EVs@Scale
U.S. Department of Energy

EVs@Scale Deep Dive - SCM/VGI

Day 2: SCM/VGI Demonstration

September 29, 2022

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

NREL/PR-5400-84294

EVs@Scale SCM/VGI Deep Dive - Day 1 Agenda

11:00 a.m. – 11:05 a.m. ET **Welcome**
Andrew Meintz, Jesse Bennett

11:05 a.m. – 12:05 p.m. ET **Session 1: EV Charge Scheduling,**
Jason Harper

12:15 p.m. – 1:20 p.m. ET **Session 2: Demonstration Plans**
Jason Harper, Myungsoo Jun, Ted Bohn

1:20 p.m. – 2:00 p.m. ET **Wrap-up Discussion and Feedback Gathering**
All Attendees

EVs@Scale SCM/VGI Deep Dive

11:00 a.m. – 11:05 a.m. ET **Welcome**

Jesse Bennett

EVs@Scale FUSE - Overview

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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

NREL Transforming ENERGY

Argonne NATIONAL LABORATORY

INL Idaho National Laboratory

Sandia National Laboratories

Industry Partners/Data Sources:

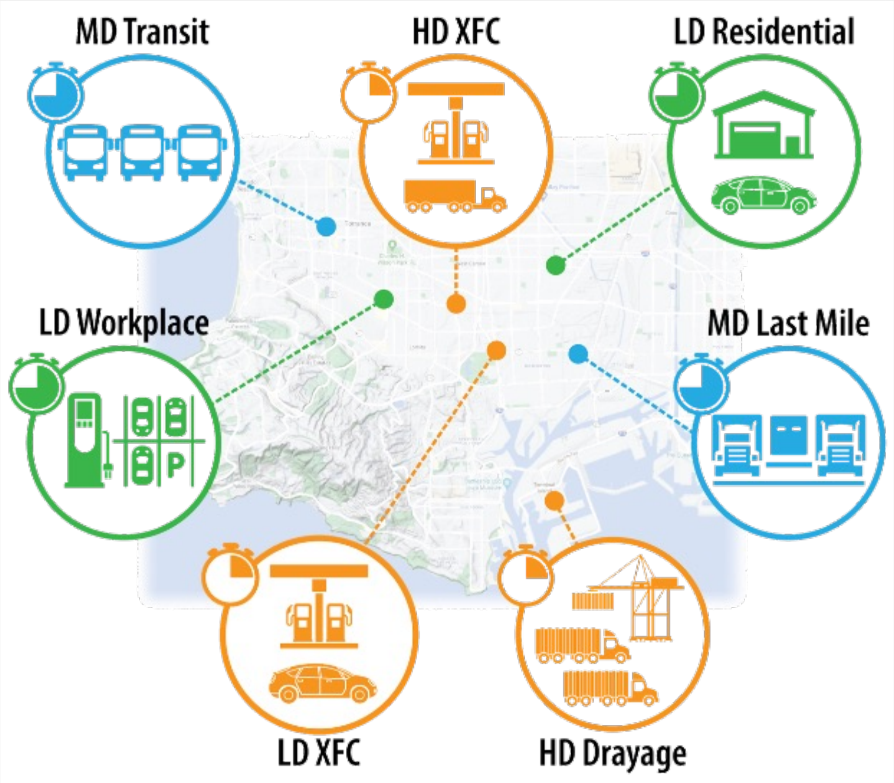
- **Electric Distribution Utilities**
  - Dominion Energy (100+ distribution feeder models throughout VA)
- **Vehicle Travel Data**
  - Wejo (~400 million trips throughout VA for Sept. ‘21 and Feb. ’22)

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.



Session 1 - Enabling Technology Development

11:05 a.m. – 11:35 a.m. ET **EV Charge Scheduling**

Presentation (20 min) *Jason Harper*

Q&A (10 min)

11:35 a.m. – 12:05 p.m. ET **Evrest and OptiQ**

Presentation (20 min) *Jason Harper*

Q&A (10 min)

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Smart Charge Management and Vehicle Grid Integration: FUSE

EV Charge Scheduling:

Background and Approaches

Jason D. Harper

ANL EV-Smart Grid Interoperability Center

Advanced Mobility and Grid Integration Technology

September 29, 2022

Controlled vs Smart Charging

What's the Difference?

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Controlled Charging only takes into account the needs of the EVSE owner, premise owner and/or grid operator and does not attempt to meet the needs of the driver (required energy by departure time)

Smart Charging takes into accounts the needs of the EVSE owner, premise owner, grid operator and the EV driver (all actors).

ISO 15118 based charging provides the opportunity for the EV and controlling entity (premise, grid, etc.) to negotiate a charge schedule with the EV/driver

The EV provides the following:

- Max and Min Charge Limits (Current),
- Requested Energy (kWh)
- Departure Time (HH:MM:SS)
- Charging Schedule (power vs time)

With this <u>accurate</u> information we can ensure the needs of all actors are met.

SCM Controlled Charging

OCPP 1.6J Smart Charging Profile

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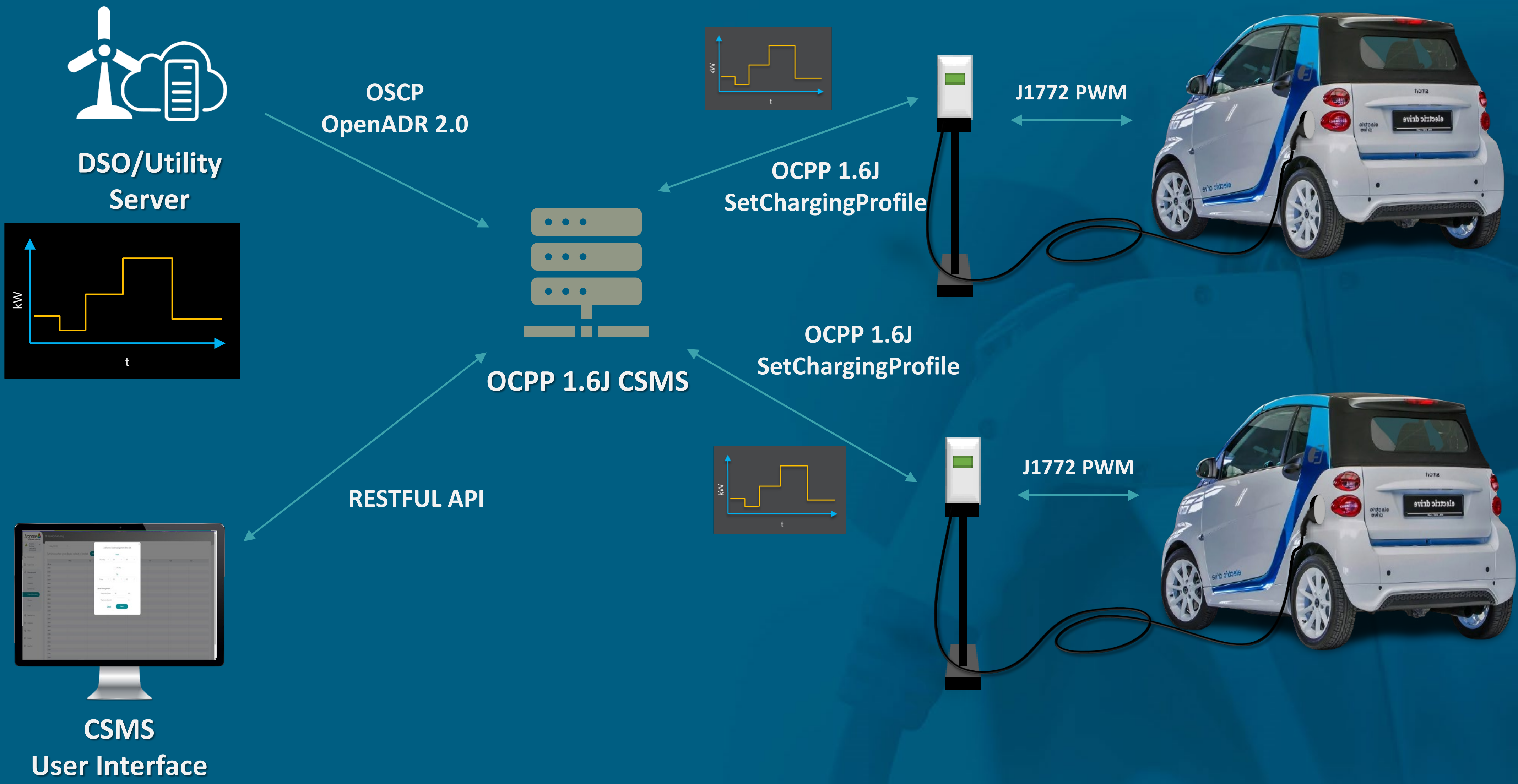
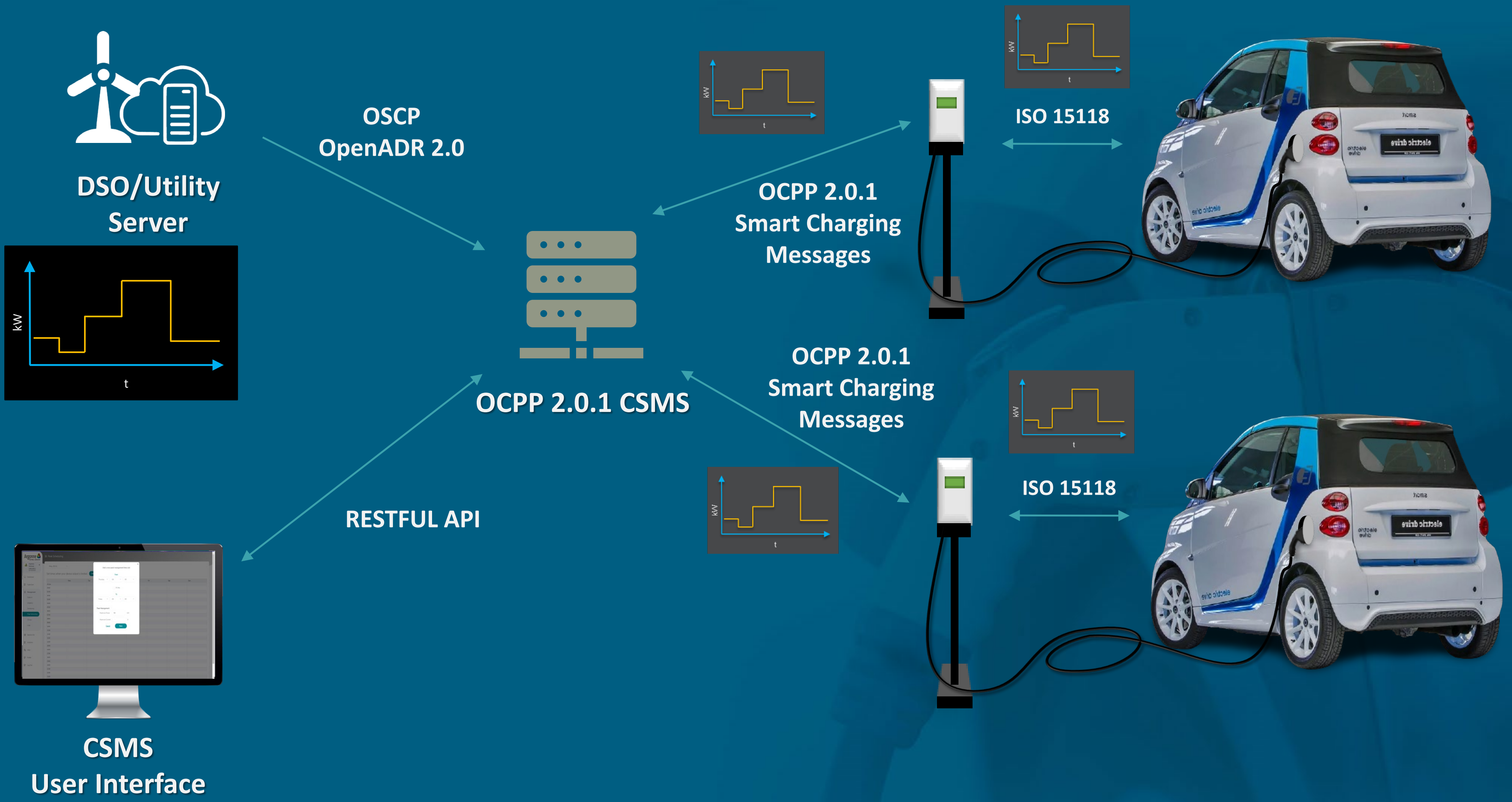


