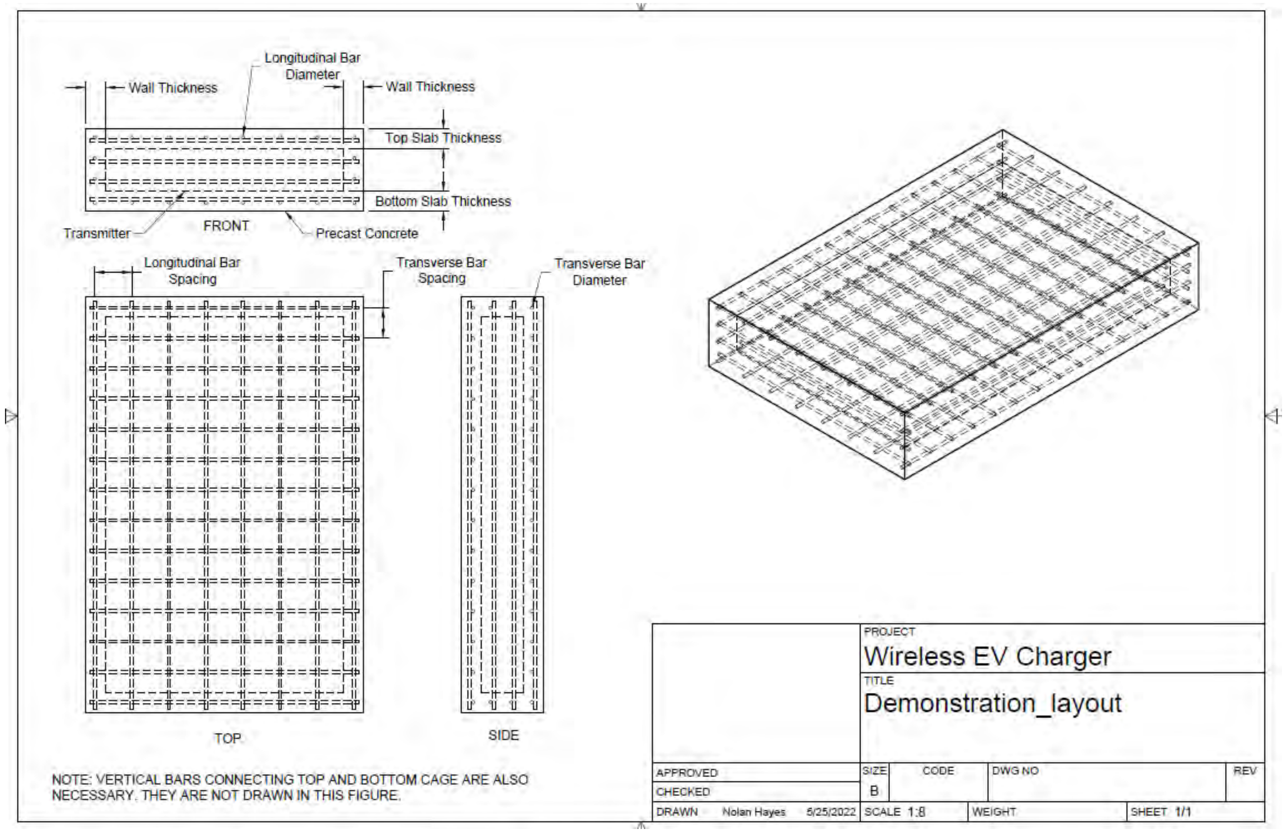
Preliminary Structural Design Review

Detailed structural and mechanistic design review of ORNL developed 200 kW DWPT transmitter

- Preliminary review initiated by ORNL
- Comprehensive review to be conducted with VTTI



200 kW DWPT system with transmitter set in precast Master flow 648 Epoxy Resin Grout



Preliminary Structural and Deployment Focused Design Review:

- MasterFlow 100 – 5000 Psi
- Equivalent design specification
  - Vehicle axle load of 8000 – 32,000 Lbs (Kona 3200 Lbs)
  - Precast concrete shell was designed as a buried box culvert (coil provides no structural support)
  - Loading scenarios were derived using AASHTO LRFD (American Association of State Hwy and Trans. Officials, Load Resistance Factor Design)
  - Strength capacity of the top slab of the box culvert was calculated for a variety of reinforcement layouts using ACI 318 (Building Code Requirements for Structural Concrete) and ACI 440 (information on fiber reinforced polymer for internal and external reinforcement of concrete)
  - Deflection (displacement) of the top slab was also checked to minimize the possibility of damage to the embedded components

Vehicle	Axle Load	Top Slab Thickness (in)	Short Direction		Long Direction	
			Reinforcement Size	Reinforcement Spacing (in)	Reinforcement Size	Reinforcement Spacing (in)
Small vehicle	8000 lb	2.5	#5	4	#5	6
Small vehicle	8000 lb	2.5	#6	6	#5	6
Small vehicle	8000 lb	2.5	#8	12	#5	6
Small vehicle	8000 lb	3	#5	6	#5	6
Small vehicle	8000 lb	3	#7	12	#5	6
Small vehicle	8000 lb	4	#4	6	#5	6
Small vehicle	8000 lb	4	#6	12	#5	6
Heavy Truck	32000 lb	3	#8	4	#5	6
Heavy Truck	32000 lb	4	#6	4	#5	6
Heavy Truck	32000 lb	4	#8	6	#5	6

Reinforcement Size	Diameter (in)
#4	0.5
#5	0.625
#6	0.75
#8	1

Simple Lift Test of 200 kW DWPT Transmitter

200 kW DWPT transmitter set in precast Master flow 648 Epoxy Resin Grout

Status of High-Power DWPT System Validation in ACM

- **Planned demonstration/characterization on the road at ACM**
- Four pre-cast concrete blocks in ACM
- Four primary side power electronic units assembled, tested and ready to be shipped
- Two vehicle side units assembled and ready to be shipped

Coils with fiber glass re-enforcement being concretized

Assembled and tested 200 kW primary side HF inverter

4 primary side HF power electronics units

Concretized DWPT transmitters at ACM

Next Steps: Engage with Relevant Stakeholders and Experts

Partner	Expertise
ORNL	Power electronics, Wireless Power Transfer system design, development and validation
INL	Data acquisition, EM shielding, and WPT system characterization
NREL	Deployment scenario and analysis
ACM	Validation ground
HATCI and Stellantis	Vehicle OEMs

+ planned strategic partnership with:

VIRGINIA TECH TRANSPORTATION INSTITUTE
VIRGINIA TECH.

Virginia Tech Transportation Institute - Center for Sustainable and Resilient Infrastructure

- Expertise
  - Vehicle pavement interaction
  - Structural evaluation
  - Accelerated pavement testing
- Facilities
  - Accelerated pavement aging facility (CSRI and VDOT)
  - Asphalt pavement analyzer

Looking for extensive discussion and collaboration with all relevant stakeholders – DOTs, OEMs, technology providers, Tier-1s

Next Steps: R&D to Transition DWPT to Real-World Roadways

Full scale accelerated aging testing using Accelerated Pavement Testing Facility (VTTI).

- Leverage Accelerated Pavement Testing Facility and heavy-vehicle simulator to evaluate structural integrity and electrical performance as the testing progresses

- Test for structural integrity and electrical performance after -
  - Retrofit and test for structural integrity
  - Develop new pavement as in real-world process
  - Asphalt laying down process

- Specifications:
  - 1000 hours – 500,00 axles or 250,00 drive overs
  - Loading 9,000 Lbs, 12,000 Lbs, and 15,000 Lbs

Analyze performance based on characterization data and map next steps.

Conclusion and Next Steps

Review

- 200 kW DWPT system validated in the laboratory for rated power in stationary and dynamic mode with recorded efficiency of over 90 %
- Primary coil embedded in concrete and vehicle coil mounted on vehicle were both tested separately and did not show interference to satisfactory performance
- Preliminary structural review and design conducted per AASTHO and ACI standards and guidelines

Next steps

- Conduct 200 kW DWPT demo in field
- Conduct comprehensive review of 200 kW DWPT system and identify gaps to deployment in real world
- Develop and validate technology and solutions needed to transition technology from proof-of-concept system to real-world practicable system

Audience Poll Questions

Join by Web

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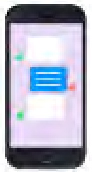
Join by Text



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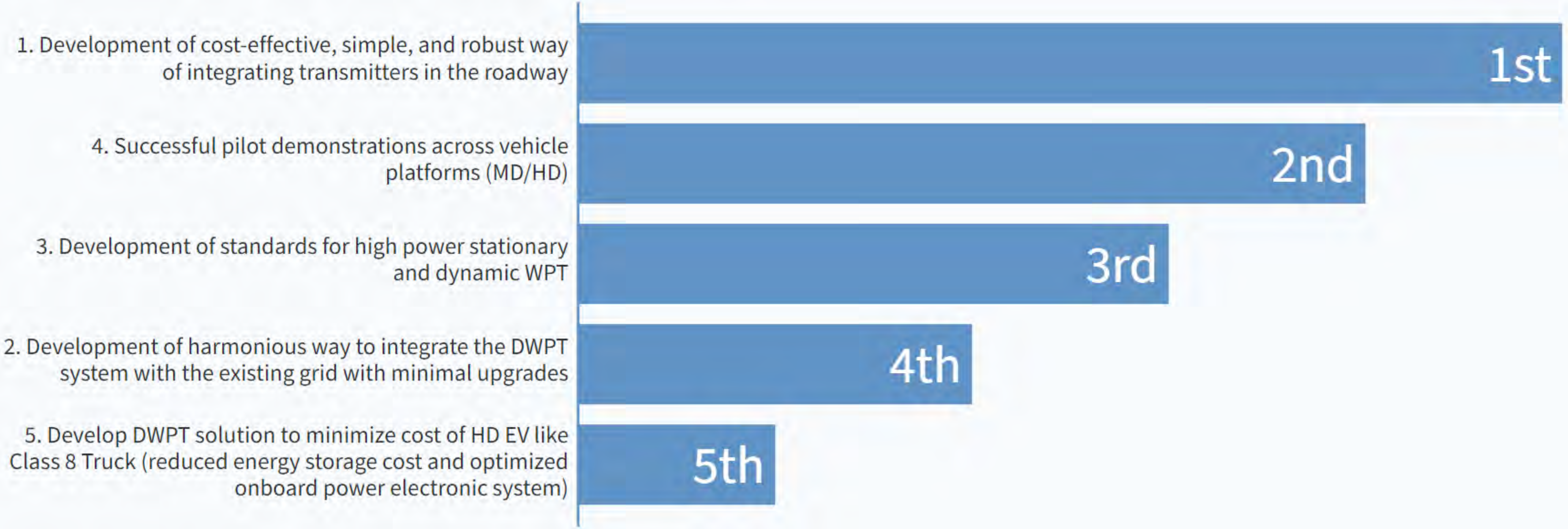
Respond at **PollEv.com/burakozpineci620**

What do you see as the critical step in realizing practicable real-world dynamic wireless charging system? (Rank from 1 to 5, 1 being highest rank)



Thank You!

Join us for the

Wireless Power Transfer Pillar: High Power and Dynamic Wireless Charging

May 03

Contact : galigekerevn@ornl.gov

EVs @ Scale

U.S. Department of Energy

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U.S. Department of Energy

Cyber-Physical Security Pillar

Barney Carlson: Idaho National Lab

Barney Carlson: Idaho National Lab

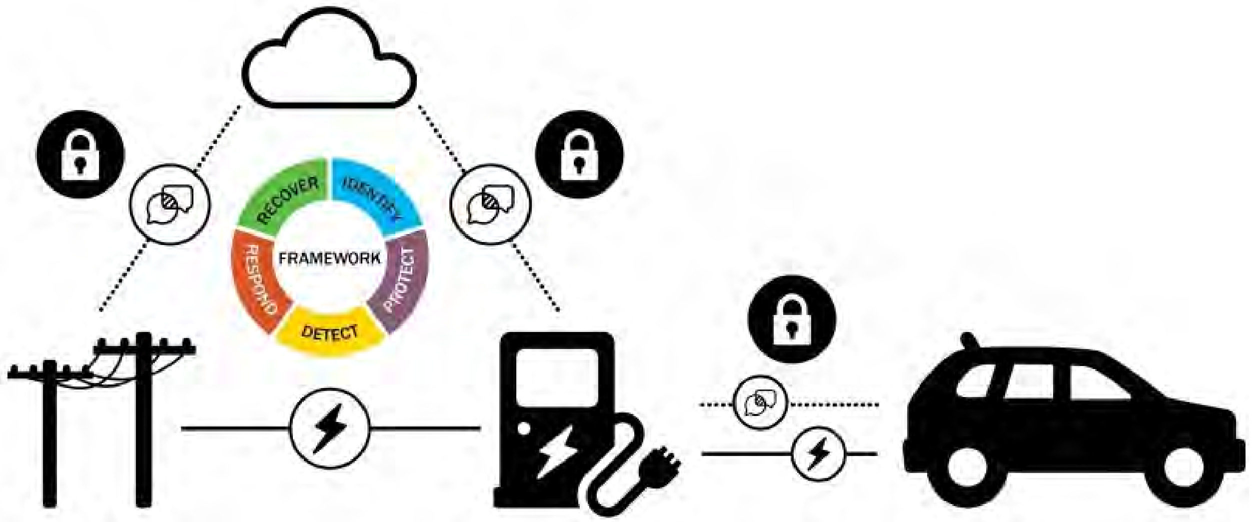
April 5, 2023

Cyber-Physical Security Pillar Overview

Objective: Contribute to the continuously evolving cyber-physical security methods and solutions needed to ensure EV charging infrastructure safety, reliability, & resiliency

Projects:

- *CyberPUNC* assessments, mitigation R&D, training
- *Zero Trust Architecture* for EV charging infrastructure
- *eVISION* for resilient EV charging infrastructure



Outcomes:

- Implementation and utilization of the latest security methods and best practices
- Identify vulnerabilities in new technology features and standards impacting electrified transportation
- Mitigation solutions for cyber-physical security impacting EV charging infrastructure
- Training for the next-generation of EV charging infrastructure cybersecurity workforce

Idaho National Laboratory | Sandia National Laboratories | Pacific Northwest National Laboratory | Argonne National Laboratory | NREL Transforming ENERGY | Oak Ridge National Laboratory

CyberPUNC Project Overview

CyberPUNC Project Tasks:

- Securing EVSE with PKI Integration
- Cyber Tools and Solutions for EVSE
- Cybersecurity Workforce Training
- Mitigation Solutions Development
- CSMS Communication Assessment

CyberPUNC Project - Securing EVSE with PKI Integration

Implementing the latest security methods and best practices

Background

– Baseline cybersecurity requirements (Certificate Profiles) come from ISO 15118-2 and -20

– SAE industry Cooperative Research Project (CRP) implemented initial PKI design and refinement

– Completed series of functional testing events at NREL, enabling industry progress

Current Focus and Progress

– Use open-source minimega/Phēnix tools for PKI emulation and testing

- Evaluating scalability and risks of large-scale deployments
- Refining design and processes for increased resilience and robustness

– Review of the Threat Model and Policy Document

- Frame possible testing and research needs that enhance system robustness and recovery

Insights

– Modeling large scale systems; optimizing PKI structure, operations, and governance

Future Directions

– Target future testing of cyber vulnerabilities, response and recovery efforts

– Model large scale systems interactions; compare differing PKI designs (e.g. unified vs. federated)

PKI Progress and needs to be highlighted in panel session at DOE Cyber Conference

CyberPUNC Project - Securing EVSE with PKI Integration

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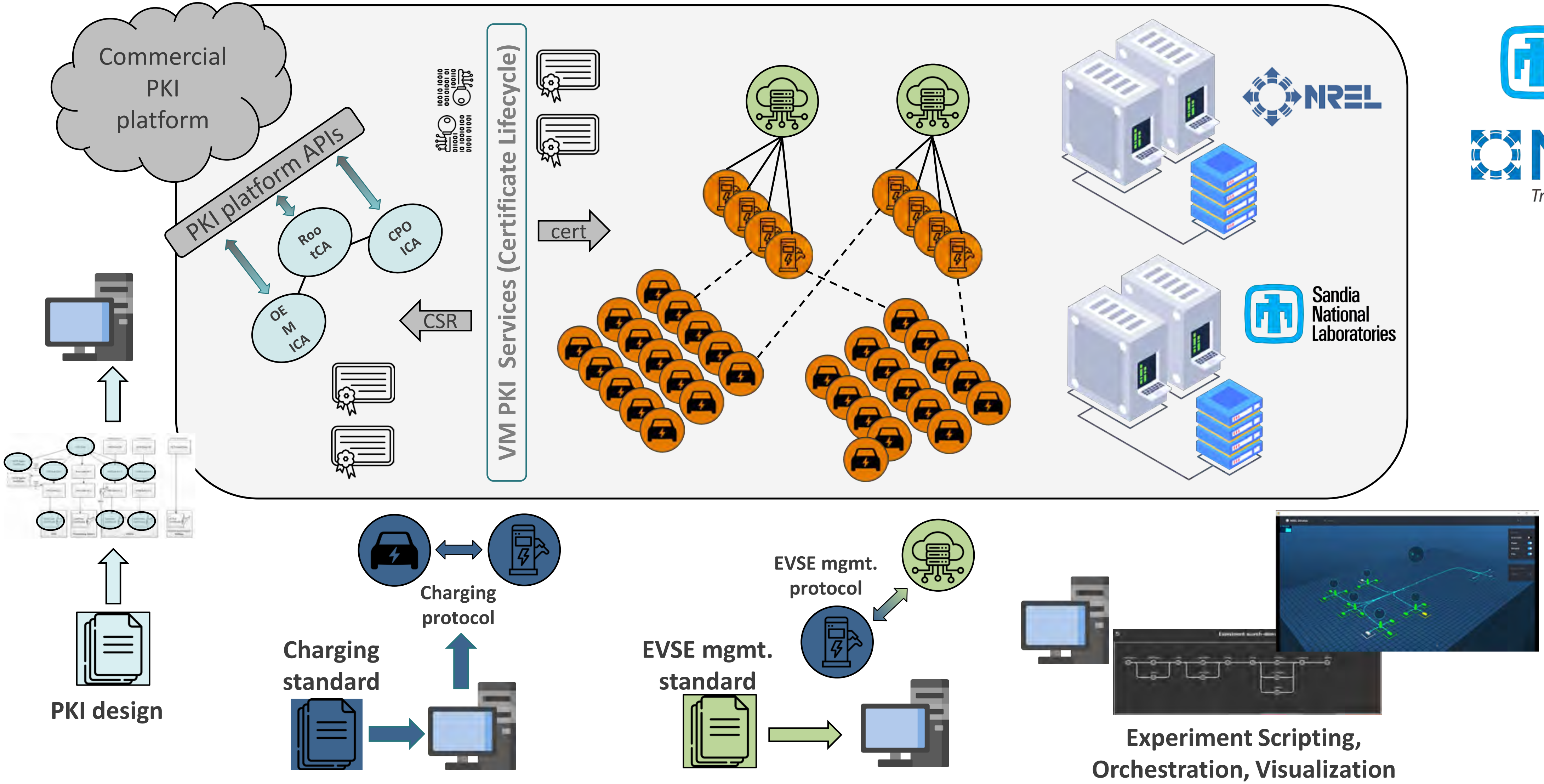
EV charging PKI emulation on minimega/Phēnix