Optimized Smart Charging

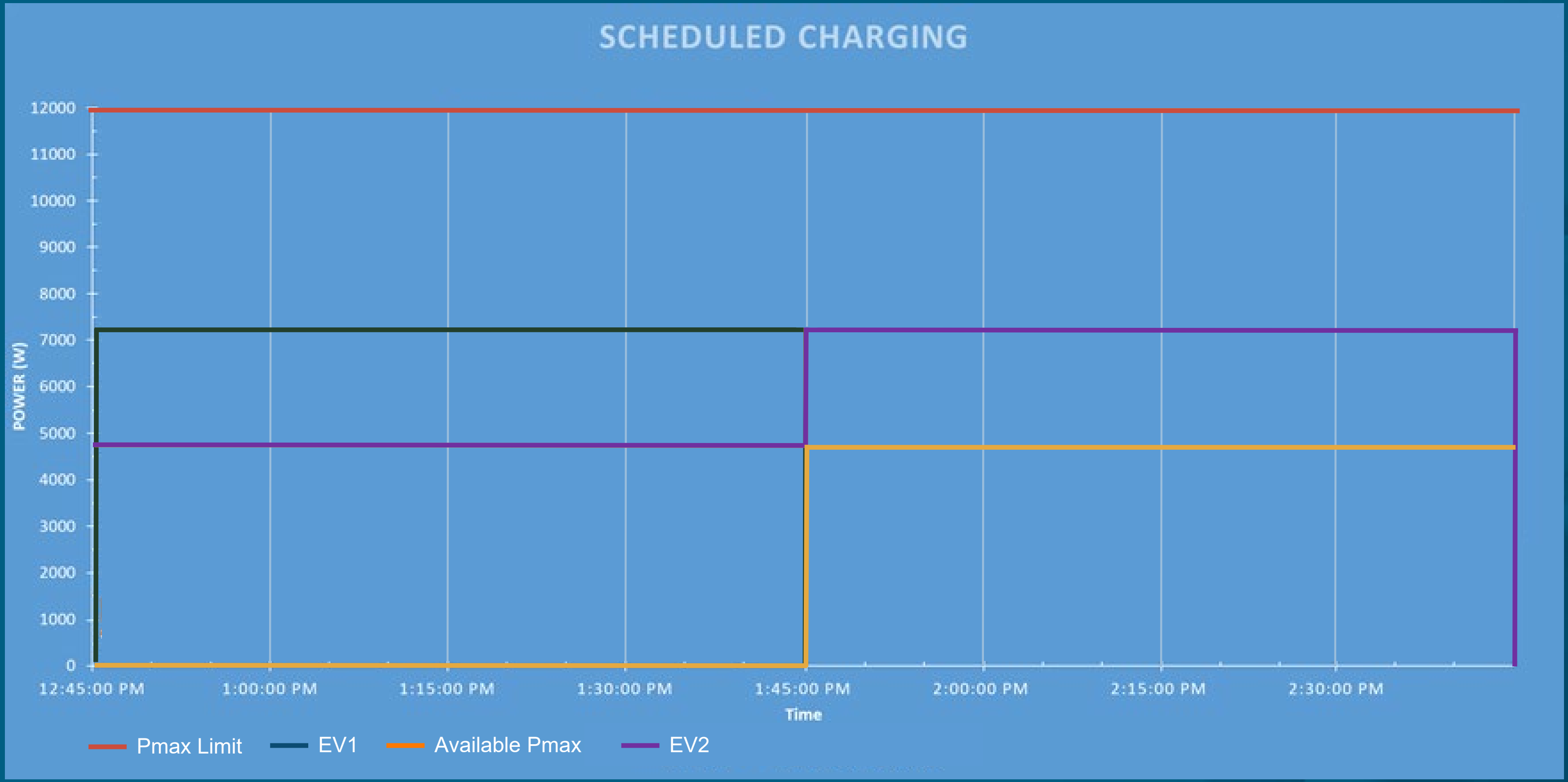
OCPP 2.0.1 with ISO-15118-2/20



Charge Scheduling

Example

A list of time intervals and power levels, signifying maximum power draw during an interval
Pmax: Available Max Power



Could also send pricing intervals as well (Sales Tariff)

Purpose is to maintain a specific power profile on the grid while meeting the needs of the EV driver

DOE Smart VGI Development

Background

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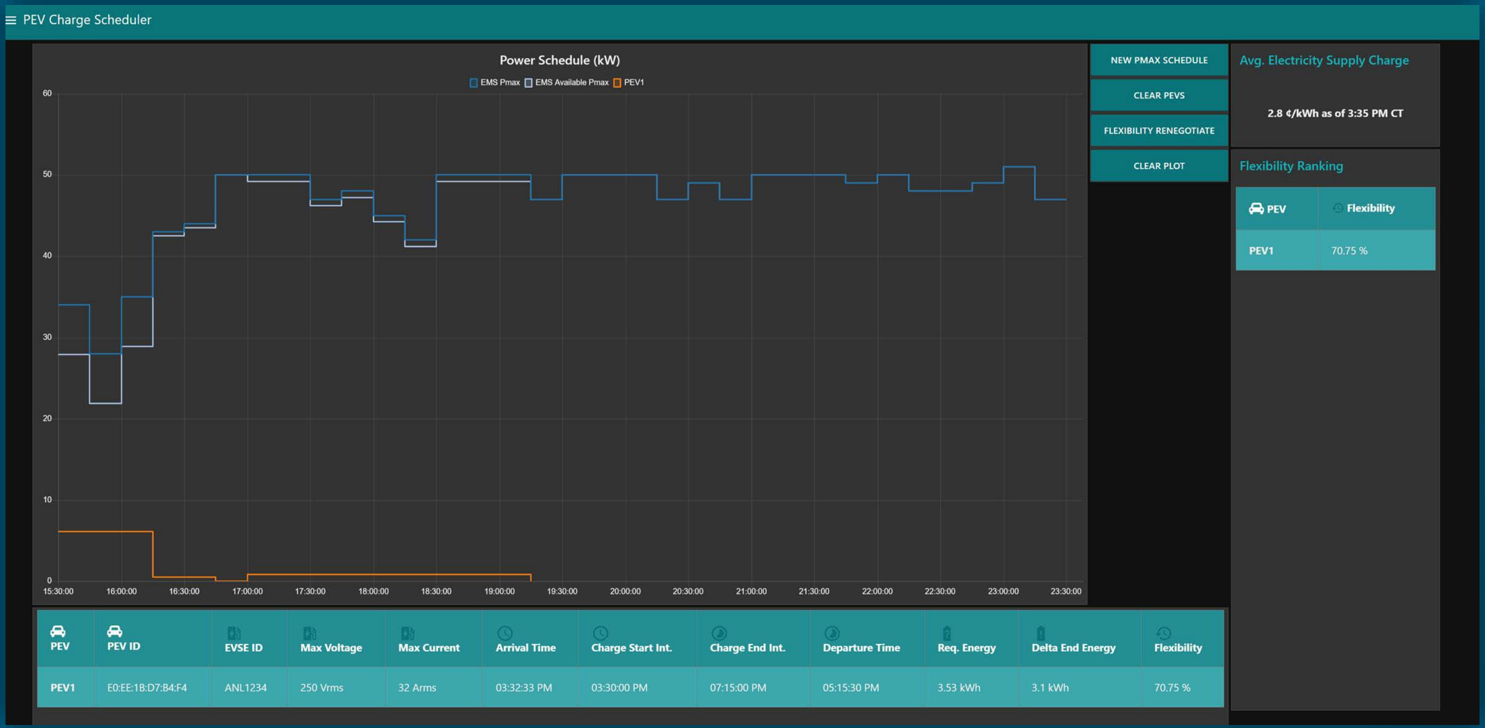


OCPP 2.0.1 and ISO 15118 standards describe the process of how to exchange power intervals and charge schedules, but the development and implementation of an actual charge scheduler is not detailed.

Logic:

- **Version of Bin-packing problem**
- **EV initiated renegotiations**
- **Charge Scheduler initiated renegotiations**
- **Different approaches to scheduling**

Flexibility:

A metric (0-99.99%) calculated by Charge Scheduler to determine how flexible a PEV is with respect to their departure time (hours), target energy (kWh) and max charging power (kW). A higher flexibility PEV means charging can be delayed if needed.

Flexibility Ranker:

Charge Scheduler creates a list from least to most flexible EVs.

FUSE 15118 Charge Scheduler

Further Development

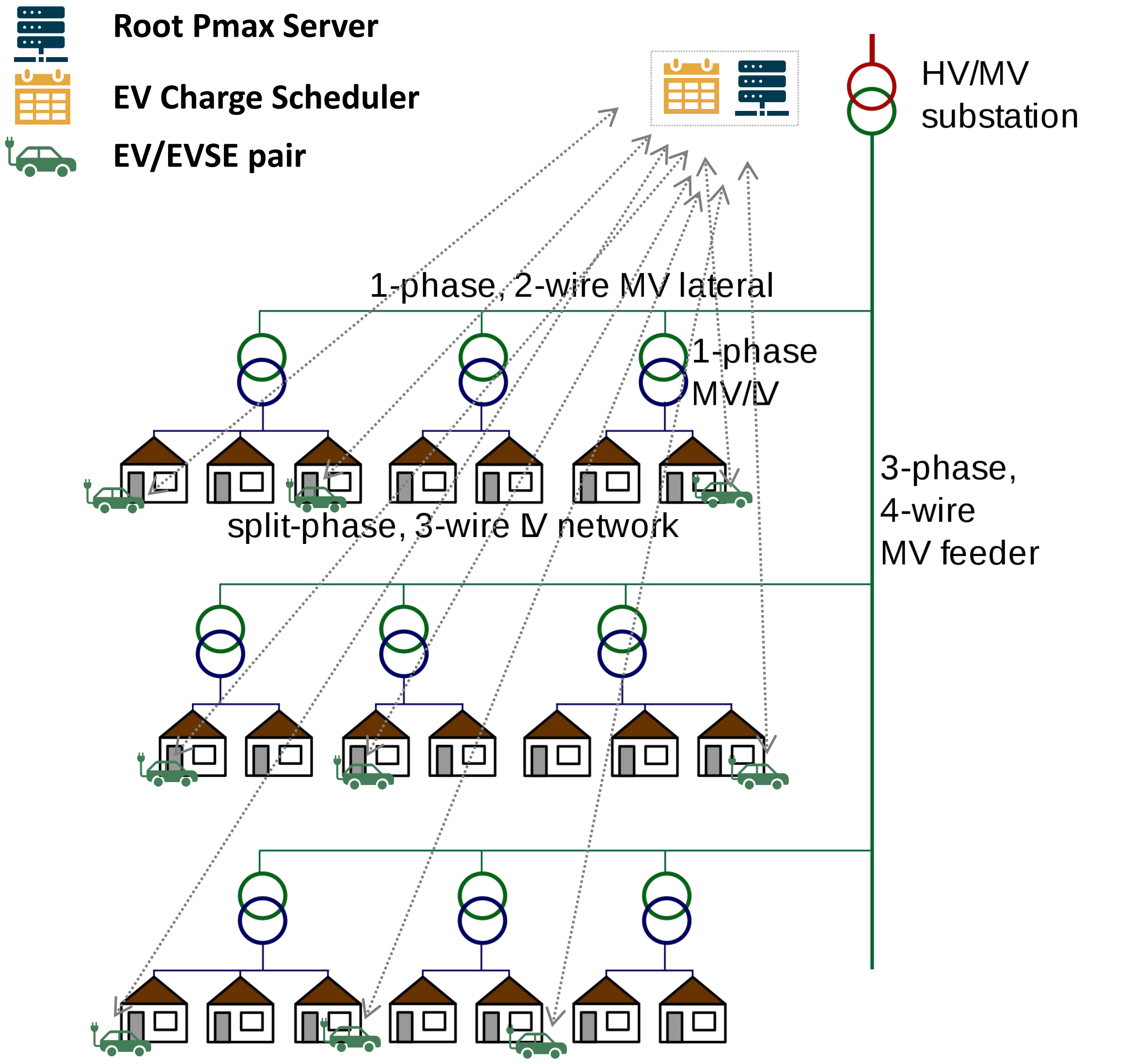
- Implemented in Go and Python
- Meet the needs of the EVs while meeting the needs of the grid
- Distribute available power across all EVs each with its own energy demands and departure times
- Optimal charge schedule is a version of bin-packing problem
- Design a heuristic algorithm to solve this problem
- Re-run the algorithm when new vehicles join but try to keep existing vehicles schedules the same to reduce the number of renegotiations that occur upon plugin
- Communication over MQTT (utilizes OCPP 2.0.1 JSON Schema)
- Scaling with multiple vehicles connecting and disconnecting at the same time
- High performance server than can handle 1000’s of connections concurrently without over allocation
- Uses a database to store EV and power tables in a persistent manner
- Can also accept pricing tables and schedule vehicle based on price

15118 Charge Scheduler

Deployment Strategies

Centralized Approach

- One Root Pmax Server, One EV Charge Scheduler
- All EV's negotiate schedule with the single EV Charge Scheduler