Sandia National Laboratories

NREL Transforming ENERGY

CyberPUNC Project – Cyber Tools and Solutions for EVSE

Implementing the latest security methods and best practices

Background

– Prior national lab work collected insights on subset of industry tools and capabilities

– Opportunity to map tools and capabilities to EVSE security functions and needs

Current Focus and Progress

– Constructed a dynamic database (OpenEI platform) for engaging with industry

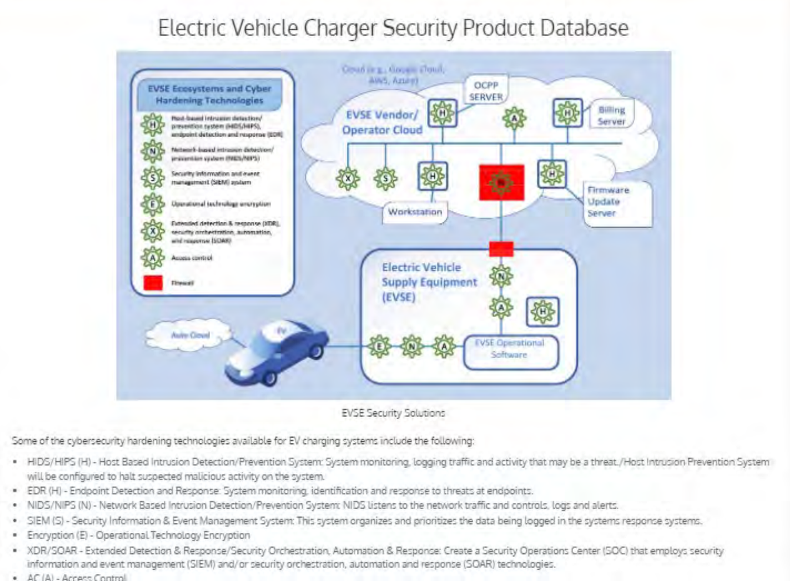
– Ingested initial data from surveys

Future Directions

– Report out on industry use and updates to the security solutions database

– Assess where there may be gaps in needed security functions

– Role these insights into the development of assessment tools with EVSE stakeholder specific risk identification



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CyberPUNC Project – Cybersecurity Workforce Training

CyberAuto Challenge Training the Next-Generation Cyber Workforce

- Annual 1-week long, collegiate event in Mich. focused on automotive cybersecurity
- *CyberAuto* 2022 included a few EVs and one DC fast charger
- *CyberAuto* 2023: increased focus on electrified transportation and EV charging infra.
- 2024 & beyond: expand into *CyberInfrastructure Challenge* focused on EV charging infrastructure (including bi-directional), DER, and the associated communications
- **OEMs (EV & EVSE) are encouraged to participate in the *CyberAuto* July 24-28, 2023**
  - Contact: Karl Heimer (karl.heimer.pro@gmail.com) or Barney Carlson (richard.carlson@inl.gov)

CyberAuto Challenge

Idaho National Laboratory

CyberStrike Training for Network Defenders

- Labs will include open-source information gathering, API/cloud vulnerabilities, firmware inspection, over-the-air updates, smart phone app inspection, and more
  - Substantial progress creating cyber range (EVSE emulation environment + cloud)
  - New OCPP simulation capabilities with machine-in-the-middle and replay attacks
- Physical environment is being built with solar and wind elements as well and branded CyberStrike STORMCLOUD. Hardware is funded by DOE CESER through INL.
- Final lab, software, and hardware buildout expected in Sept 2023.

CYBER STRIKE

Sponsored by the U.S. Department of Energy

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CyberPUNC Project – Mitigation Solutions Development

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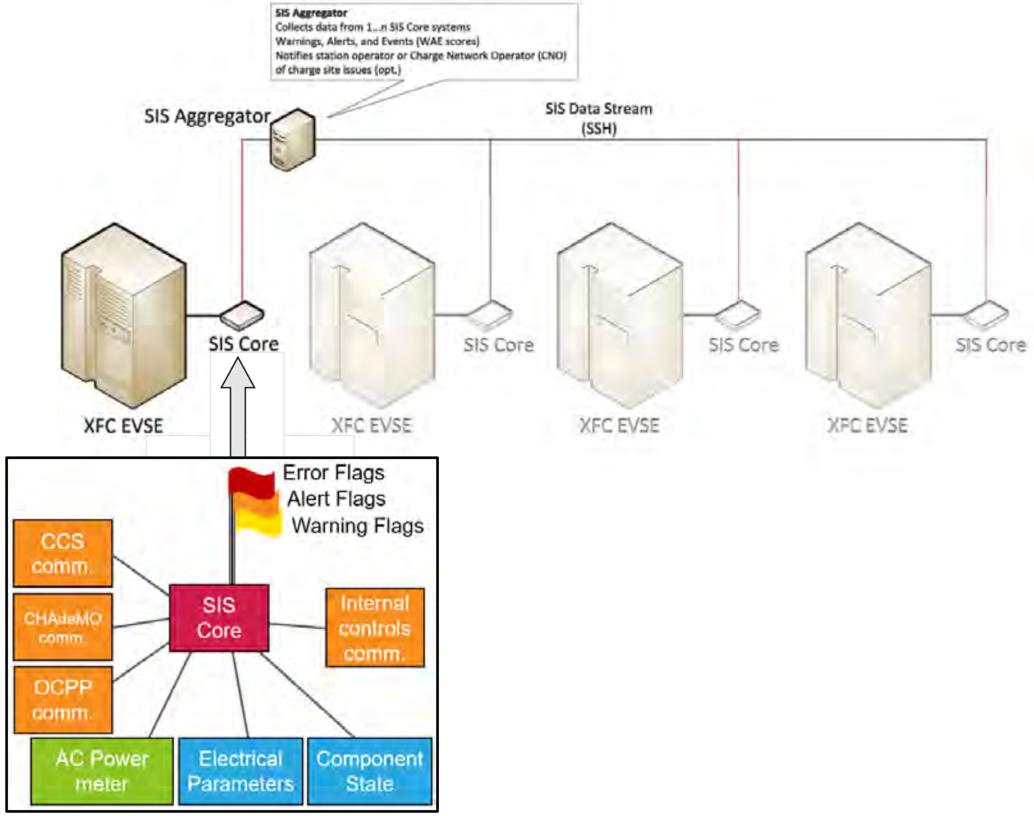
Mitigation Solutions R&D for High-Power EV Charging Infrastructure

Idaho National Laboratory

- Mitigation solutions that detect, respond, & recover from cyber exploits
  - *CERBERUS* (cybersecurity detection, response, and recovery) for high-power DC Charging Infrastructure
    - Core module integral to each EVSE
    - Aggregator module at each charge site
- 2022 efforts focused on detection and prioritization of exploit severity
- 2023 efforts are developing response and recovery solutions to ensure safe and resilient continued charging operation
  - Charging functionality and CCS communications
  - EVSE internal controls communications and operations
  - External communications including smart energy management, service provider, charge point operator, manufacturer, and others
- Mitigation performance will be demonstrated on the June 7, 2023, at the *EV SALaD* demonstration funded by the U.S. DOE CESER office
- Industry engagement is encouraged for future field deployments & demonstrations focused on high-power DC charging sites



CyberPUNC Project – CSMS Communication Assessment

EVSE UpstAnD (Upstream Analysis and Design)

- Project focus lies within the “next layer up” from the EVSE including tunnels back to EVSE manufacturer networks, interactions within CSMS (public/private/hybrid), and retrieving/securing assets within cloud environments
- This project is still in scoping
- The rest of the year will encompass an assessment of CharIN and other documentation of CSMS deployments, identification of open-source identifiers of EVSE management systems (such as the SteVe OCPP management software), and mapping of these risks to mitigating solutions within NIST 800 special Publications Series.

- CSMS vendors or EVSE manufacturers interested in WAN or “callback” risks. Past participants in these projects can vouch for benefit from on-site red teaming and dissemination of results to strengthen and bolster security posture.

Conclusion and Next Steps

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Review

- PKI assessments using open-source minimega/Phēnix tools
- Cyber Application Tools and solutions for EVSE
- Mitigation solution R&D for High-Power Charging Infrastructure under development
- Cybersecurity workforce training support
- CSMS communication assessment

Next steps

- The *2023 CyberAuto Challenge* with increased focus on electrified vehicles and charging infrastructure
  - July 24-28, 2023 in Warren, MI
- High-power DC charging Infrastructure cyber-physical security mitigation solutions will be demonstrated as part of the 2023 EV SALaD project demonstration
- Simulation of CCS EV charging with PKI Integration will move from 10s to 1000s of device endpoints
  - Panel session at DOE Cyber Conference including EV industry participants will highlight PKI
- Cyber Tools and Solutions for EVSE will open interface to industry solution providers and work towards a fall milestone of defining initial integration strategies for EVSE active cyber defense

Audience Poll Questions

Join by Web

1. Go to **PollEv.com**
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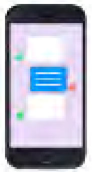

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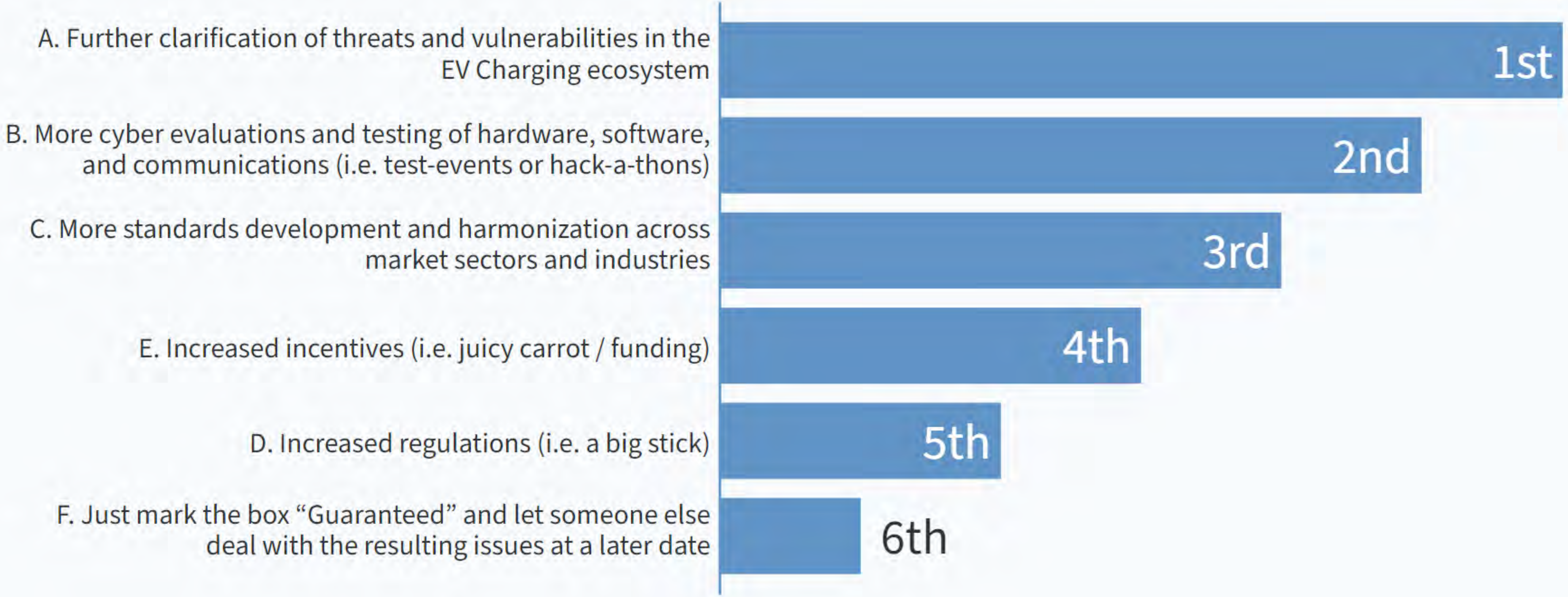
Text **BURAKOZPINECI620** to **22333** once to join

Respond at **PollEv.com/burakozpineci620**

What is the most effective way to 'close the gap' on cybersecurity & cyber-physical security for EV charging infrastructure?



Thank You!

Join us for the

Cyber-Physical Security Deep-Dive
May 24

contact Craig Rodine: crrodin@sandia.gov

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Electric Vehicle Integrated Safety, Intelligence, OperatioNs (eVISION)

(ORNL, PNNL, INL)

Michael Starke, PhD
Oak Ridge National Laboratory
April 2023

Resilient High Power Charging Facility: Overall Purpose and Approach

EVs@Scale
U.S. Department of Energy

Overall Approach:

Develop control and anomaly detection techniques to improve the resiliency of the electric grid and charging stations.

CHIL RT-SIM

Charger Level Controls
Electric vehicle charger topologies and controls
Electrical vehicle charger fault identification
Electrical vehicle charger resilient operations

Oak Ridge National Laboratory

Idaho National Laboratory

Hardware

Threat and Failure Detection
Cyber security threats and attacks
Physical equipment threats and attacks
Communication failures

CO-SIM HIL

Station Level Controls
Electrical charging network
Supporting Energy Storage / Renewables
Islanding Options

Pacific Northwest National Laboratory

Validation of technology development performed in both controller hardware in the loop and hardware platforms.

Technical Approach: Architecture Combining Areas of Resiliency

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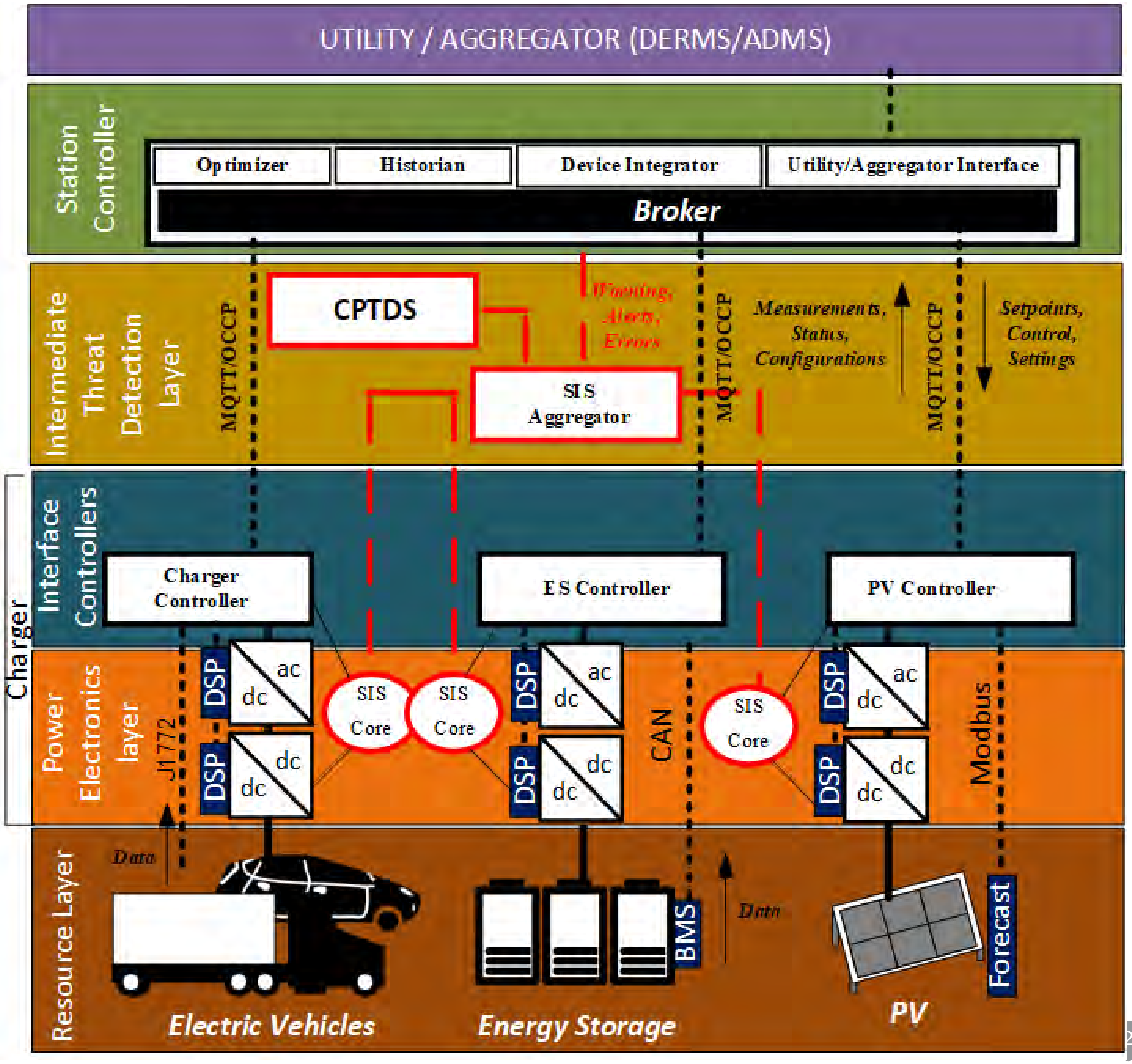
U.S. Department of Energy

Architecture: Common framework to link development stages.