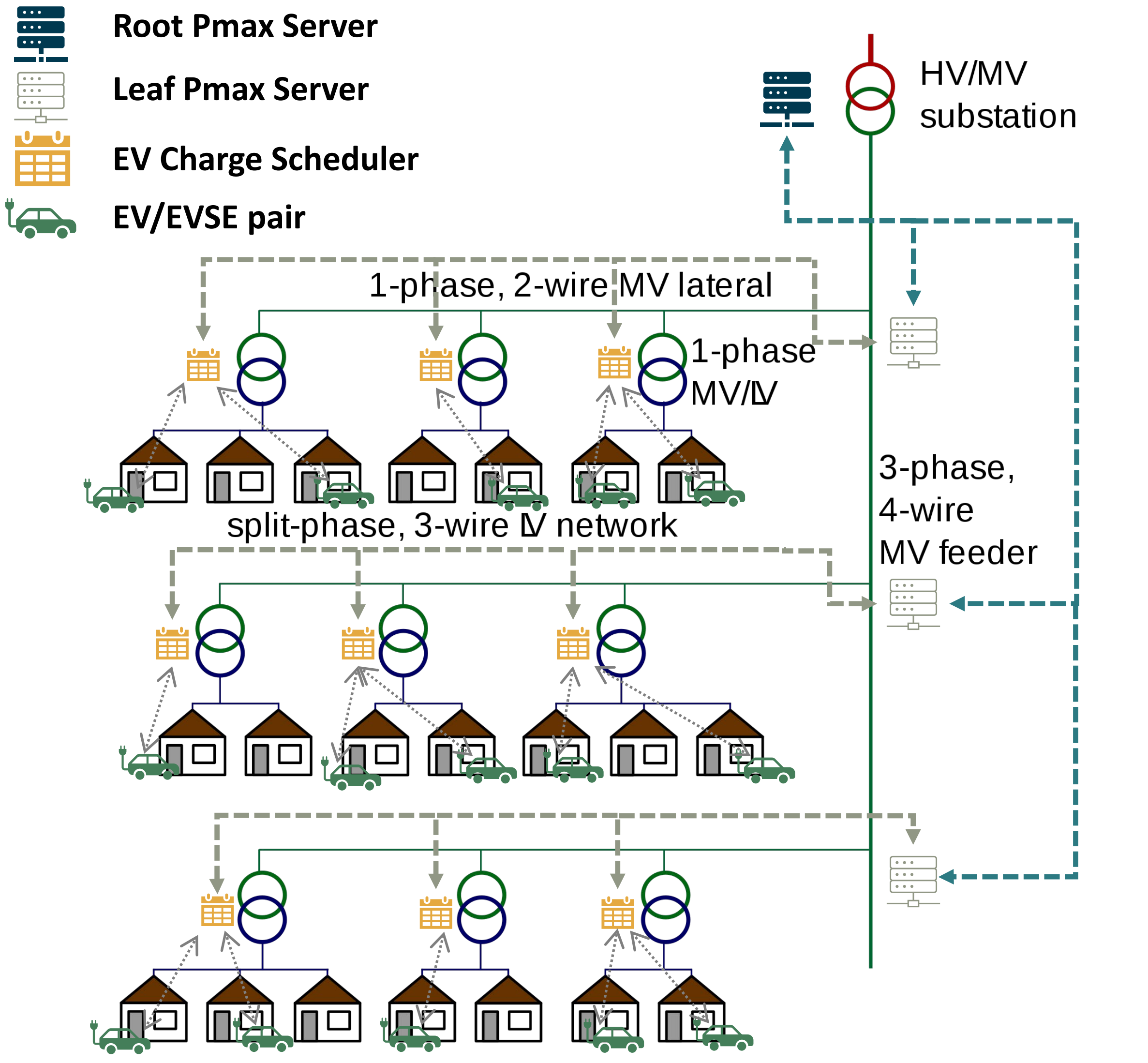


15118 Charge Scheduler

Deployment Strategies

Hierarchical Distributed Approach

- One Root Pmax Server, multiple Leaf Pmax servers, multiple EV Schedulers
- Leaf Pmax Servers negotiate Pmax profiles with Root Pmax Server
- All EV's negotiate schedule with a single EV Charge Scheduler

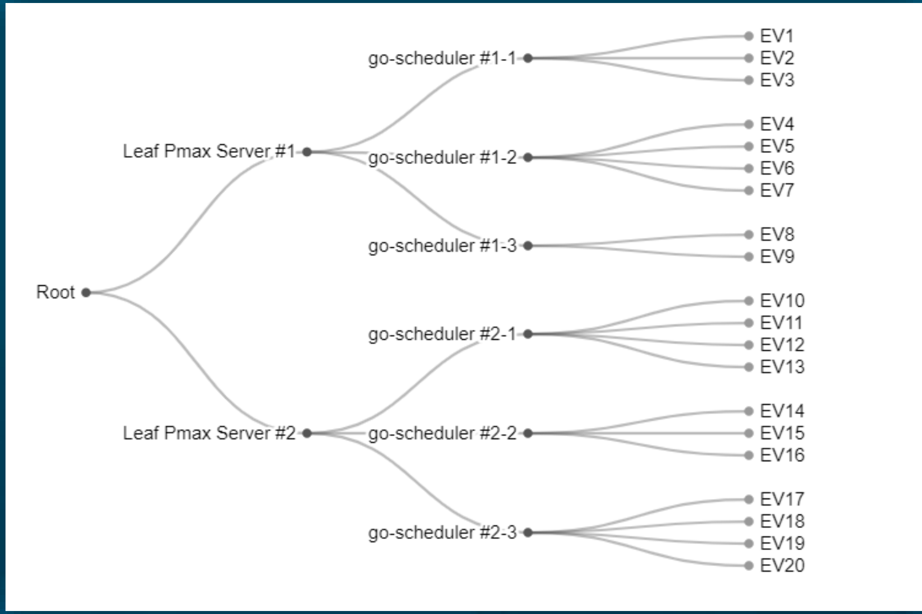


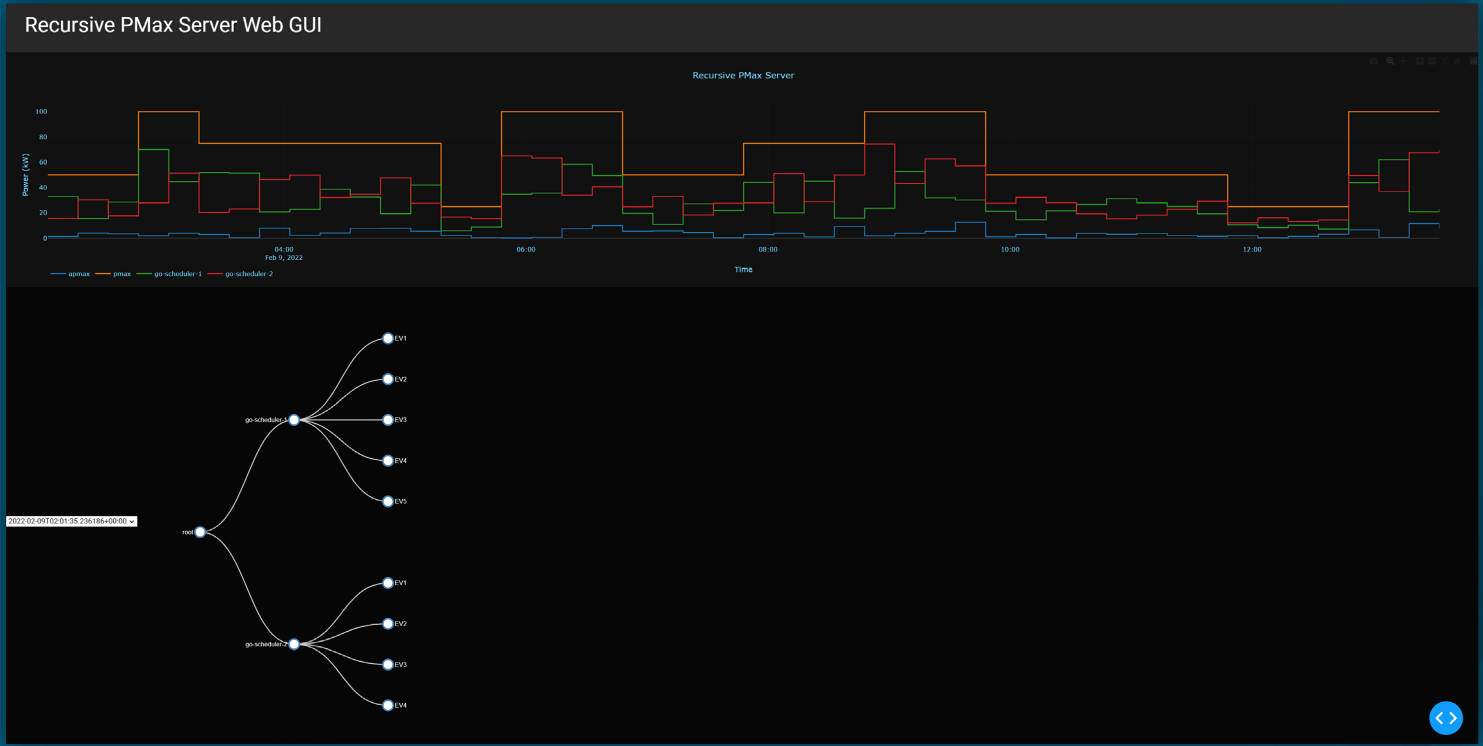
Pmax Servers

How to Distribute and Coordinate Available Power Profiles

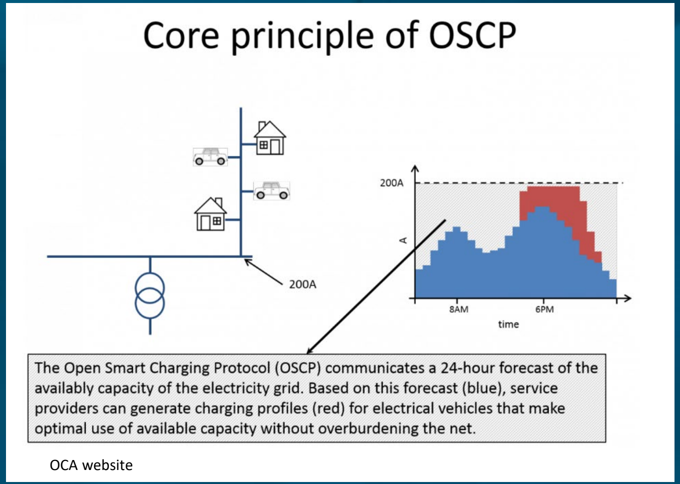
Recursive Pmax Distribution Protocol (RPDP)

- Required to propagate energy information from the Root (Utility) to Leaf Pmax Servers and ultimately to EV Schedulers
- Distribute available power across multiple Leaf Pmax Servers
- Recursively gets power from a parent via Websockets
- Root server has no parent (Utility)





OPEN SMART CHARGING PROTOCOL (OCSP)?

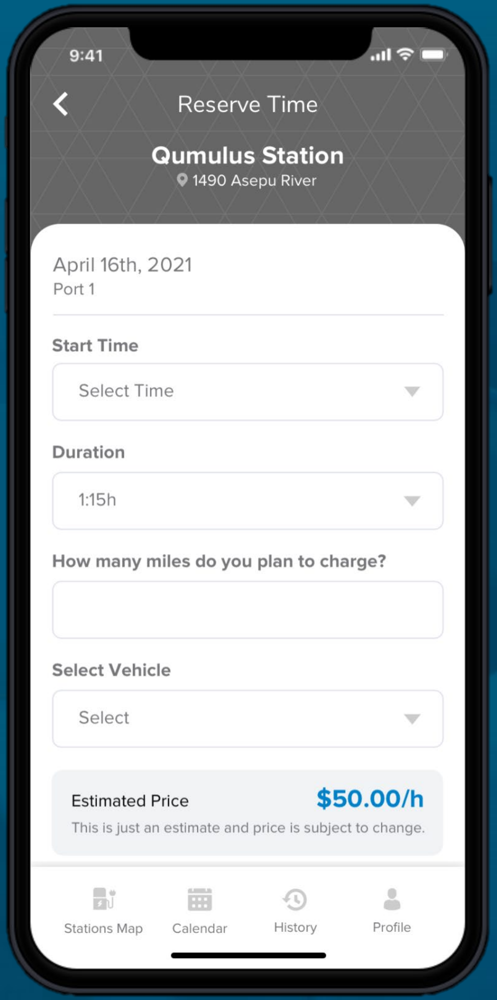


Non-15118 Vehicles

How Can They Participate?

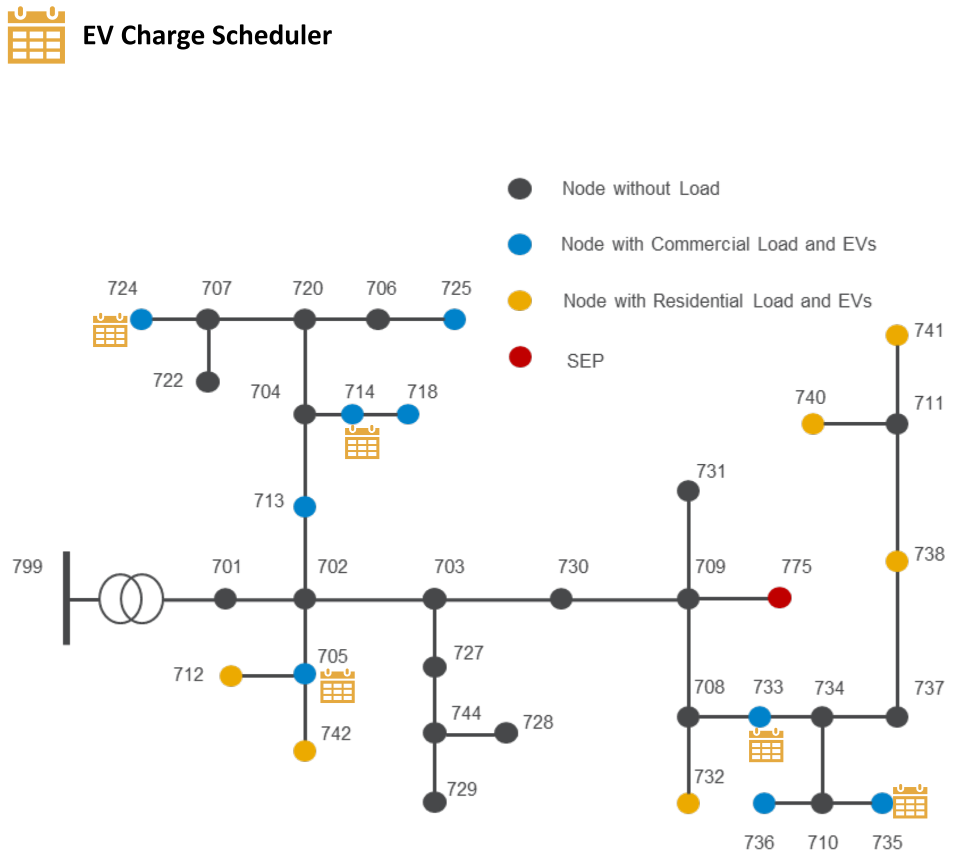
Charge Scheduler Bridge

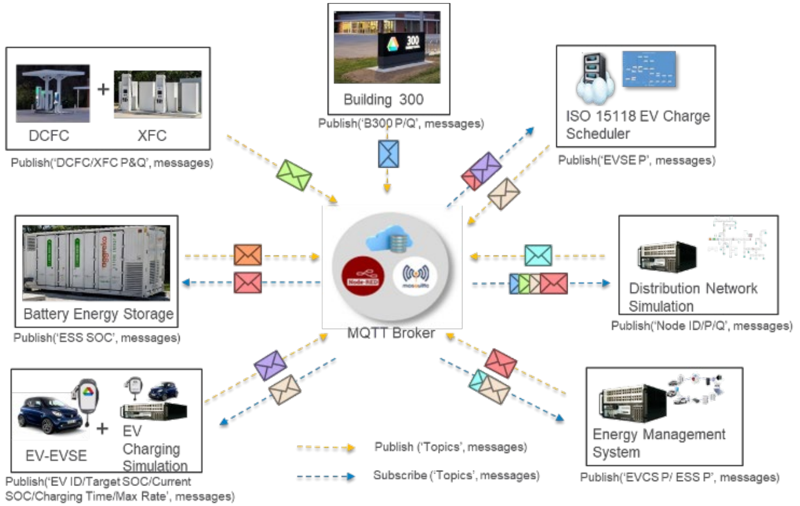
- **EV Agents deployed on behalf of non-ISO 15118 EVs**
  - Agents act on behalf of EV to interface and negotiate charge schedule
  - Emulates ISO 15118 messages (Charge Scheduler unaware)
  - Negotiated Charge Profile sent to OCPP station
- **Leverage Mobile App to inform EV agent of following:**
  - EV id
  - Departure Time
  - Max Power Draw of PEV
  - Target Energy
- **Leverage CSMS backend to inform EV agent of following:**
  - Real Time Meter Values (Energy, Power, etc.)
  - EVSE Status
- **Leverage CSMS backend to Set Charging Profile at Station**
- **EV agent monitors session and renegotiations (agent initiated as well as scheduler initiated)**