- Anomaly detection methods provide a means to signal a identified challenge.
- Station controller can receive these signals and respond accordingly with control signals to resources.
- Provides opportunity to development independently and represent connections and potential message sharing associated with

M. Starke, M. Chinthavali, N. Kim, T. Carroll, F. Tuffner, B. Varghese, C. Rieger, K. Rohde, T. Pennington, "Supporting Resilience for Electric Vehicle Charging" IEEE Power and Energy Society General Meeting 2023 (**Accepted**)



Resilient High Power Charging Facility: Approach Details

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***Use Case:* Defines a mechanism that could lead to potential failure of the charging station. This could be a piece of equipment, communication network, or line outage as examples.**

Use Case 7: Cyber Security Threat

Use Case 2: Device Reliability and Continued Operation

Use Case 8: Physical Equipment Threats

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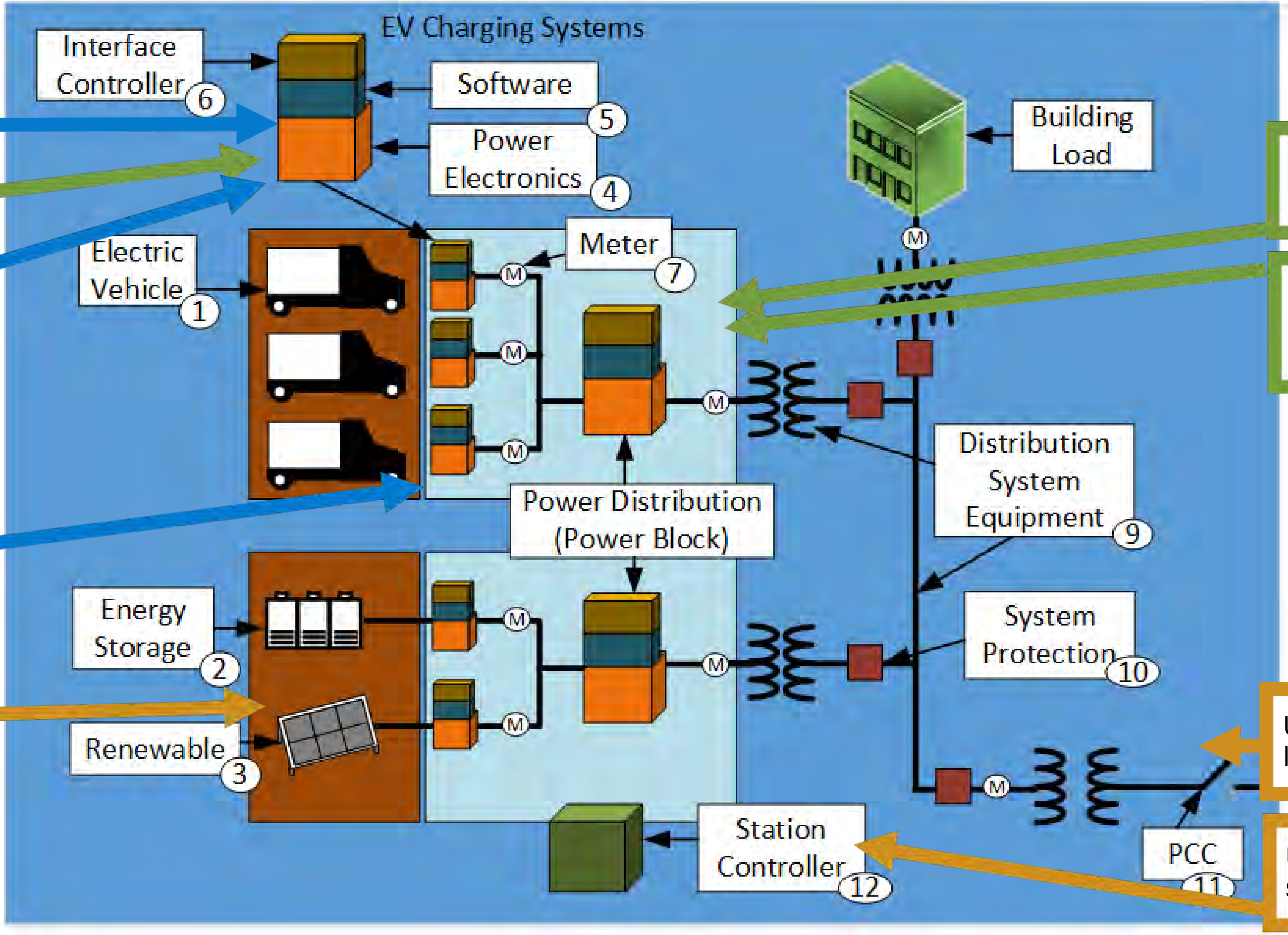
Use Case 8: Communications failure / disruption

Use Case 6: Renewable and Energy Storage Support Failures



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Use Case 1: Distribution Fault and Fault Ride-through

Use Case 3: Integrated Storage and continued operation.

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Use Case 4: Grid Fault and Islanding Considerations

Use Case 5: Station controller system reconfiguration.

Leveraging CODAS Platform

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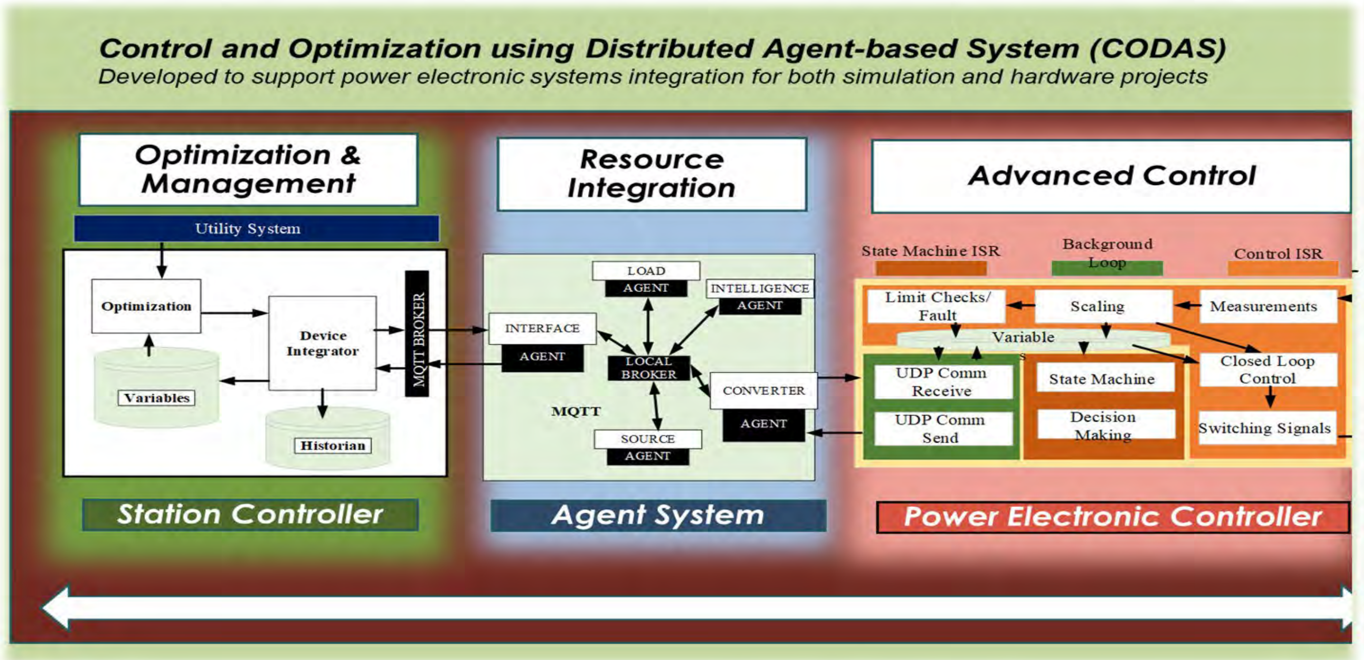

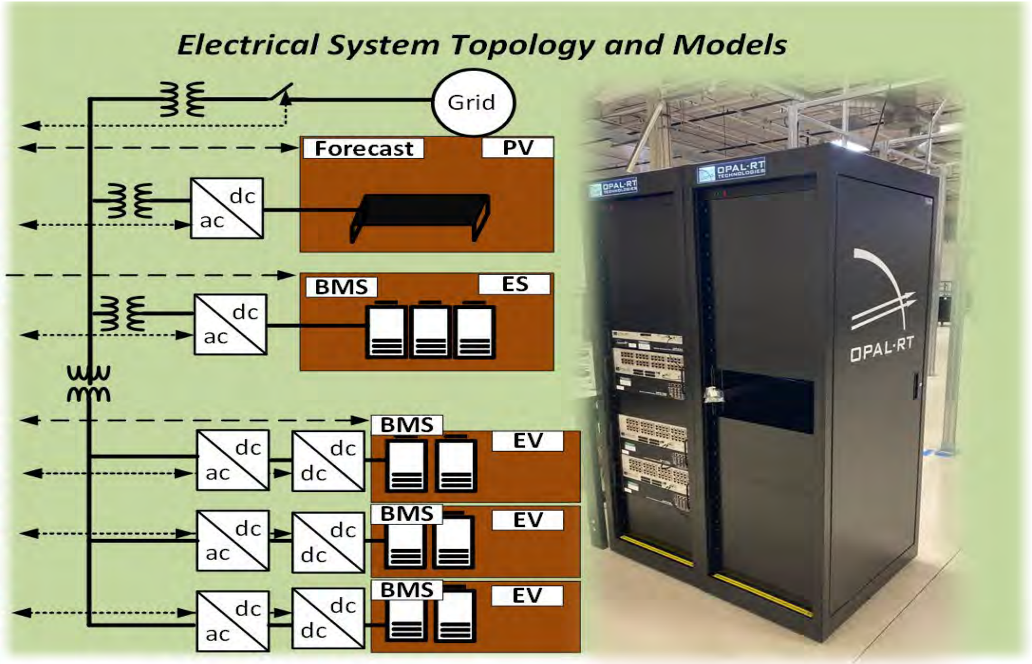

Station Architecture

New Alerts Messages for Faults and Ride through Enabling			Automated Run Code to Run Simulations (Tool)
Resource Management Controller GUI	Converter GUI Updates	Ride-through (DC/DC) (Droop)	Model automatic fault creation based on timer.
Fixes on Fault and Error Code Distribution		Identification of Failures and Control Adjustment	DC fast charging models in Typhoon

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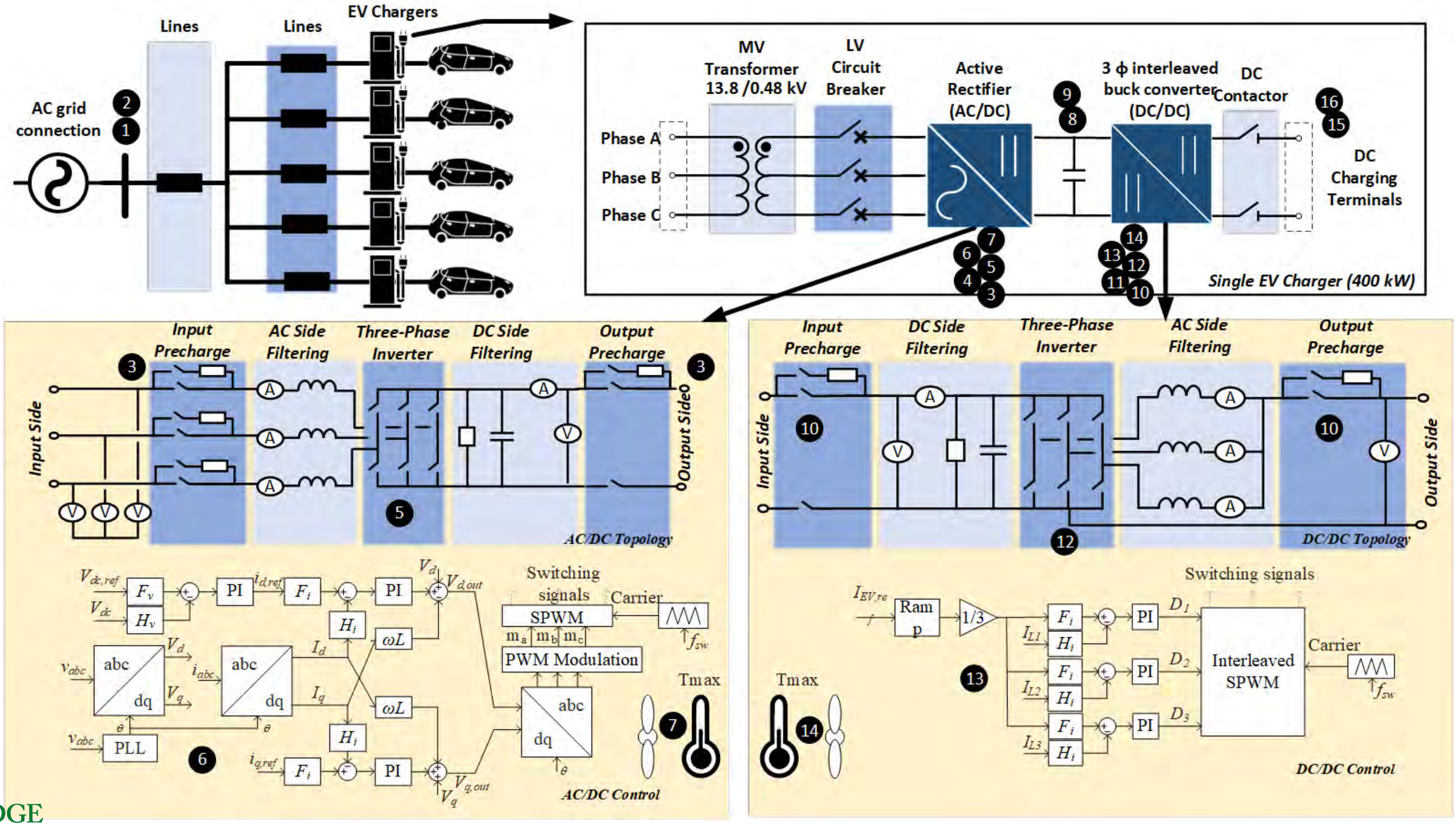
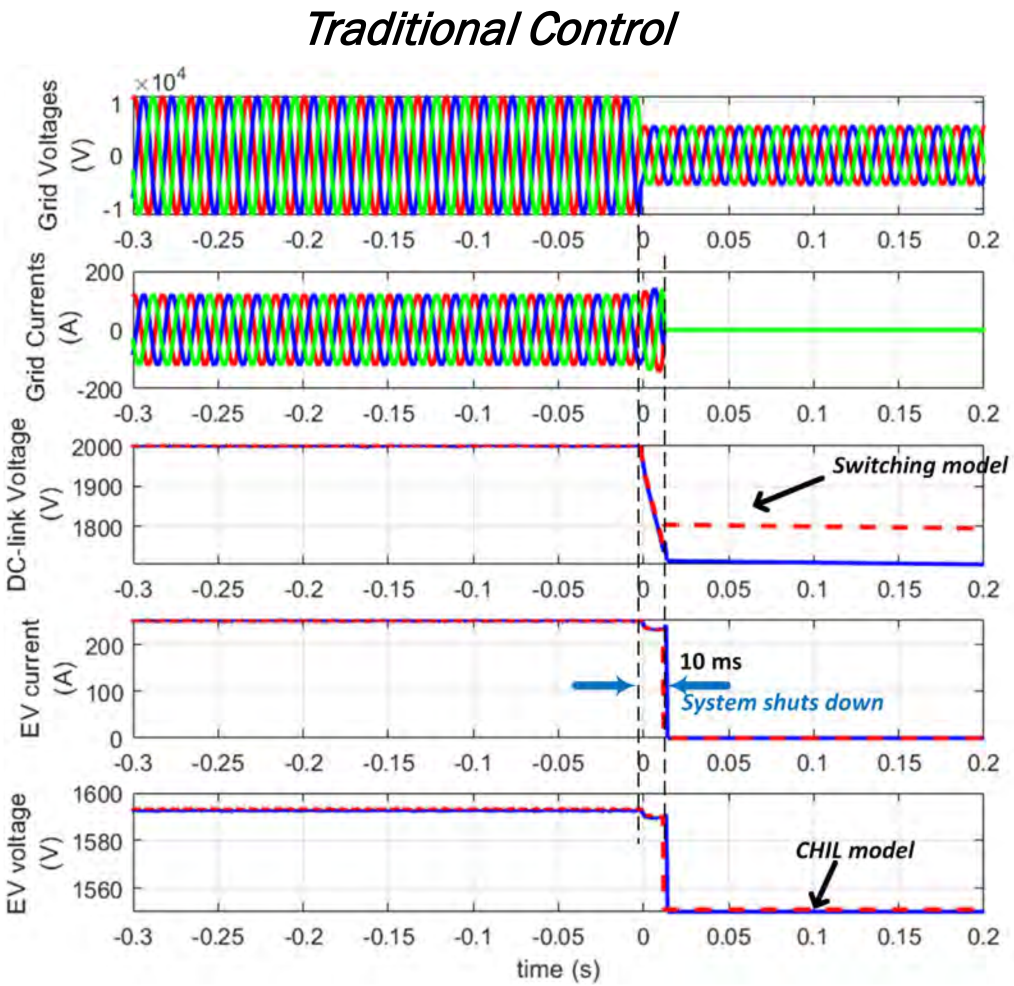
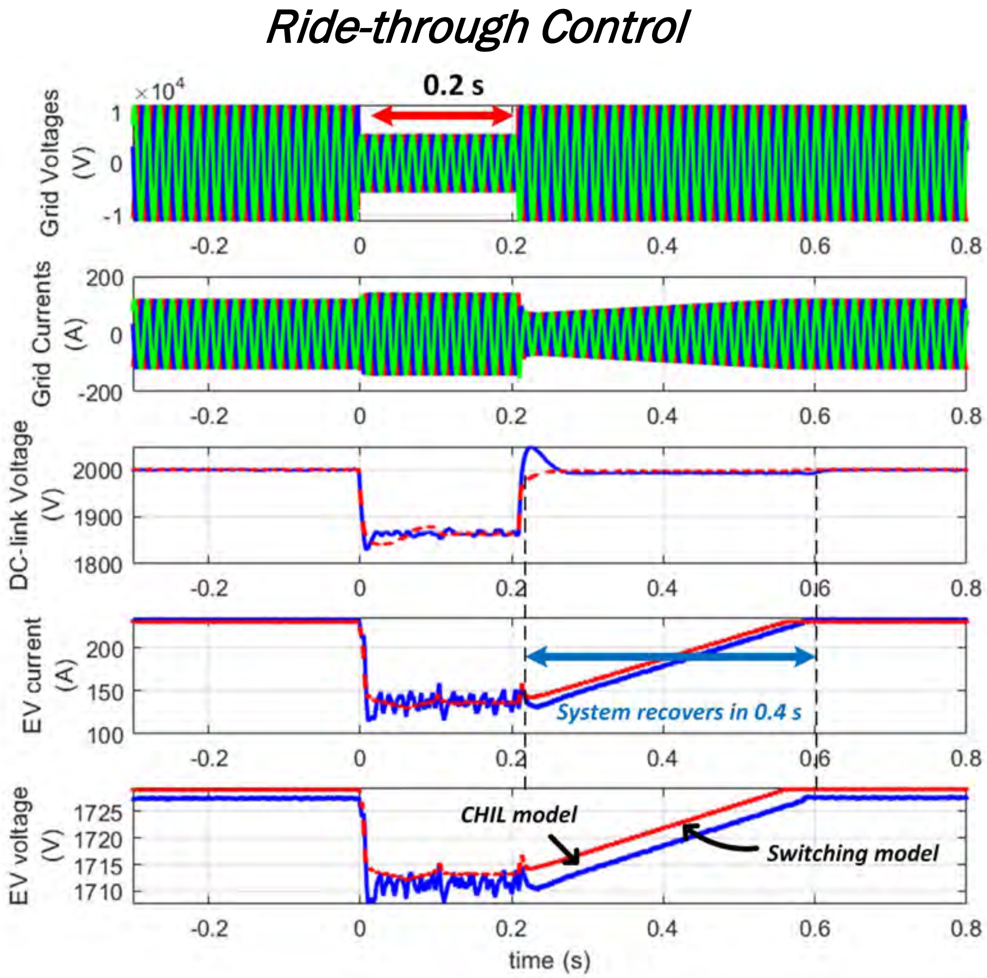
Potential Failure Modes in Charging Eco-System



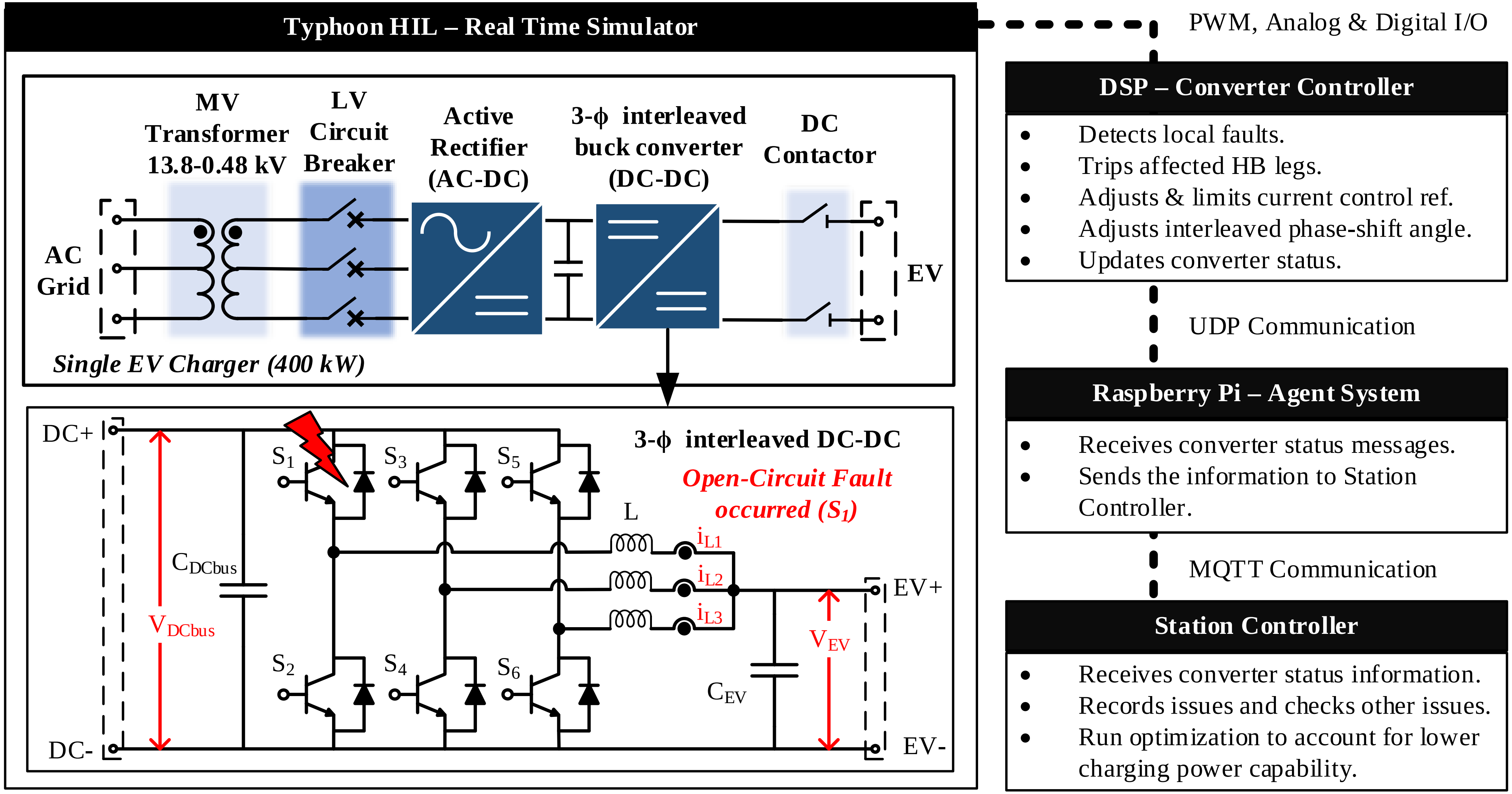
Use Case: DC/DC Converter Ride-through





M. Starke, S. Bal, M. Chinthavali and N. Kim, "A Control Strategy for Improving Resiliency of an DC Fast Charging EV System," 2022 IEEE Transportation Electrification Conference & Expo (ITEC), 2022, pp. 947-952.

Use Case: Device Failure Ride Through (DFRT)



DSP – Converter Controller

- Detects local faults.
- Trips affected HB legs.
- Adjusts & limits current control ref.
- Adjusts interleaved phase-shift angle.
- Updates converter status.

Raspberry Pi – Agent System

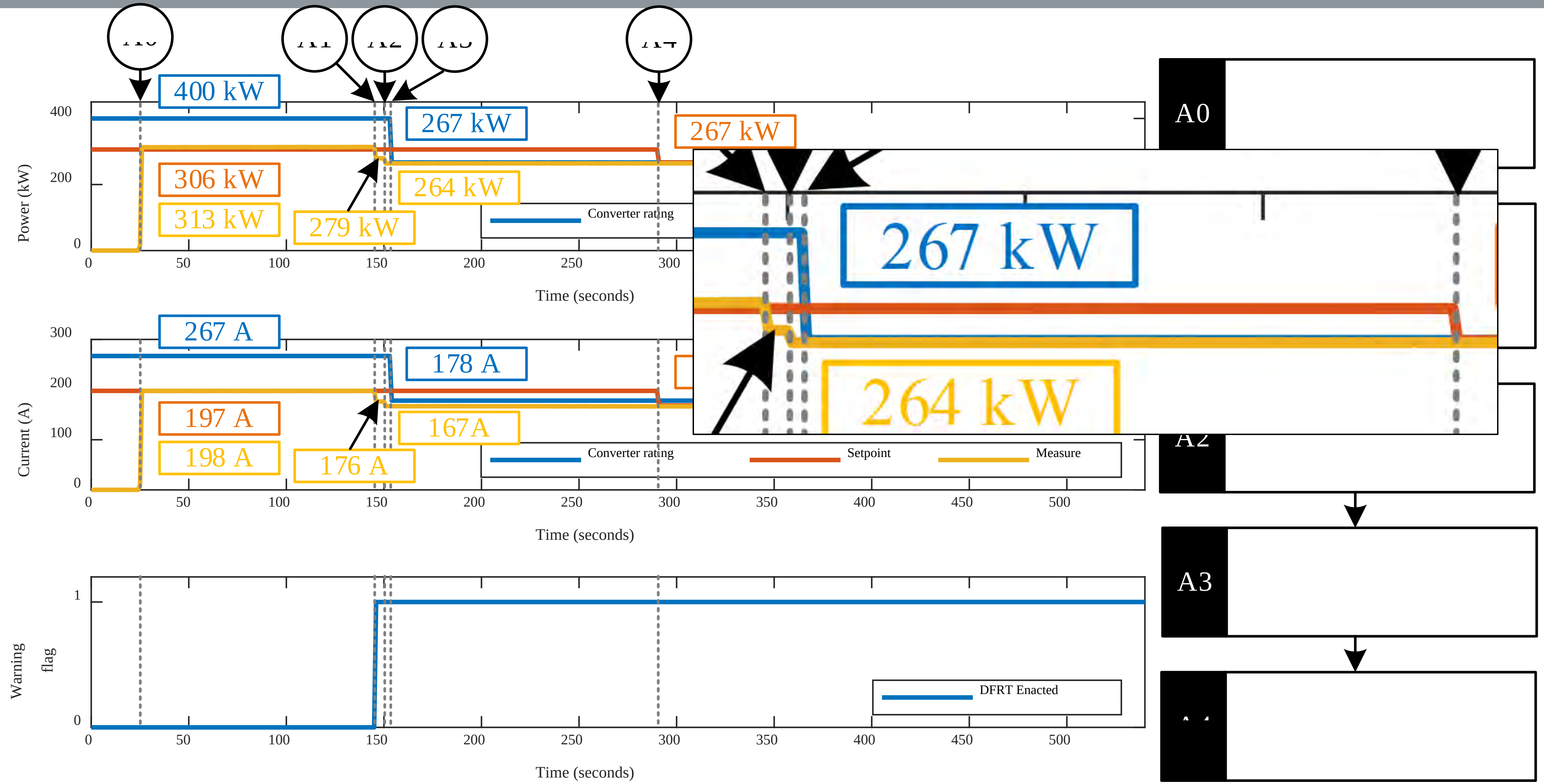
- Receives converter status messages.
- Sends the information to Station Controller.

Station Controller

- Receives converter status information.
- Records issues and checks other issues.
- Run optimization to account for lower charging power capability.

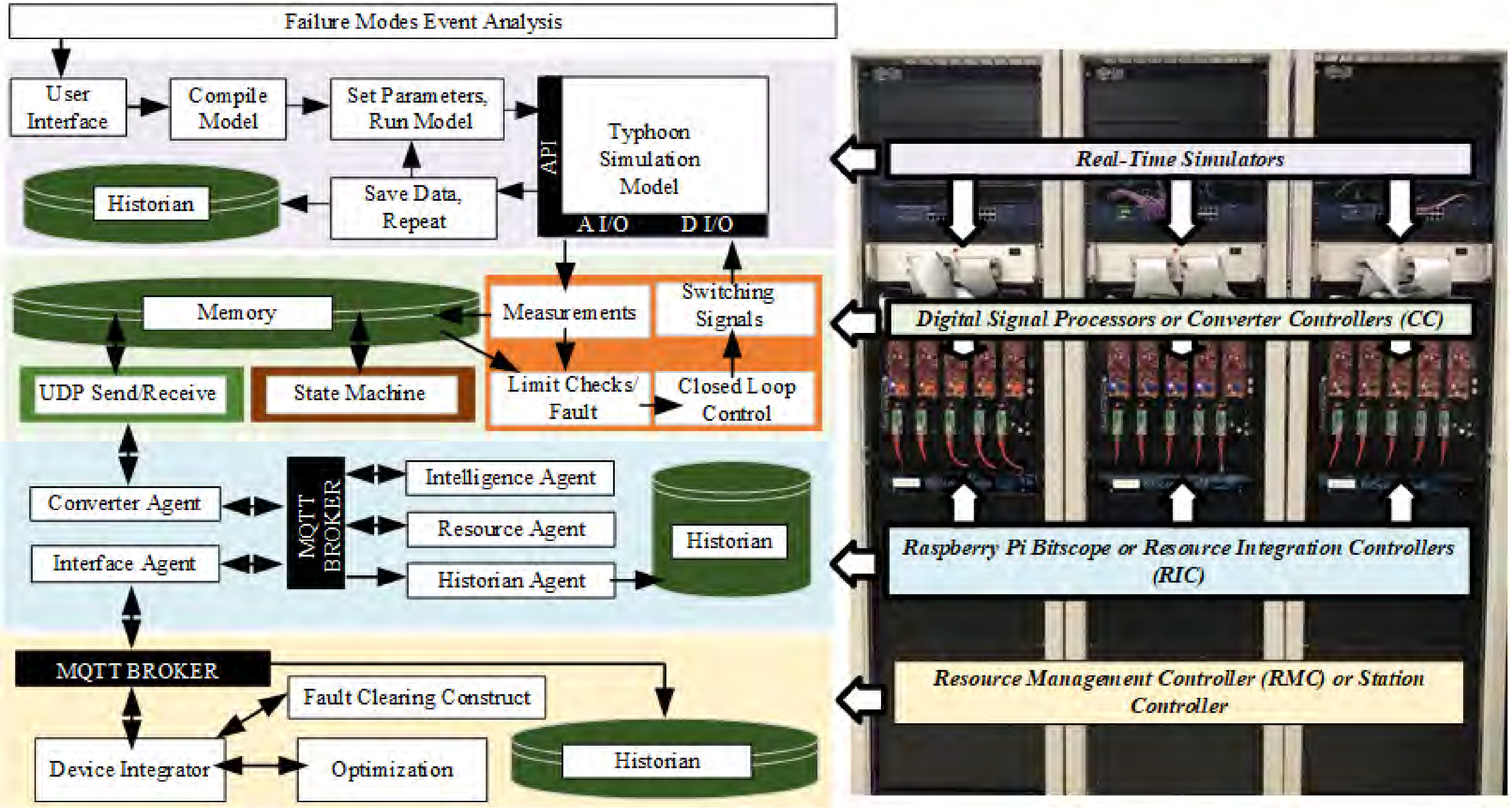
N. Kim, M. Starke, B. Dean, "Improving EV Charging Resilience under a Device Fault Condition," ECCE 2023 (Digest Submitted)

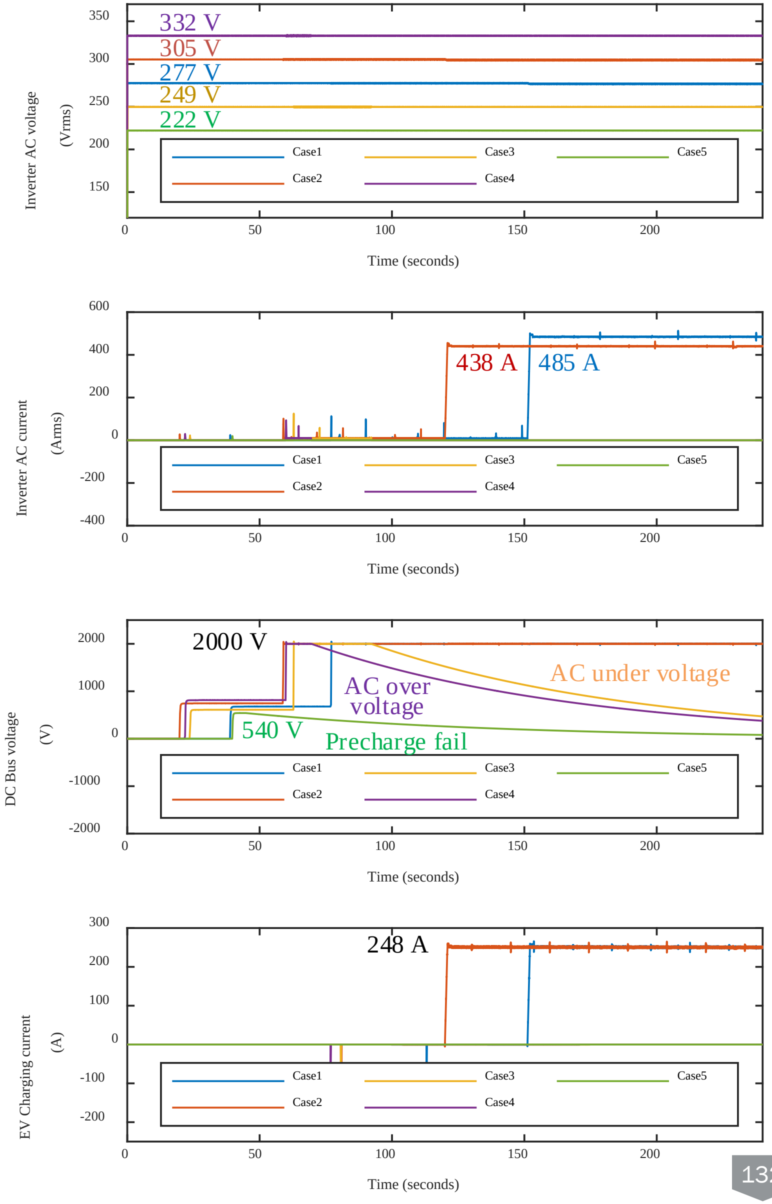
CHIL RT Simulation Results: Optimization



N. Kim, M. Starke, B. Dean, "Improving EV Charging Resilience under a Device Fault Condition," ECCE 2023 (Digest Submitted)

Automating and Integrating

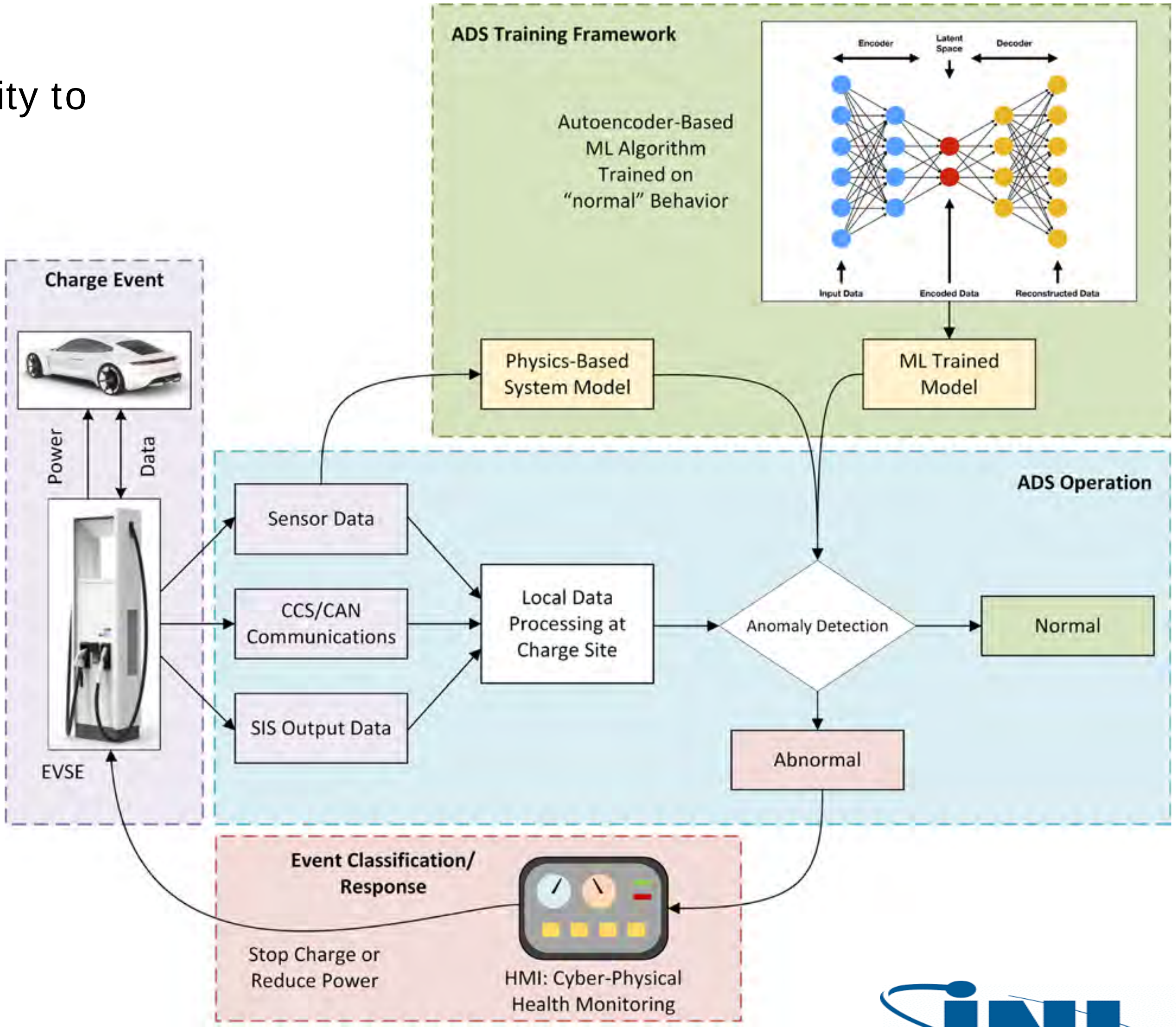




M. Starke, N. Kim, B. Dean, "Automated Controller Hardware-In-The-Loop Testbed for EV Charger Resilience Analysis," ITEC 2023 (**Digest Accepted**)

Anomaly Detection and System Architecture

- Autoencoder Neural Network:
  - No data of abnormalities/attacks is needed; ability to learn complex non-linear patterns within data.
- Detection performance
  - Scenario 9-1 is presented in the figure: Anomalous behavior observed after the exploit with unstable cooling
  - Performance on baseline data *test: ~100% (only one false positive data record)*
- Performance on all anomaly tests*: 38/39 (97% accuracy)*
- Future work
  - Integrate physical features into the ML model for improved anomaly detection
  - Evaluate a second real-time data collection system on DCFC; shows extensibility to additional charger types.