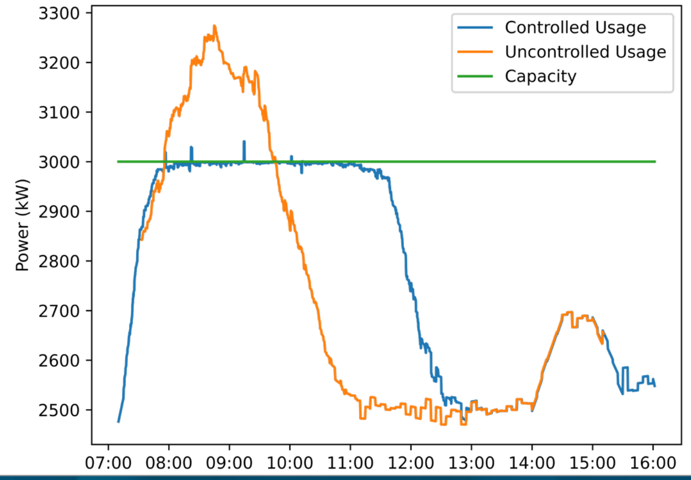


Charge Scheduler Bridge Simulation

Real-Time Digital Simulation of Distribution Network



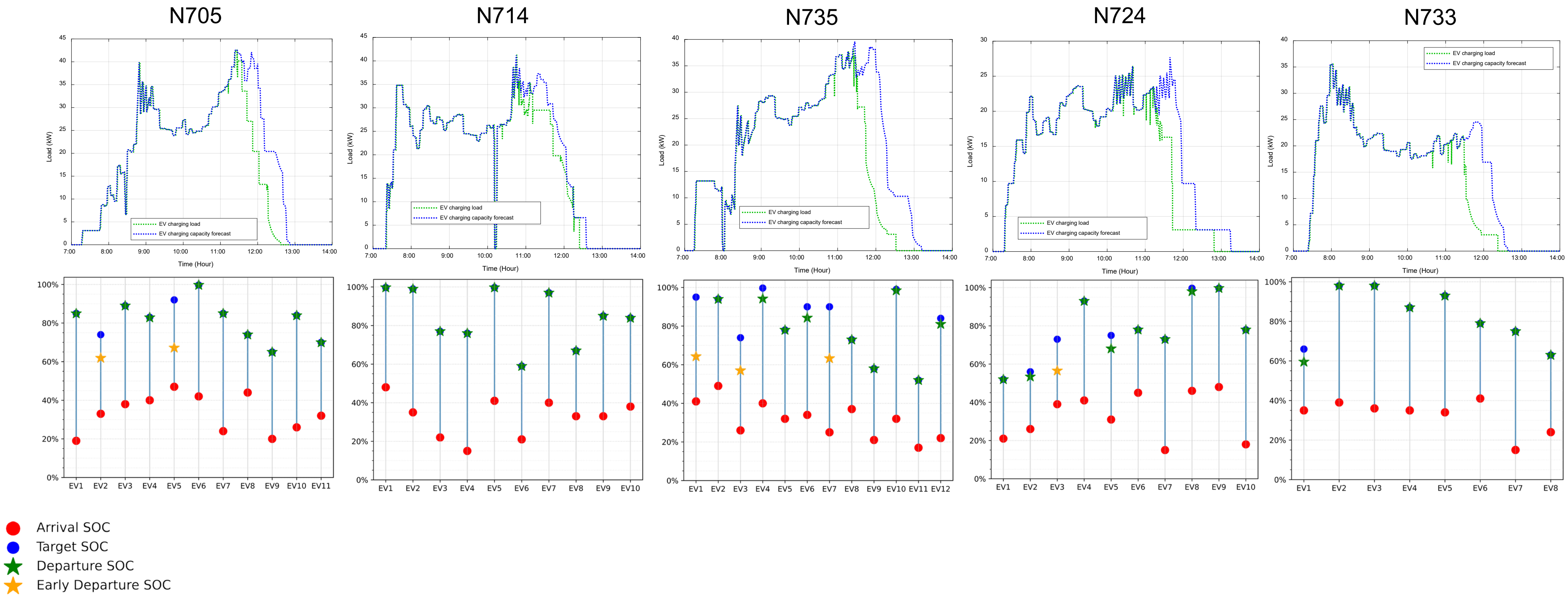




Wu, Z., Manne, N., Harper, J., Chen, B. et al., "A Cloud-Based Simulation and Testing Framework for Large-Scale EV Charging Energy Management and Charging Control," SAE Technical Paper 2022-01-0169, 2022, https://doi.org/10.4271/2022-01-0169.

Charge Scheduler Bridge Simulation

Were the driver's energy requirements met?



Charge Scheduler

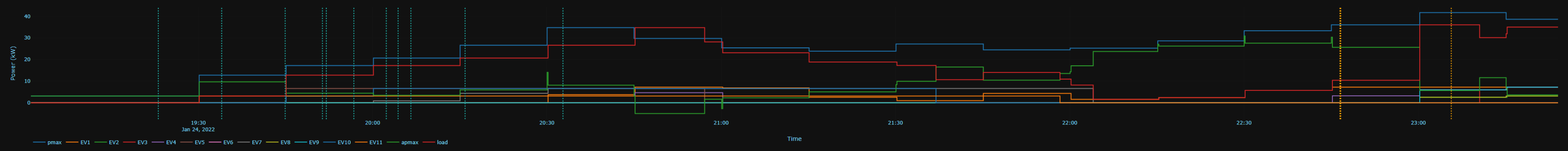
Post-Processing Logs

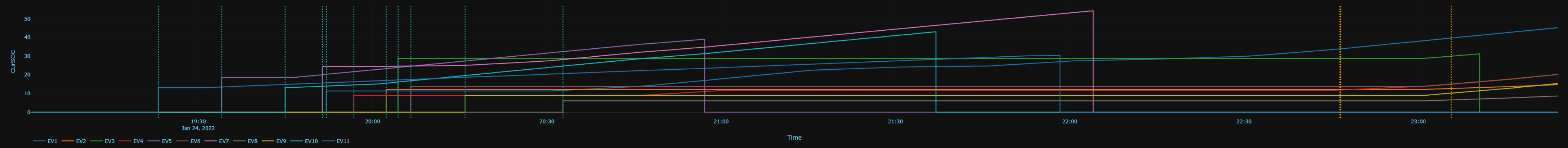
Simulation Bridge Visualization GUI

Upload Simulation JSON

Upload PMAX CSV

Simulation started at 2022-01-24 19:01:11.338222





EV Name	Arrival Time	Scheduled Departure Time	Actual Departure Time	Energy Target	Energy at Arrival	Energy at Departure	Needs Met
EV1	2022-01-24 19:52:01.445317	2022-01-25 01:55:41.445317	2022-01-24 23:24:02.384378	51.0	11.4	45.33	No
EV2	2022-01-24 20:02:20.385795	2022-01-25 00:02:49.385795	2022-01-24 23:24:02.384378	26.84	12.2	14.87	No
EV3	2022-01-24 20:04:22.308741	2022-01-24 23:10:37.308741	2022-01-24 23:10:20.813756	57.6	28.8	31.31	No
EV4	2022-01-24 19:56:45.358540	2022-01-25 00:14:54.358540	2022-01-24 23:24:02.384378	37.8	9.0	20.38	No
EV5	2022-01-24 19:34:00.947388	2022-01-24 22:47:21.947388	2022-01-24 20:56:59.045321	39.058	18.536	39.12	Yes
EV6	2022-01-24 20:06:34.443323	2022-01-25 01:24:26.443323	2022-01-24 23:24:02.384378	53.4	13.8	20.31	No
EV7	2022-01-24 19:51:20.965247	2022-01-24 22:22:49.965247	2022-01-24 22:03:52.030678	54.284000000000006	24.494	54.34	Yes
EV8	2022-01-24 20:32:44.957657	2022-01-24 23:23:52.957657	2022-01-24 23:24:02.384378	18.91	6.1	8.81	No
EV9	2022-01-24 20:15:54.495141	2022-01-25 01:35:12.495141	2022-01-24 23:24:02.384378	50.4	9.0	15.51	No
EV10	2022-01-24 19:44:56.895774	2022-01-24 23:50:13.895774	2022-01-24 21:36:47.751154	43.03	13.24	43.12	Yes

1 / 2

Time	Severity	Event Message
2022-01-24 20:45:10.602836	Error	Power Usage over PMax by 5.00 kW for 718 seconds
2022-01-24 22:46:31.552124	Info	EV Schedule Rengotiation
2022-01-24 22:46:31.859364	Info	EV Schedule Rengotiation
2022-01-24 22:46:31.969344	Info	EV Schedule Rengotiation
2022-01-24 22:46:38.316083	Info	EV Schedule Rengotiation
2022-01-24 23:05:39.759907	Info	EV Schedule Rengotiation
2022-01-24 23:10:20.813756	Warn	EV3 did not meet energy need by 26.29 kWh by departure time
2022-01-24 23:10:20.813756	Warn	Not enough power to charge EV3

Thank You

Jason D. Harper

jharper@anl.gov

Stakeholder Feedback
(10 minutes)

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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.