Initial Result Analysis

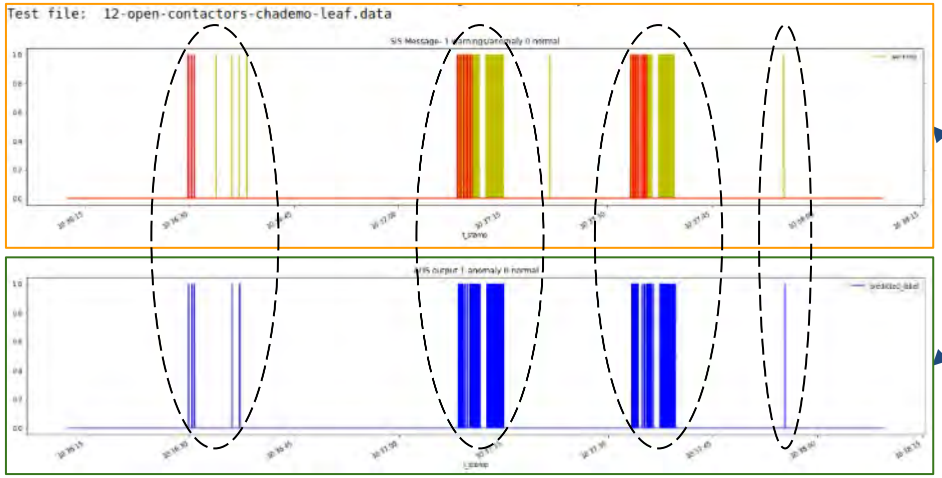
- SIS reports:
  - Anomalies (ALERT, ERROR), Warnings
  - It is anticipated these will be specific for (benign) physical and (malicious) cyber => ADS will differentiate
- Test accuracy on normal behaviors:
  - 99.99% (ADS detected 99.99% records as normal from the normal records identified by SIS)
- Test accuracy on abnormal behaviors:
  - Anomalies only: 98.05% (ADS detected 98.05% anomalies identified by SIS)
  - Warnings only: 92.94% (ADS detected 92.94% warning records identified by SIS)
  - On anomalies and warnings: 95.19% (ADS detected 95.19% anomalies identified by SIS)

(cyber, malicious)

SIS outputs: red line represent anomalies (1: anomaly, 0:normal), *yellow line* (1:warning, 0: normal)

ADS output: *blue line* (1: detected anomaly, 0: normal behavior)

(cyber, malicious)



ADS matches the SIS outputs

Anomaly Detection and Application to Hardware

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U.S. Department of Energy

Exploit: Chiller disables & CCS cable temperatures spoofed during high-power charging

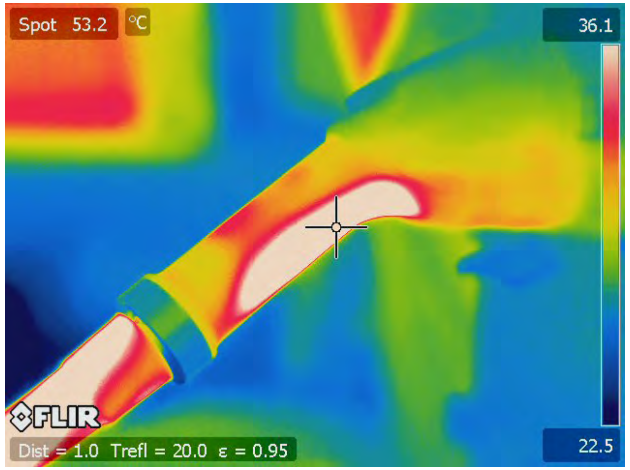


Fig. Thermal image of CCS connector during Scenario 9-2 showing a 52 C hotspot

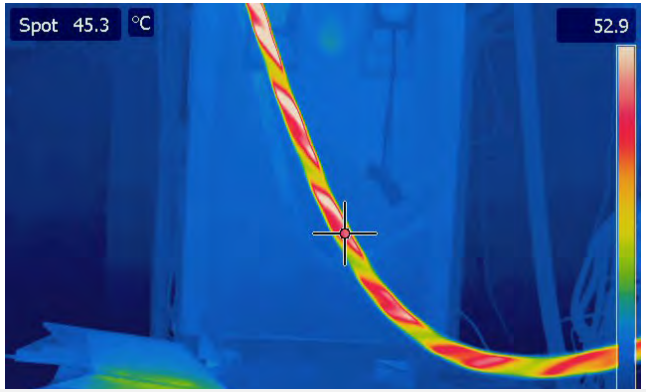
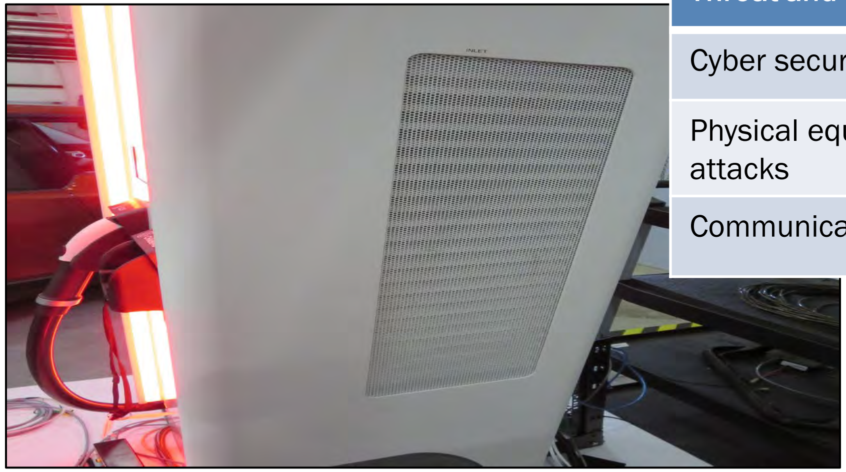


Fig. Thermal image of CCS cable during Scenario 9-2 showing a 45 C hotspot

SIS successfully detected anomalous behavior caused by the intrusion and exploit
Low chiller current error: 1 sec. detection time
Temperature limit: 1 to 9 sec. detection time

Exploit: Air Inlet Blocked on EVSE

Threat and Failure Detection
Cyber security threats and attacks
Physical equipment threats and attacks
Communication failures



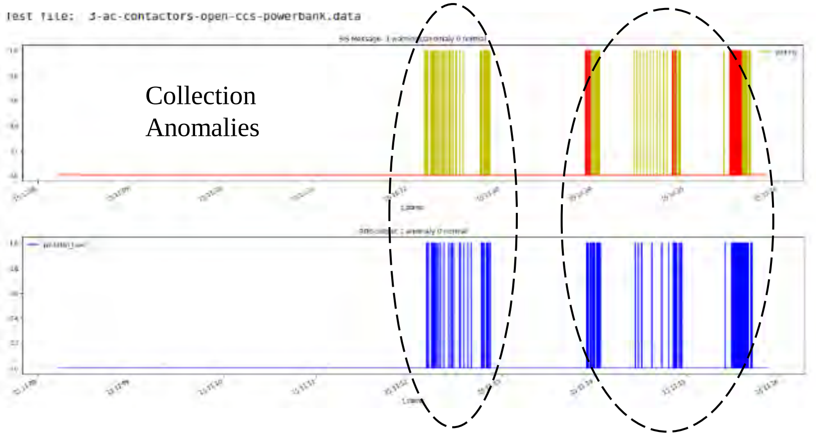
Charge session throttles after ~185 sec

Blocked air inlet: When undetected, this anomaly results in a faster rise in cable temperature and a throttling of charging power. This condition only resets after physical power cycling (reboot) of EVSE, resulting in denial of service and consumer inconvenience.

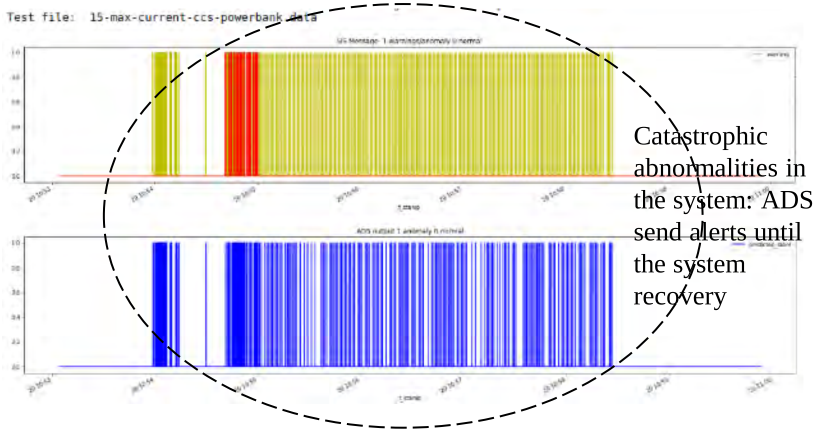
Idaho National Laboratory

Initial Result Analysis

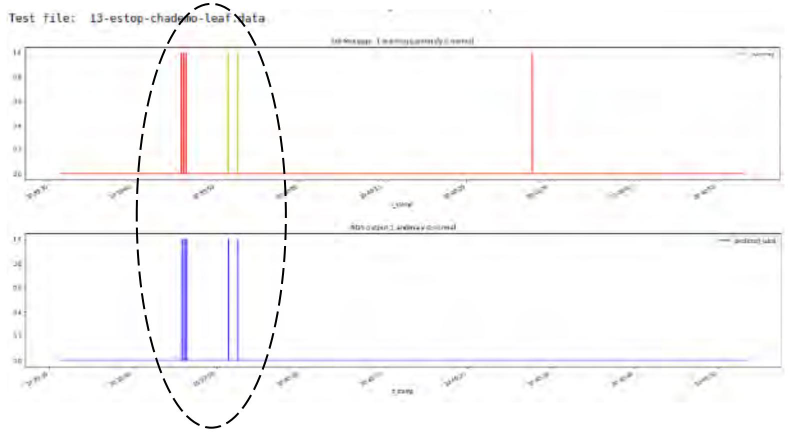
Main AC contactors opened during high-power charging (files 3, 8, 12) - cyber, malicious



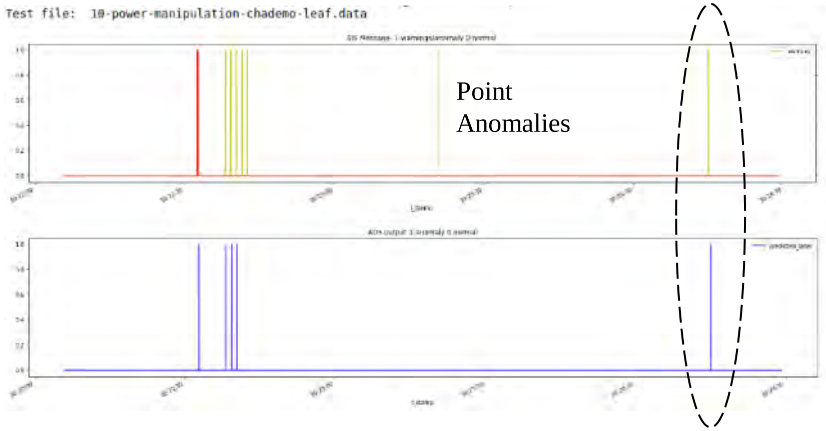
Max Current CCS Blocked Chiller Air Inlet: (files 14, 15, 17) - physical, benign



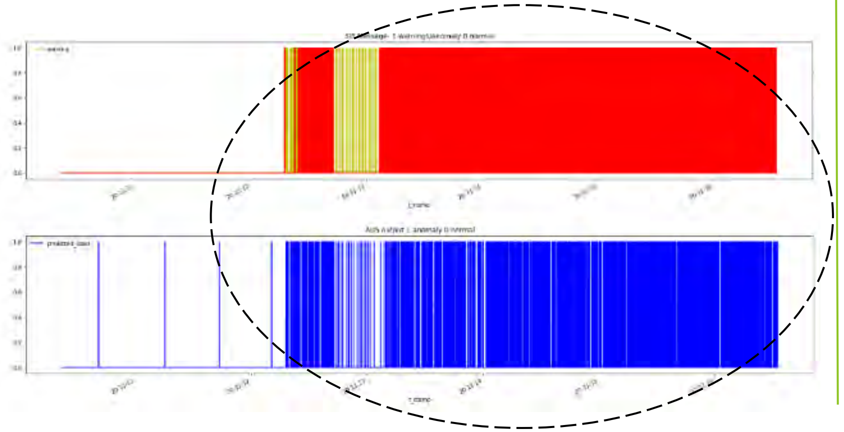
Cyber: e-Stop (files 4, 13) - cyber, malicious



Power Module Manipulation: (files 2, 7, 10, 11) - cyber, malicious



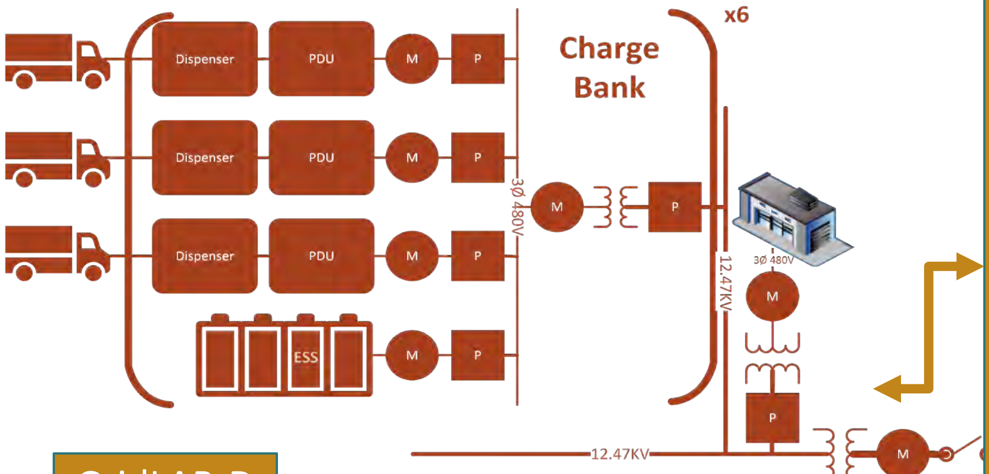
Max-current-ccs-chiller-disabled-powerban: (file 16) - cyber, malicious



Conclusion:
Initial ADS prototype
- Higher detection rate on anomalies
- Successfully detecting anomalies detected by SIS.

System Level Optimization and Control Response

Simulation development and validation of station level controls



GridLAB-D Model

HELICS

Open-source, co-simulation system aligns temporal data from multiple sources.