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Smart Charge Management and Vehicle Grid Integration: FUSE

EVrest and OptiQ:

CSMS/EV Charge Reservation Platform
Smart AC L2 EVSE Background and Development

Jason D. Harper
ANL EV-Smart Grid Interoperability Center
Advanced Mobility and Grid Integration Technology

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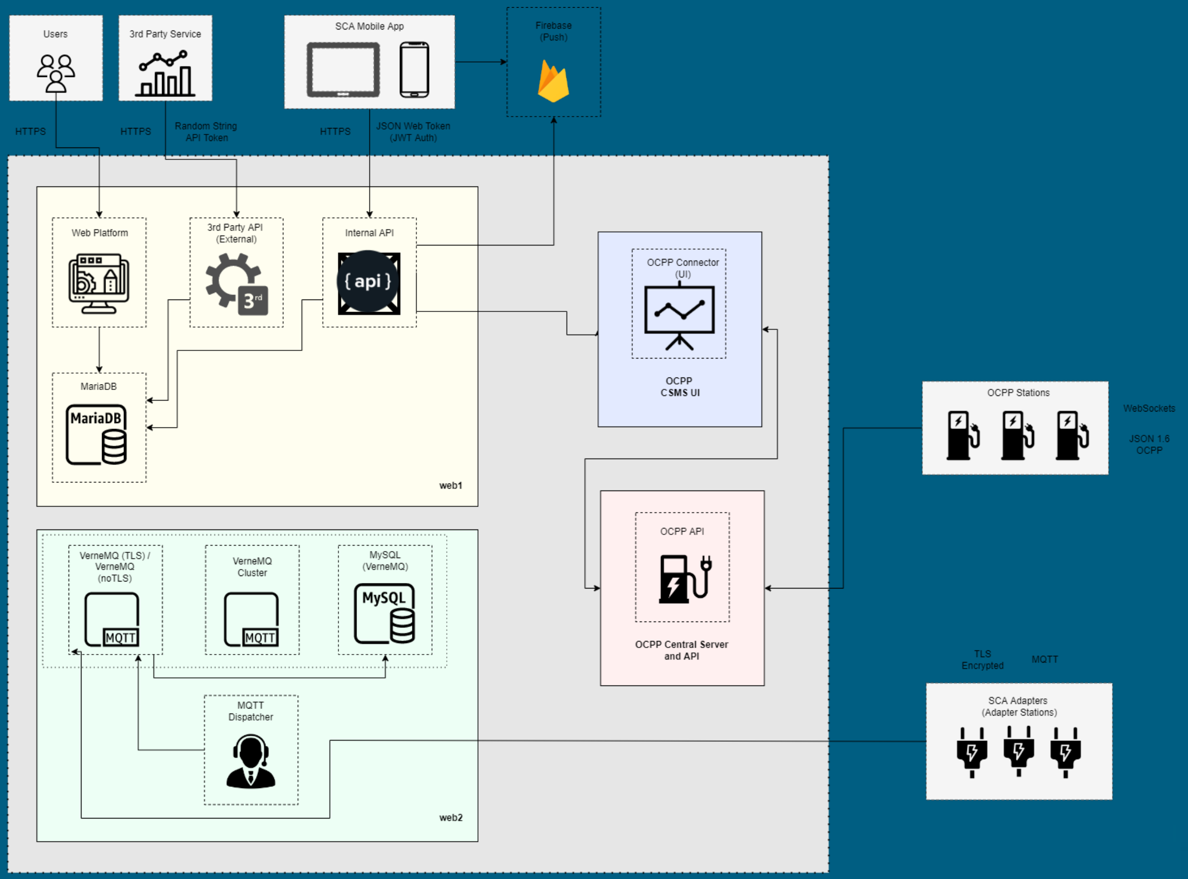
Charge Station Management System (CSMS)

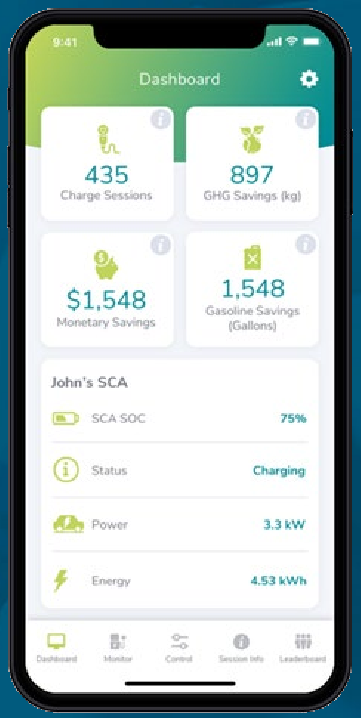
Background

Charge Station Management System: a system/platform consisting of applications and servers that allow for monitoring and controlling EVSE