DirectX // Caldera Charge Profiles

Discrete event simulator for vehicle arrivals.
Temporal EV Energy Required, battery size, and SOC, EV Energy Delivered

Grid Conditions
Temporal PCC voltage input
Temporal PCC Power and sub-transmission

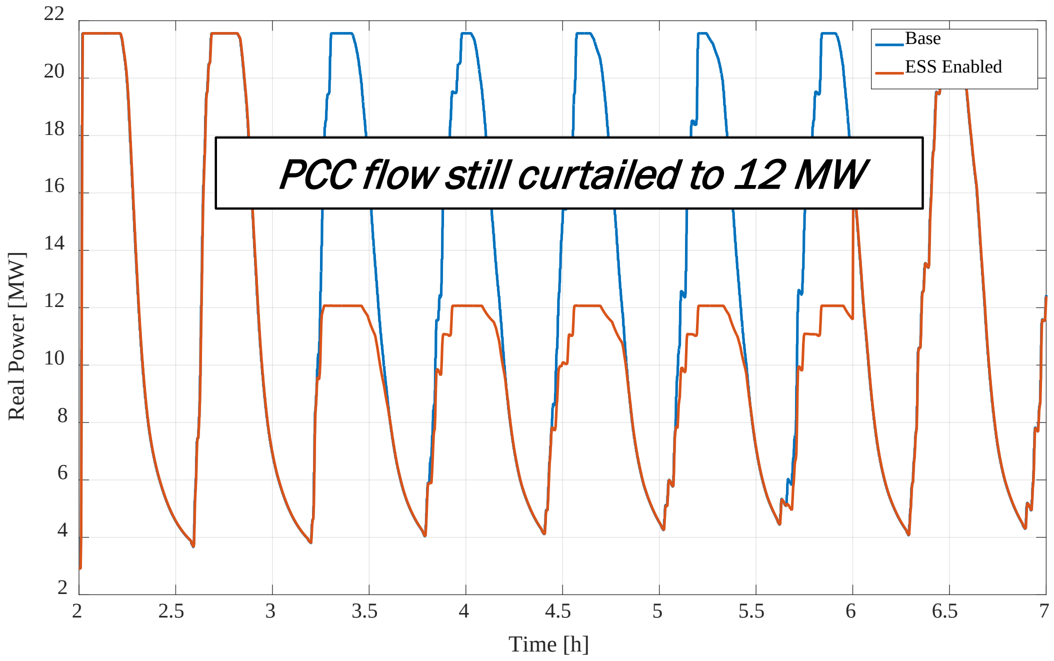
Controller
VOLTTRON-managed power control

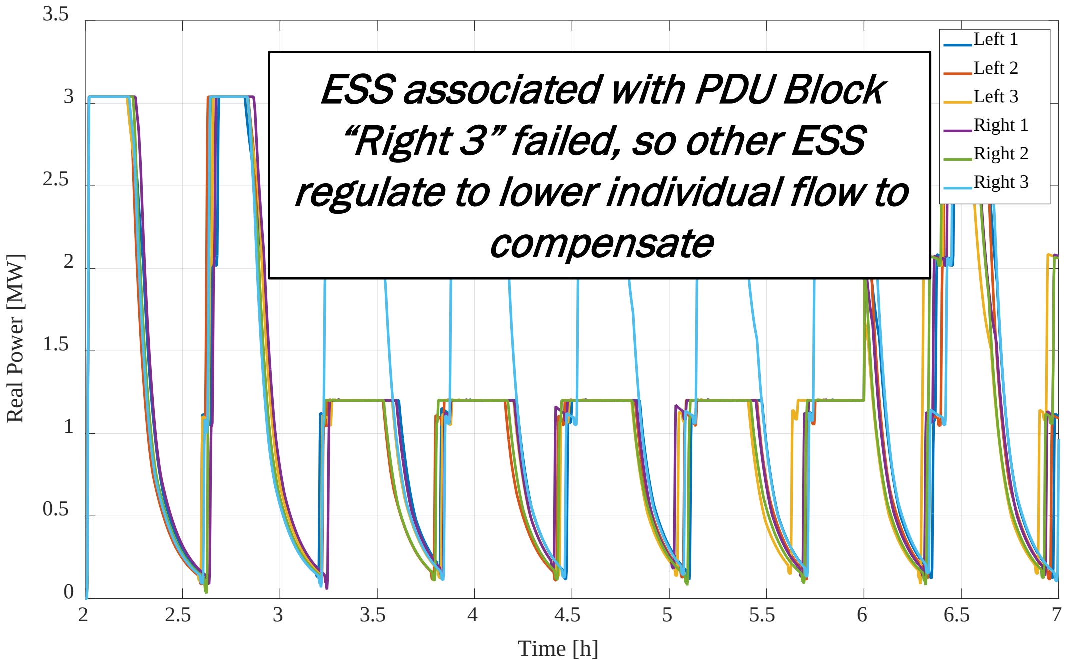
Building & Renewables Asset Integration
Building, Stationary Storage and Solar Generation Integration

Modeling Description:

- Studying a 24-hour short-haul freight service, operating a medium-duty EV fleet
- Depot performs a short-dwell, return-to-base mission, operating in two shifts
- Every vehicle serves both shifts
- 18 MW charging capacity; subdivided into six modular banks; each bank has a local ESS and three PDUs+dispensers
- Warehouse is a static load
- ESS regulates the PCC and microgrid voltages
- Demonstrates an AC-coupled architecture, where the ESS and PDU share a common AC connection

Station Level Controls
Electrical charging network
Supporting Energy Storage / Renewables
Islanding Options





- Interruption duration and interruption frequency are both zero in these cases (ESS compensates for limitation – no impact to EV charging)
- Recovery could be impacted, if charging curtailed instead of using ESS.

Conclusion and Next Steps

Accomplishments

- Multiple Conference Publications developed and presenting approaches for improving EV charging resilience
- Journal Publications in Development
- Use cases developed at Various Levels and Evaluated in both CHIL and in hardware systems.

Next steps

- Finalizing combined use case: California Extreme Heat Event
- Expansion of Use Cases
- Standards involvement: IC22-002

Audience Poll Questions

Join by Web

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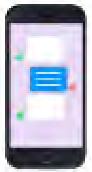
3. Respond to activity

Join by Text



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Respond at **PollEv.com/burakozpineci620**

Text **BURAKOZPINECI620** to **22333** once to join, then **A, B, C, or D**

Which of the following aspects of resilient high-power charging has your organization implemented or will implement in the next 6 months:

Thank You!

Michael Starke, PhD

starkemr@ornl.gov

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Zero Trust Approach to Electric Vehicle Charging Infrastructure Security

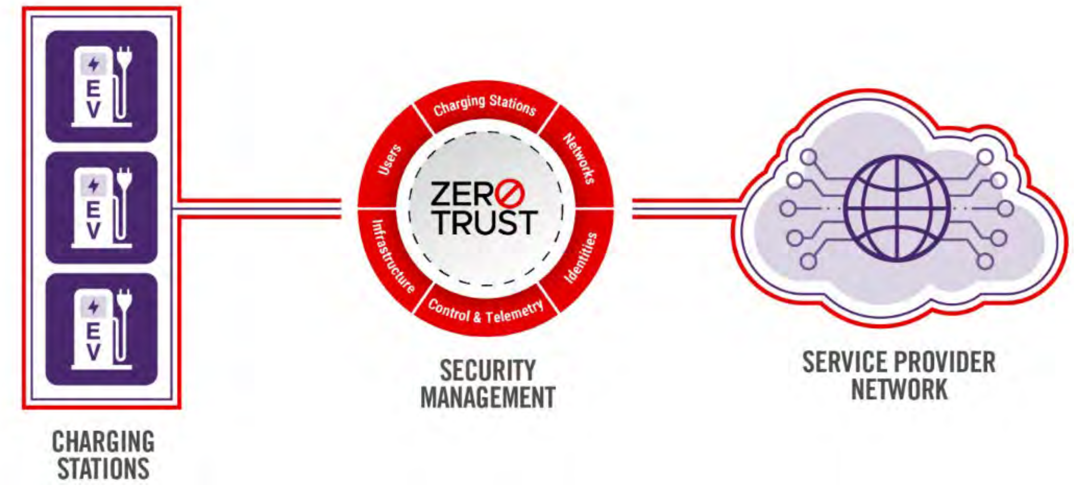
Thomas E. Carroll, PNNL

April 5th, 2023

U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Cyber-Physical Security (CPS): Zero Trust Overview

Objective: Develop, demonstrate, and evaluate Zero Trust approaches to bolster EV Infrastructure security by reducing the attack surface.



Outcomes:

– **Design architecture** for incremental deployment and infrastructure integration

– **Characterize and assess** architecture to address vulnerabilities

– **Prototype architecture** in a testbed

– **Develop blueprint**

Industry Partners:

Cisco Talos | PLM Electric Power Engineering | NetFoundry

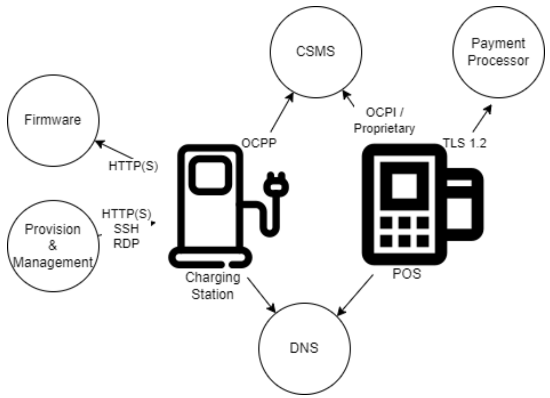
What is Zero Trust?

Zero Trust architecture implements network security approaches following the tenet “Never trust, verify everything”

- **Zero Trust’s goal is to reduce implicit trust**
  - Removal of implicit trust limits compromise scope
  - Increases adversary cost to exploit the system
- **Operationally Zero Trust:**
  - Independently considers each access request
  - Uses policy, identity and environment in each access request decision
  - Ensures adherence to “least privilege” and “separation of duties” principles

Implicit trust – a vulnerability resulting from limited verification | Least privilege – authorization level | Separation of duties – privileges limited based on role

Zero Trust Project Approach



Define Requirements & Security Objectives

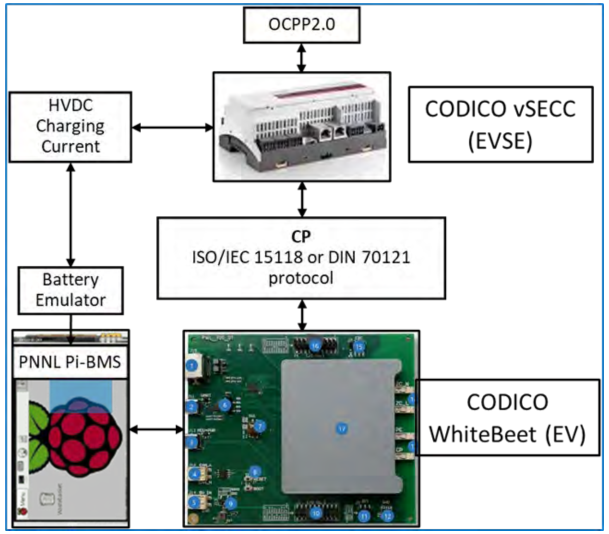
Focus on Charging Station Operator (CSO)

Design Architecture

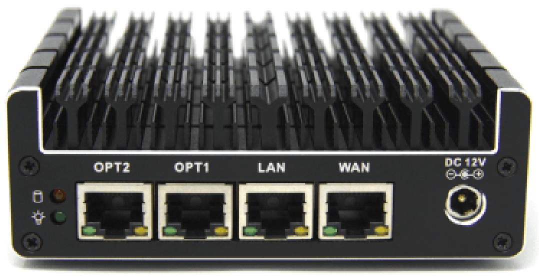
Prototype

Evaluate & Analysis

EV/EVSE Charging Emulator

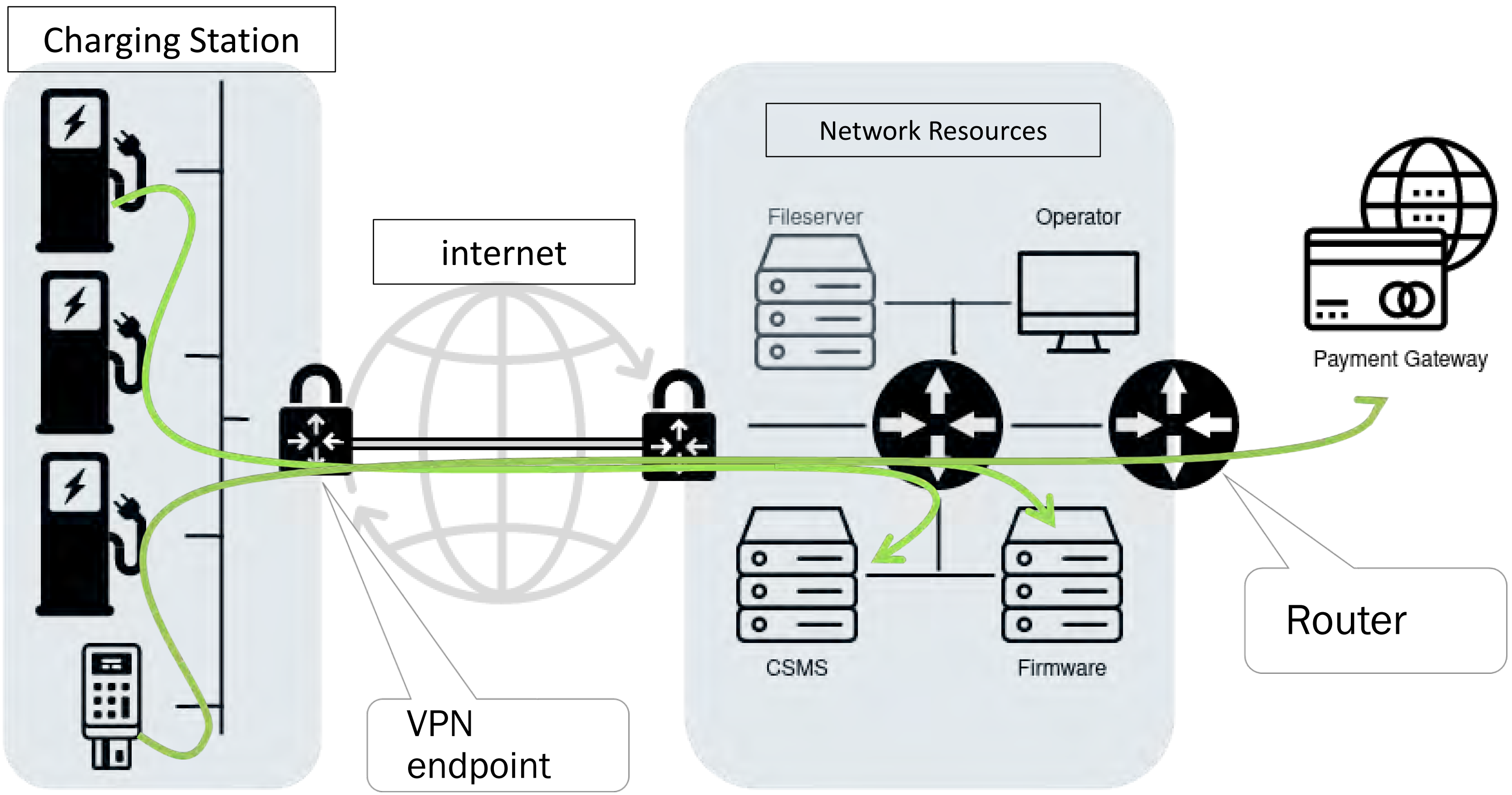


Security Service Edge Gateway



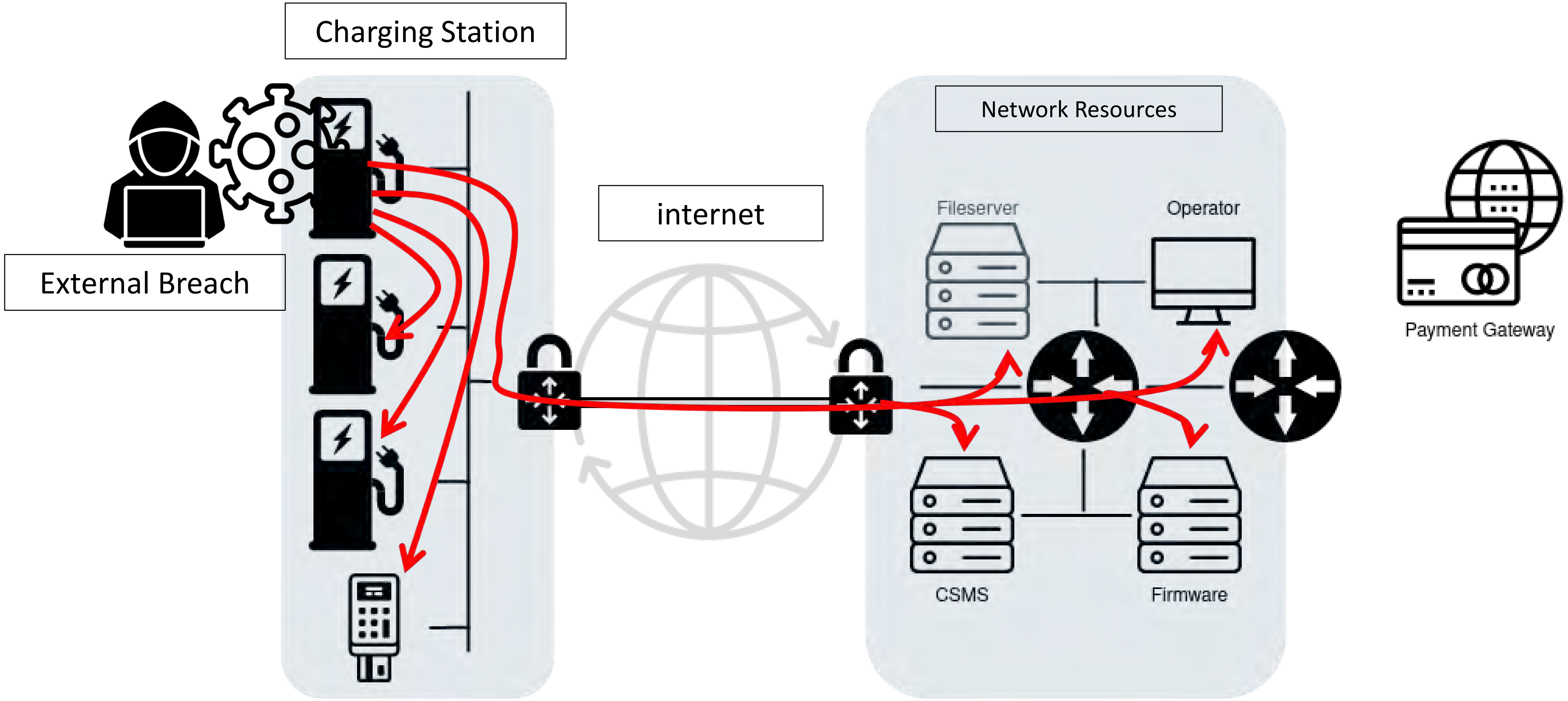
Charging Station Operator – entity responsible for the operation and maintenance of chargers and supporting equipment and facilities.

Conventional EV Service Provider + WAN



CSMS – Charging Station Management System - software for remote and real time charge point operation control (e.g., OCPP 2.0.1).

Breach to a Conventional EV Service Provider + WAN



Zero Trust Architecture to Prevent Breach to a Conventional EV Service Provider

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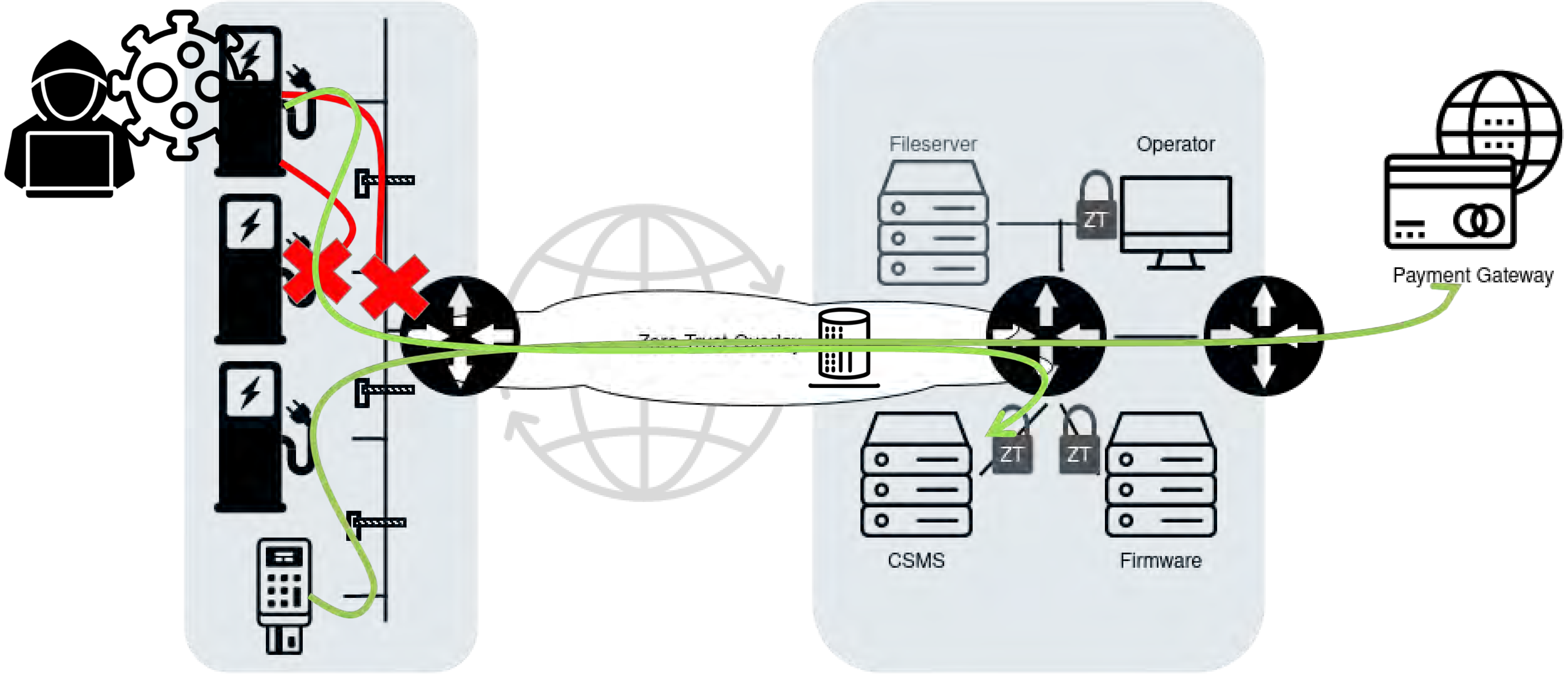
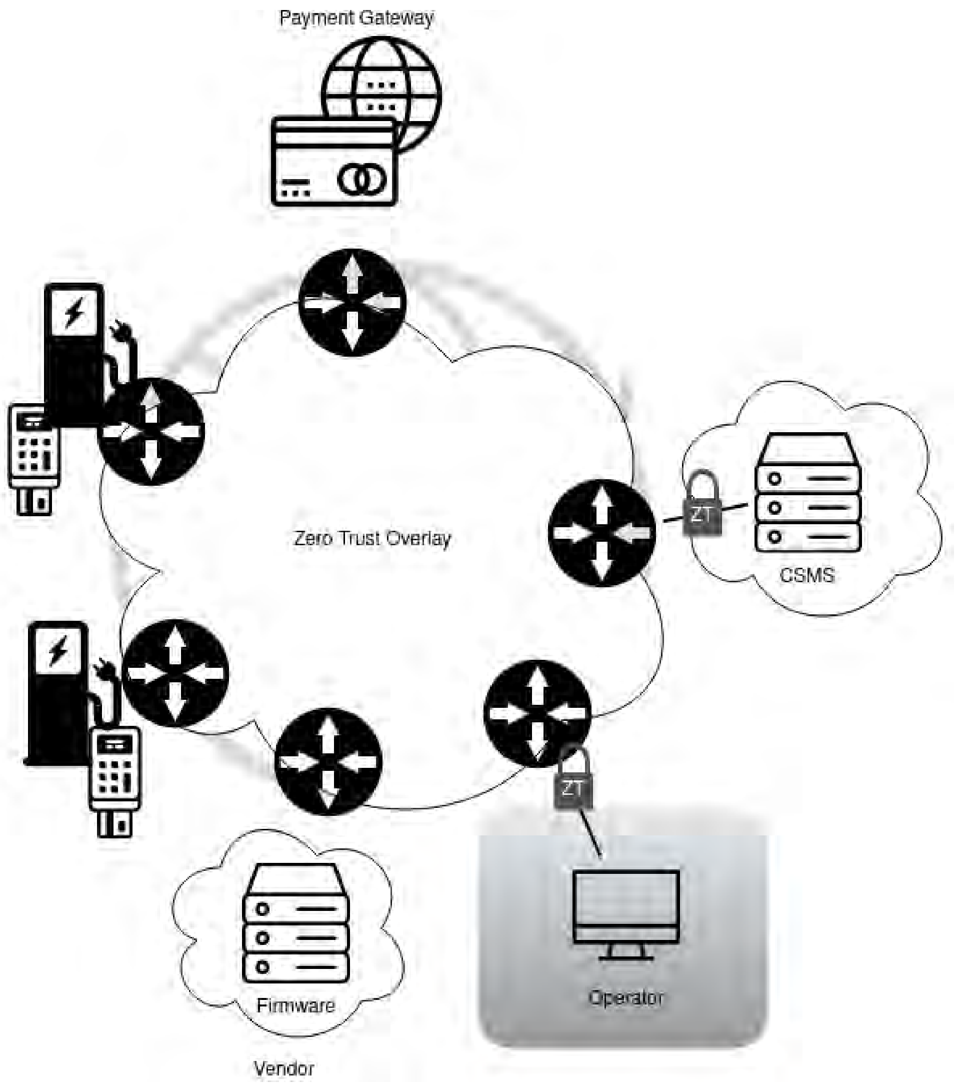


Zero Trust Architecture For The Internet



Zero Trust Conclusion and Next Steps

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Review

- Project Overview
- Zero Trust architecture design
- Test bed prototyping – EV/EVSE Charging Emulator
- Industry partner relationships and mutual engagement deepening with each meeting
- Spun-off a university Senior Design Team

Next steps

- Continue to evolve the use cases, test cases, and evaluation criteria
- Evaluation of architecture in context of test cases
- Implement a second prototype based on a different stack to help generalize the approach
- Transition from virtualization to embedded systems
- Continuous engagement with NetFoundry & Cisco

CPS: Post Quantum Cryptography (PQC) Project Overview

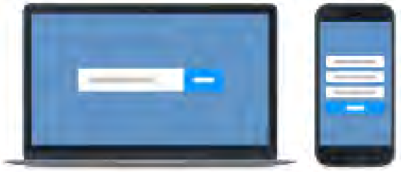
Objective: Study the impact and develop guidance for a Post Quantum Cryptography transition

Outcomes:

- Identify classical public-key cryptography applications
- Assess PQC impacts with a test-and-measure approach
- Identify gaps and challenges
- Develop guidance for an orderly PQC transition

Audience Poll Questions

Join by Web



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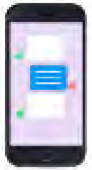
Join by Text



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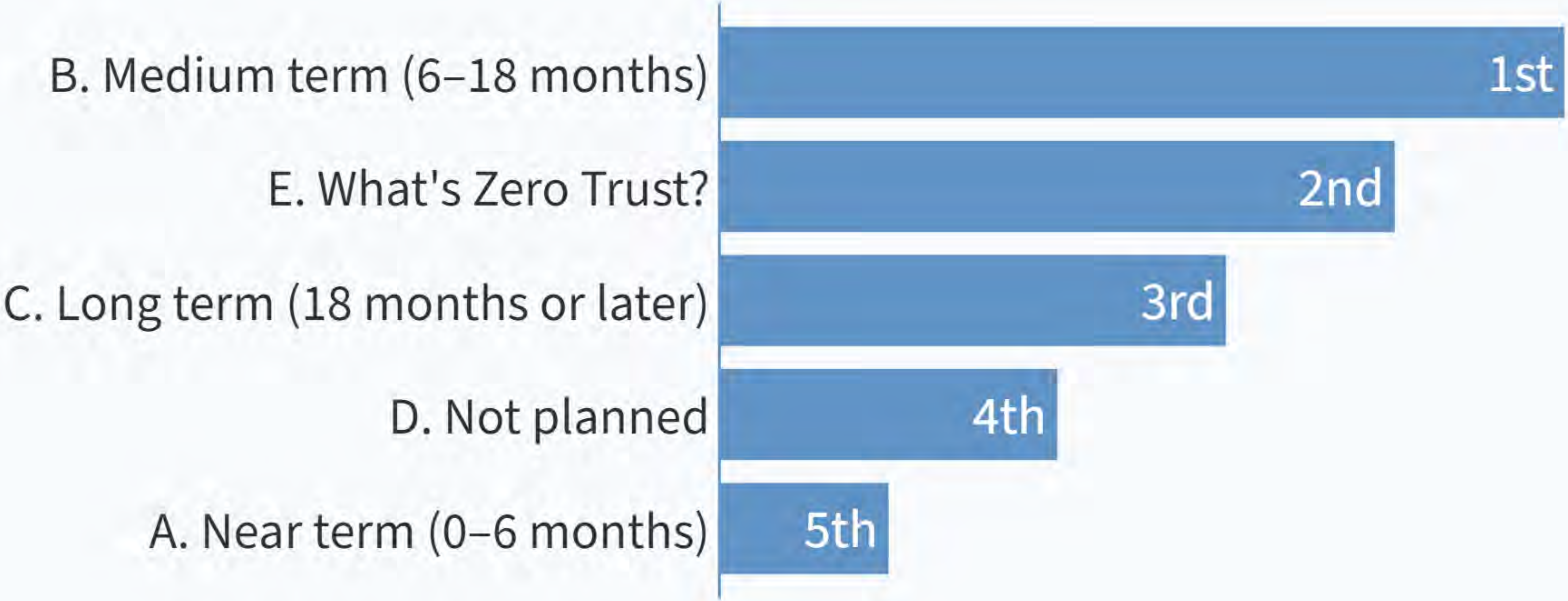
Text **BURAKOZPINECI620** to **22333** once to join

Respond at **PollEv.com/burakozpineci620**

Where is Zero Trust implementation on your organization's cybersecurity roadmap?



What are two questions / concerns you have regarding Zero Trust implementation?

"WHAT IS IT"

"How do you manage things like software BoM to incentivize more zero trust features?"

"Should this be standard practice for CPOs, or are other stakeholders needed to initiate?"

"Whether charging vendors are implementing zero trust, or and standards-making organizations are including it."

"Does zero trust architecture introduce additional points of failure into the system?"

"If via an internet connection, capacity would also be a concern (the burden of the internet provider) as more charging stations come online"

"Aren't there trusts we need to function, which prevents ZT?"

"In general, what is the potential cost of implementing zero trust?"

"How does zero trust affect operability and modularity?"

"What is zero trust"

"Is this charge station/csms dependent?"

"Is ZT just a buzz word for something we might already be doing?"

"Is this a EVSE or EV issue - whose problem?"

"Will this result in no charge events to legit users"

"Why would anyone set up a network without segmented networks? that is just an open invitation to losing your data and reputation."

"What do we need to be looking at as utilities?"

"Are you considering chargers with parent-child communications features?"

"Isn't this IT's problem?"

"What's Zero Trust?"

Thank You!

Join us for the

Cyber-Physical Security Deep Dive on May 24th

Thomas.Carroll@pnnl.gov

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Codes and Standards Support

Theodore Bohn
Argonne National Laboratory

April 5th, 2023

Outline

- Initiative Overview
- Identification of codes and standards activity priorities enabling EVs at Scale
- ‘Divide and Conquer’ approach by lab teams to cover mulitiple standards areas
- Standards areas covered by each participating laboratory
- Focus areas and progress in standards development in FY2023
- Summary of FY23 deliverables/milestones
- Conclusion and Next Steps

Codes and Standards Support Initiative Overview

Objective: Codes & standards support priorities focus on development of the most critical standards for EVs at Scale, i.e., high power DC charging, storage (microgrid, DERMS) integrated with DC charging, vehicle-grid integration, high power scalable/interoperable wireless charging, vehicle-oriented system standards and energy services to support transparent optimized costs/delivery.

Outcomes:

- – Establish and complete draft of SAE J3271 Megawatt Charging System (MCS), AIR7357 TIRs
- – Create work group to develop EV Standards Roadmap based on 2012 ANSI EVSP roadmap
- – Develop and demonstrate a reference DC as a Service (IEEE P2030.13) implementation with off-the-shelf hardware and Open API Energy Services Interface (ESI) implementation
- – Complete a study w/summary reports in support of identified high importance standards
- – Active participation in SDO standards meetings/committees to close gaps in EVs@S standards

Argonne National Laboratory
- Theodore Bohn
- Mike Duoba
- Keith Hardy
- Jason Harper
- Dan Dobrzynski

INL Idaho National Laboratory
- Richard Carlson
- Anudeep Medam
- Tim Pennington
- Benny Vargheese

NREL National Renewable Energy Laboratory
- Yashodhan Agalgaonkar
- Jesse Bennett
- John Kisacikoglu
- Jonathan Martin
- Andrew Meintz
- Manish Mohanpurkar
- Vivek Singh
- Isaac Tolbert
- Ed Watt

Oak Ridge National Laboratory
- Veda Galigekere
- Omer Onar
- David Smith

Pacific Northwest National Laboratory
- Brian Dindlebeck
- Lori Ross O'Neil
- Richard Pratt

Identifying Codes and Standards Activity Priorities Enabling EVs at Scale

Filter Criteria: The group of lab team members proposed areas **most** relevant to EVs at Scale

Priority Areas:

- EVs at Scale standards support focus is mostly on scaling charging capabilities. I.e. how to serve more vehicles in more locations without exceeding resource limits, for a spectrum of vehicle sizes/classes (from light to medium to heavy duty; commercial and passenger cars)
  Charging rates from 30A to 3000A for conductive/wireless methods, AC or DC, µgrid, etc
- Electric power delivery oriented standards areas; V2G, local DER, integrated storage, system controls including the Energy Services Interface method of bi-directional information exchange leading to contract based optimization of resources, DC as a Service, communication protocols
- Vehicle Oriented **System Standards** (including non-road, electric aircraft) that include on-vehicle systems (power take-off, refrigeration units, battery management, battery safety, etc.),
- High Power Scalable/Interoperable Wireless Charging (SAE, SWIFTCharge) (up to 1MW)

‘Divide and Conquer’ Diverse Coverage of Standards by Lab Teams

5 Lab Teams in FY2022 Covering ‘Top 10’ Standards Areas:

National Lab participants each proposed support/development within the ‘top ten’ areas for EVs@S

General Standards task areas (shorthand summary)

- **NREL** focus on MCS coupler testing, system architectures/impacts study, P2030.13
- **ORNL** focused on wireless (WPT) topics
- **INL** on WPT, P2030.13 (grid side of charging)
- **PNNL** on EVSP roadmap, heavy vehicle charging stds, P2030.13
- **ANL** on ‘umbrella’ (chair of multiple stds groups) coverage of ongoing W&M stds, ANSI meter stds, IEEE P2030 series (.5, .11, .13, etc), MCS ‘everything’, emphasis on communication and reliability, (summary chart of active EV charging/safety standards; testing/date in support of standards)

Snapshot of Standards Engagement/Progress in 2023; Next steps

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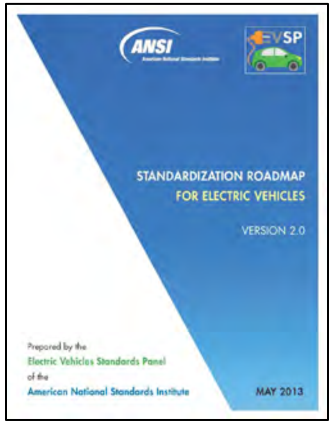
Status excerpts on active standards committees support by topic 4E resources, via labs/contractors

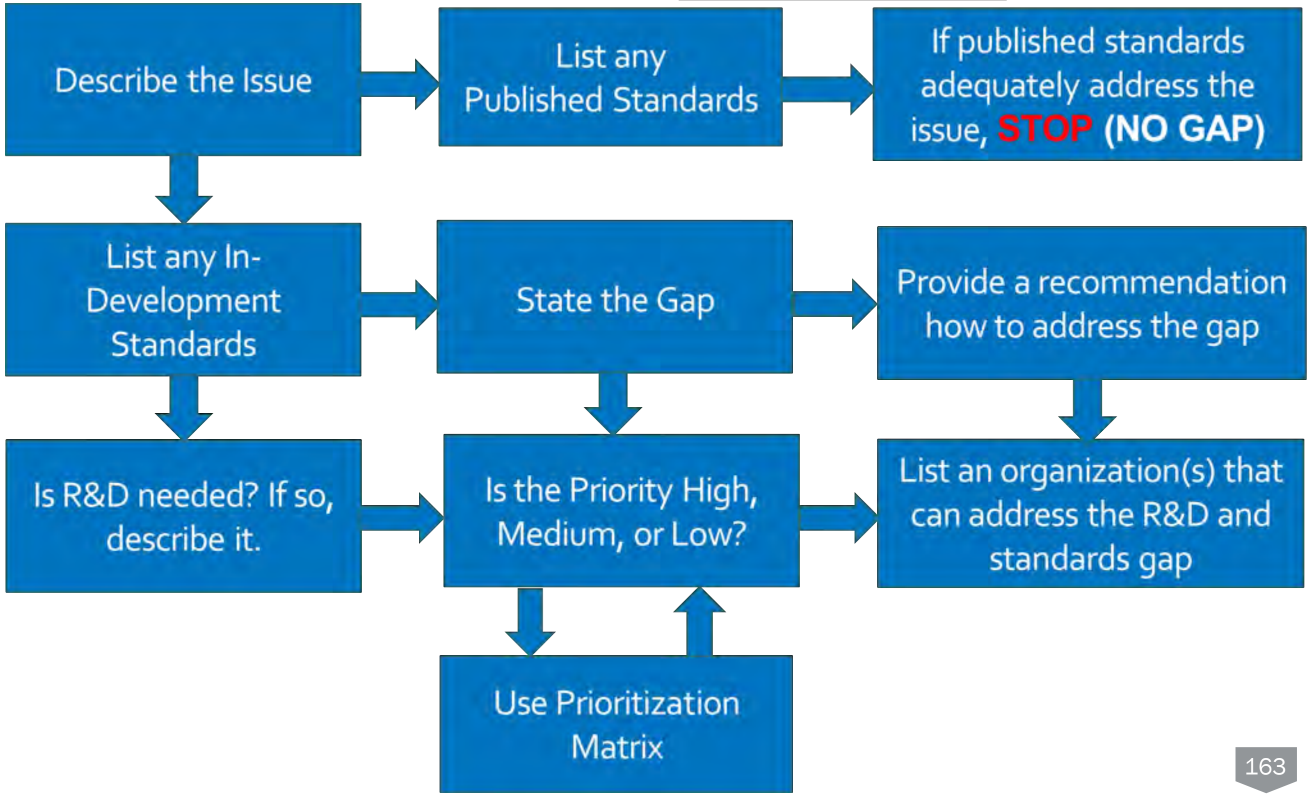
- **EVSP EV Standards Roadmap;** Year of effort/work groups, final report out for review, published June 2023
- **IEEE P2030.13 DCaaS Functional Specification for charging system feed;** out for ballot now; version 2 proposed
- **MW Level stds (J3271, AIR7357, IEC80005-4, xMCS/mining);** J3271 TIR-v0 released, xMCS(40MW) weekly meetings
- **Energy Services Exchange (ESX) implementation;** subset of P2030.13, demonstration April 2023, possible new std.
- **Weights and Measures;** Development of open source GUI for off-the-shelf HB44 test tool; HB105 transfer standard
- **'Other' SAE/IEEE standards on interoperability, reliability, safety, recycling, etc:** moving forward/expanding scope
- **Mike Duoba EV Variability study/project(s)** rolled into EVs@S C&S in FY23 {TBD relaunch}
- **Wireless Power Stds (J2954/SWIFTcharge)**; J2954/1 light duty published; J2954/2 Heavy Duty TIR released, J2954/3 dynamic charging work group just launched; SWIFTCharge on hold during past WPT patent litigation, resuming soon

ANSI EVSP EV Charging Roadmap Process/Overview

Roadmap Overview

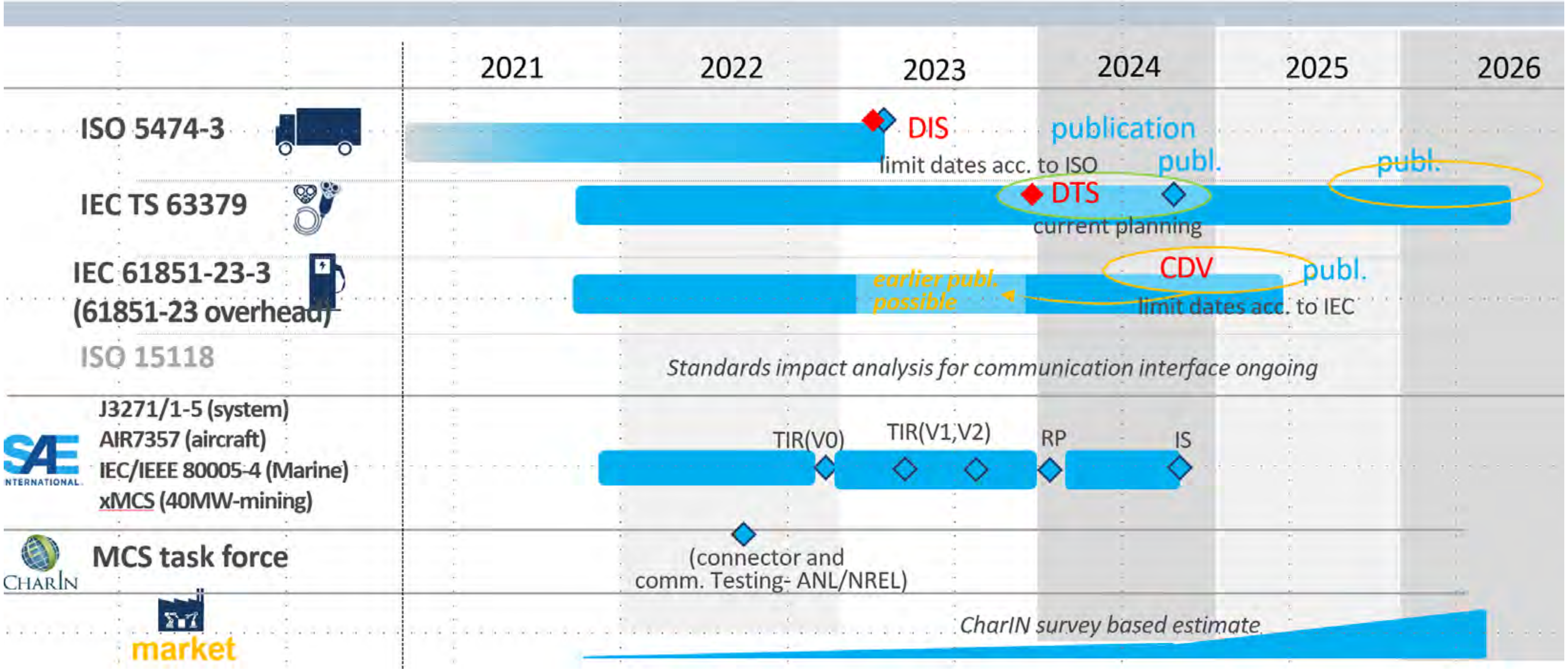
- Identifies issues as well as standards, codes, and regulations that exist or are in development to address those issues
- Identifies "gaps" & recommends development of new or revised standards, conformance and training programs, where needed
- A "gap" means no published standard, code, regulation, or conformance program exists
- Suggests prioritized timeframes for standards development and organizations that may be able to perform the work
- Focus is U.S. market with international harmonization issues emphasized in key areas
- **50 stakeholder input meetings in 2022/2023**
- Final draft for per review released April 2023
- Final report published June 2023





Harmonization of High Power Charging SDO Committees/Standards

Working together as a global team: National Lab participants in these and other standards areas need to have consensus between overlapping standards. There is not one 'global' Standards Defining Organization' so all the SDOs have to 'play nice' and create compatible/harmonized standards as a foundation for global interoperability.



Hands-On C&S Support Examples; Demonstration activities w/partners

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C&S Support Activity Collaborators:

Industry charging stakeholders (manufacturers, operators, planners, researchers, existing projects w/liaison interactions- RHETTA, eTRUC, etc)

Subcontractor subject matter experts (ANSI, University of Delaware, Rema, BTCPower, EVoke)

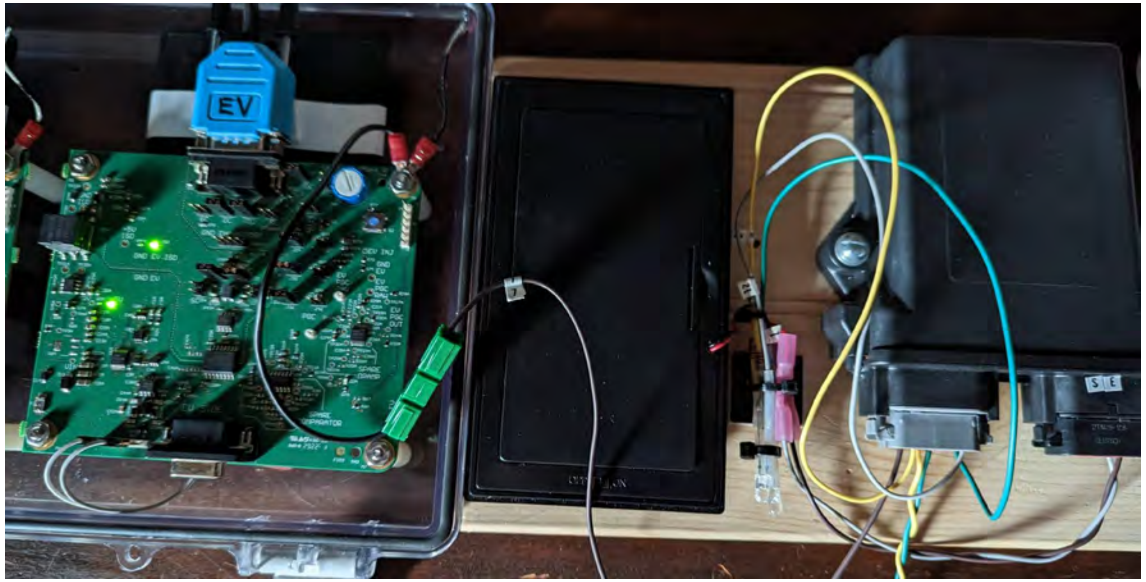
Standards organizations (SAE, IEC, ISO, IEEE, ANSI), Code panels (NCWM, UL, NFPA)

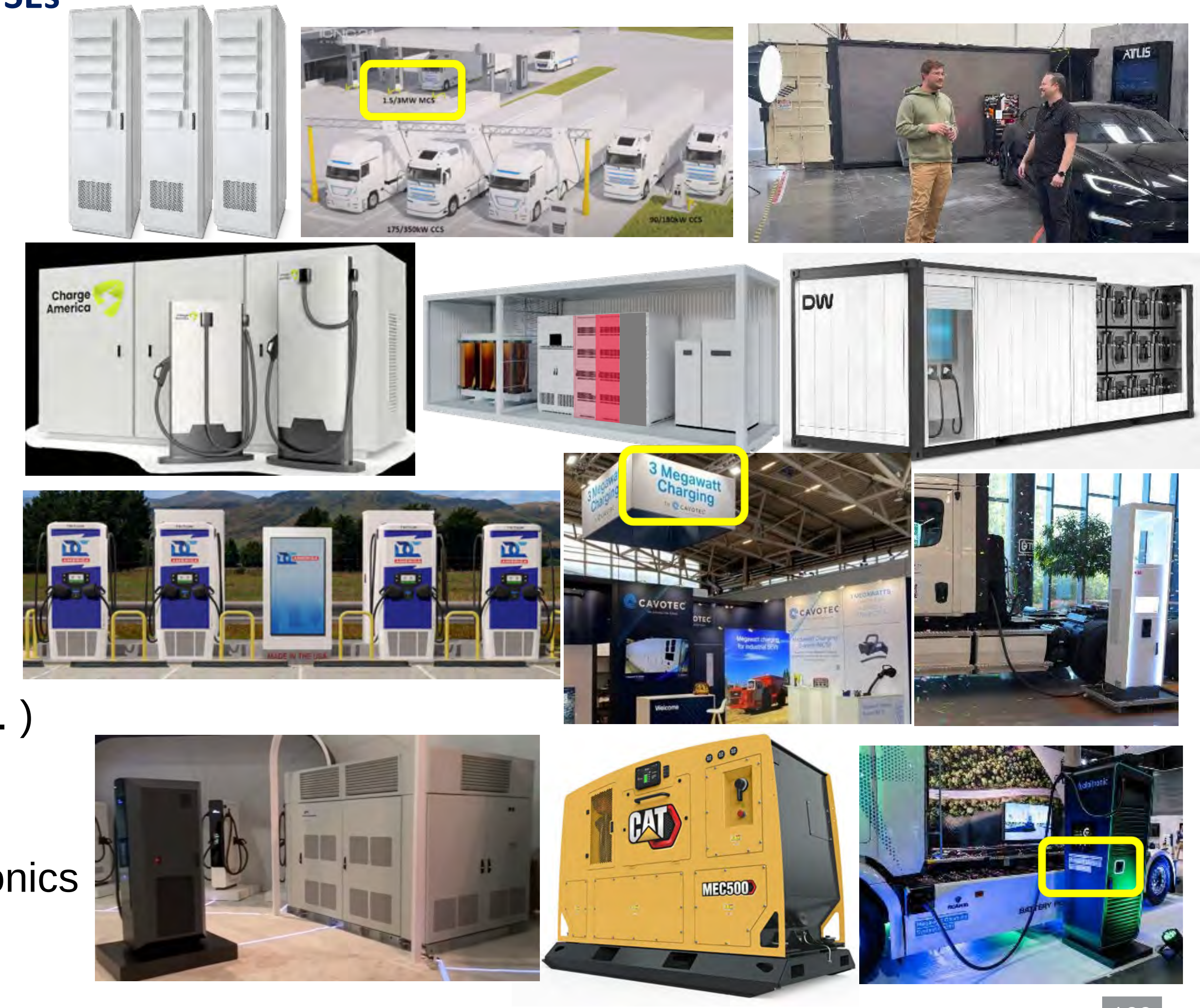
NIST SP 2022 special publication guide for developing a transfer standard procedure on HB105-10 (Traceability for EVSE field testing tools) Set for 500A/1000vdc today; 3000A/1500v next; 50ppm 'transfer standard'
ANSI C12.32 DC meter standard; **ANSI C12.33** new transducer standard

ARPAe collaboration w/Imagen Energy on 250kW blocks for on DCaaS distribution of MCS ready systems; Shoals example Skid mounted switch gear, storage, power converters (example)

Hardware-Software Development, Validation Testing Supporting Standards

- SAE J3271 communication controller reference design w/ Univ. of Delaware
- Balanced Differential CAN module; PLC-10BaseT1s options being developed
- 3000A Noise immunity testing at BTCP on production grade MCS EVSEs





SAE J3271 Coupler manufacturers (7), ~UL2251 certification
(Amphenol, Cavotec, Evalucon, Huber+Suhner, Rema, Staubli, T.E.)
~14 companies MW MCS EVSEs in development/pilot projects

(ABB, Alpitronic, Atlis, BTCP, Cavotec, (CAT), Charge America, DesignWerk, Heliox, Hitachi Energy, Imagen Energy, Power Electronics SA, Tritium)

FY2023 Milestones/Deliverables

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Milestones (shorthand)

- Report on conceptual/functional requirements for P2030.13 w/simulations
- MCS physical layer communication robustness test plan; test results (J3271/2)
- ANSI EVSP standards roadmap, draft for peer review; weekly group inputs
- IEEE P2030.13-J3271/4 based 'PowerBroker' Energy Services Interface (ESI) implementation as an Application Programming Interface (API)

Deliverables (shorthand)

- Quarterly/annual progress reports
- MCS coupler thermal-mechanical testing results report
- (critical input to…) first peer review draft of SAE J3271 (part 1-5) MCS TIR
- (critical input to…) first peer review draft of IEEE P2030.13 Functional specs
- Monthly MW+ Charging industry engagement webinar based forum for input

Conclusion and Next Steps

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Review

- Initiative Overview
- Standards Support Priority Selection Methodology
- Significant areas of standards development activities
- Implementation/validation of technology-requirements as part of standards

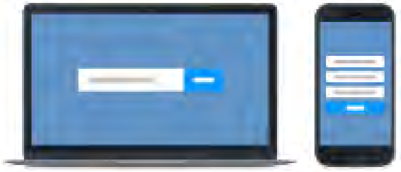
Next steps

- Continued monthly MW+ Charging Industry Engagement interactions/feedback
- Continued weekly SAE J3271(AIR7357) meetings toward TIR v2 goal in June 2023
- Continued monthly standards work group participation; drafting standards, etc
- Progress toward milestones are studies supporting WPT and P2030.13 standards
- Engagement in Interoperability (Testival) events in 2023

- Codes and Standards Deep Dive web based meeting **tentatively May 22, 1-3pm EST**
  Contact: Tbohn@anl.gov, Codes and Standards Pillar Lead

Audience Poll Questions

Join by Web



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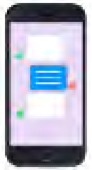

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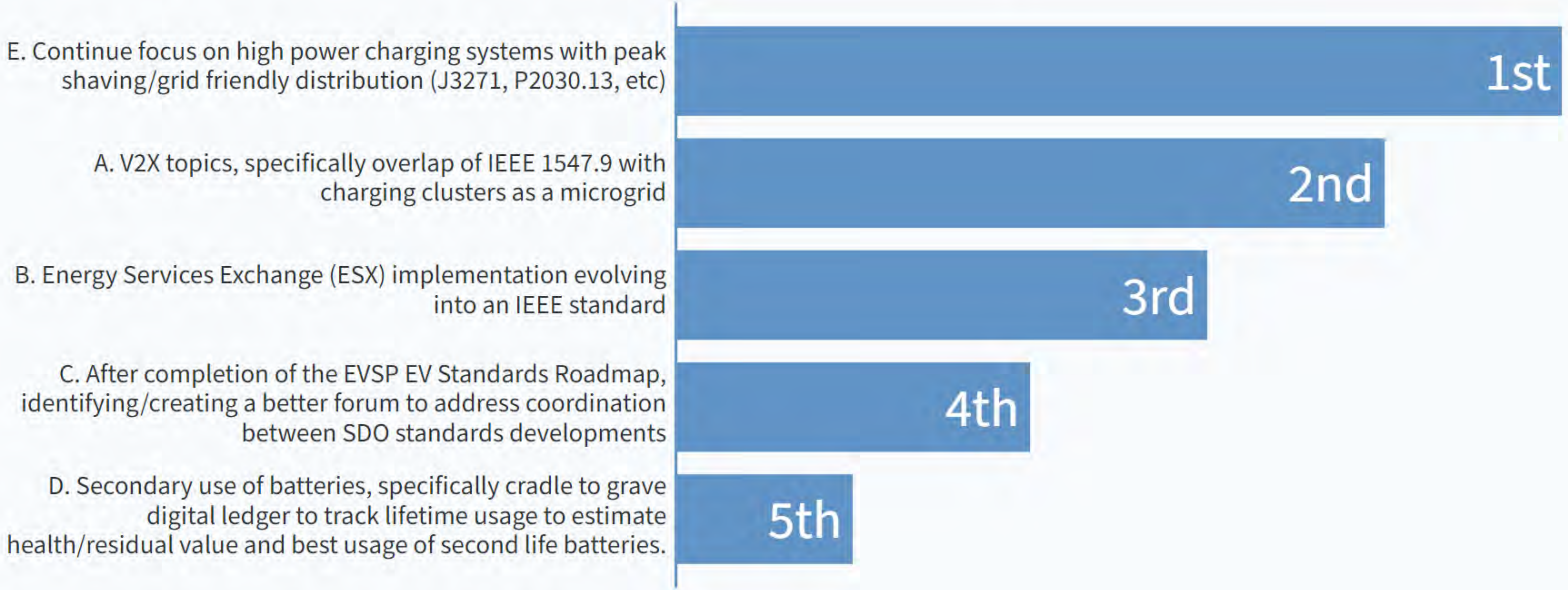
The Codes and Standard EVs @ Scale pillar group focused on the top 10 most impactful charging related standards. Which areas should move higher up the priority list as 'more important' to stake holders?



This concludes our Pillar Presentations.
We will now transition to our Panel Sessions following the break.

Please enter your response to the question that will be up during the break.

Thank you to all of our Pillar Presenters!

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Afternoon Break:
2:10pm – 2:20pm

Respond at **PollEv.com/burakozpineci620**

Text **BURAKOZPINECI620** to **22333** once to join, then text your message

Do you have any additional questions or feedback regarding this afternoon's pillar session? (Anonymous)

No responses received yet. They will appear here...

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Afternoon Break:
3:40pm – 3:50pm

Roundtable Question and Comments

- Consortium Audience Feedback Session | Lee Slezak
- Pillar Audience Feedback Session | All Pillar Leads
- Open Mic Audience Feedback Session | Attendees

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Evening Networking Break:
6:00pm – 7:00pm