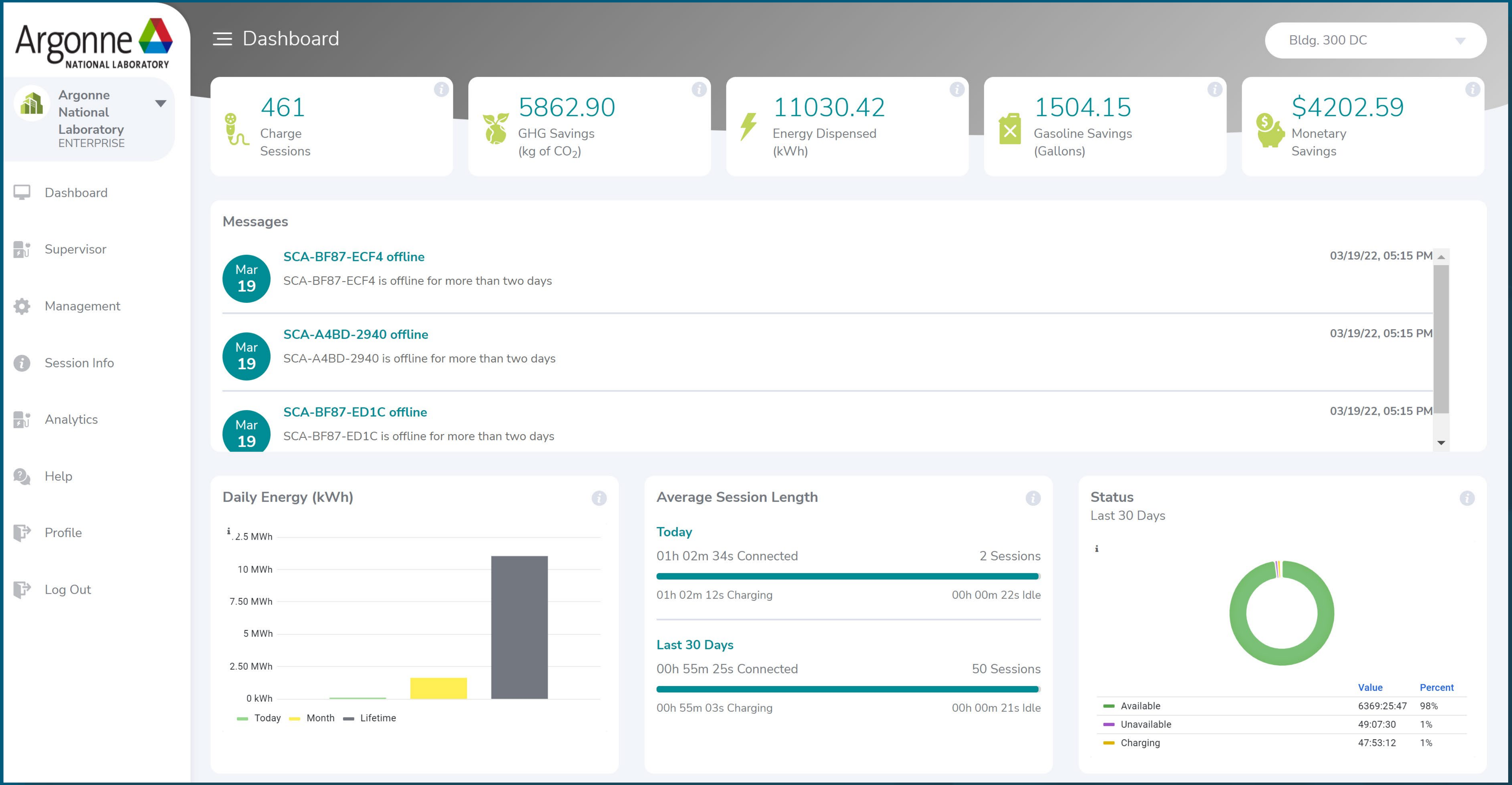
DOE TCF Project: Smart Charge Adapter

Adapter that converts non-networked EVSE to networked EVSE



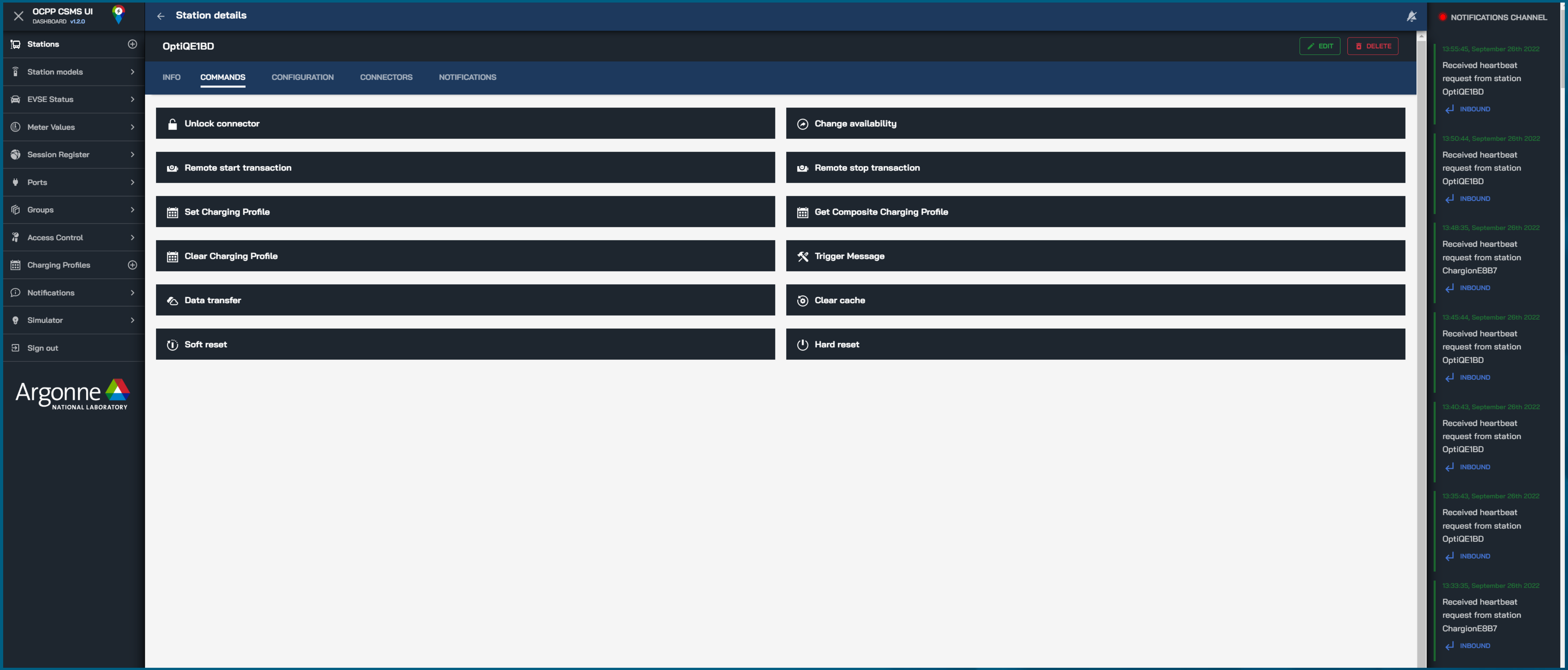
Argonne CSMS Platform

EVSE Management Web Application for Station Owners



Argonne CSMS Platform

OCPP 1.6J Central Server and User Interface



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EVrest: EV Driver Reservation System

Argonne Employee Charging Program

Current Reservation System

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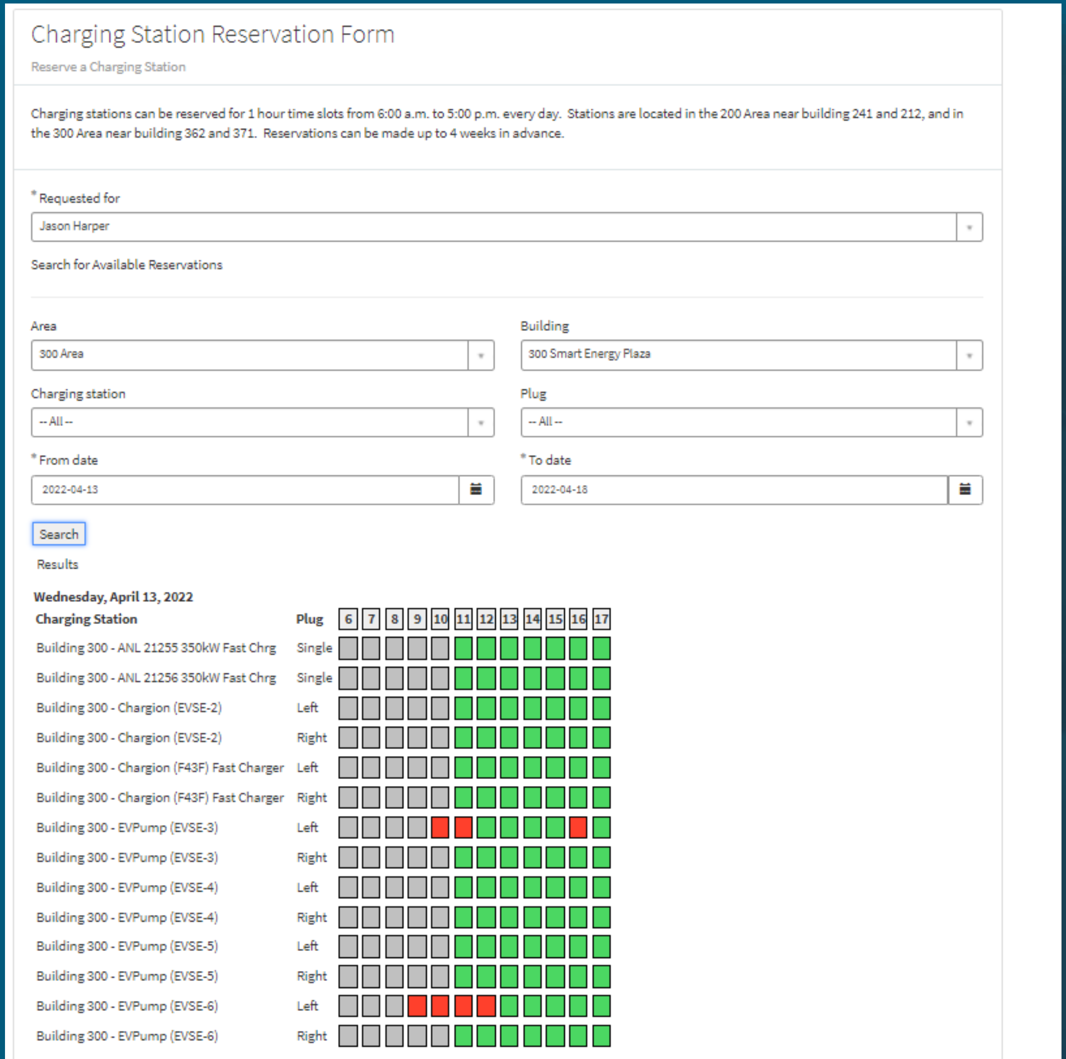
Argonne has ~50 AC ports and 8 DC Ports, mixture of networked and non-networked EVSE from multiple manufacturers

Program requires cost recovery per Federal Government rules, ANL employees pay low flat fee per month.

Employees must "reserve" a station using an online form.

No access control
No feedback to "reservation system"

Leads to upset employees who reserve stations only to find their port has been taken by someone.



Charging Station Reservation Form

Reserve a Charging Station

Charging stations can be reserved for 1 hour time slots from 6:00 a.m. to 5:00 p.m. every day. Stations are located in the 200 Area near building 241 and 212, and in the 300 Area near building 362 and 371. Reservations can be made up to 4 weeks in advance.

* Requested for: Jason Harper

Search for Available Reservations

Area: 300 Area
Building: 300 Smart Energy Plaza
Charging station: -- All --
Plug: -- All --
* From date: 2022-04-13
* To date: 2022-04-18

Search

Results

Wednesday, April 13, 2022

Charging Station	Plug	6	7	8	9	10	11	12	13	14	15	16	17
Building 300 - ANL 21255 350kW Fast Chrg	Single												
Building 300 - ANL 21256 350kW Fast Chrg	Single												
Building 300 - Chargion (EVSE-2)	Left												
Building 300 - Chargion (EVSE-2)	Right												
Building 300 - Chargion (F43F) Fast Charger	Left												
Building 300 - Chargion (F43F) Fast Charger	Right												
Building 300 - EVPump (EVSE-3)	Left												
Building 300 - EVPump (EVSE-3)	Right												
Building 300 - EVPump (EVSE-4)	Left												
Building 300 - EVPump (EVSE-4)	Right												
Building 300 - EVPump (EVSE-5)	Left												
Building 300 - EVPump (EVSE-5)	Right												
Building 300 - EVPump (EVSE-6)	Left												
Building 300 - EVPump (EVSE-6)	Right												

Argonne Charging Data

Anonymized Workplace Charging Data

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Session Info

Download

Groups | Stations | Ports | Adapters | Filter | Save | Use Saved Filter

Date	Transaction ID	Device Name	Port Name	Group Name	Station Type	Total Energy (kWh)	Peak Power (kW)	Avg Power (kW)	ID Tag	Session Start Time	Session End Time	Session Durati	Charge Start Time	Charge End Tir	Charge Duratic	End Reason	GHG Savings (kg CO2)	Gas Savings (gal)	Start SOC	End SOC
09/21/2022	93890993	ChargionDF8A/MDL2	Port2	MDL	AC	2.828	3.371	3.325	fd3f7804-029c-4fea	03:25:35 PM	04:17:05 PM	00:51:30	03:25:43 PM	04:17:04 PM	00:51:20	EVDisconnected	1.503	0.386	0.0	0.0
09/21/2022	2008685899	ChargionBB28	Port2	Bldg. 300 AC	AC	11.636	6.762	5.475	f4660839-ea42-4983	01:53:09 PM	04:01:26 PM	02:08:17	01:53:18 PM	03:41:46 PM	01:48:27	EVDisconnected	6.185	1.587	0.0	0.0
09/21/2022	239800085	B362-EVOCharge-Right	Port1	Bldg. 362	AC	2.845	0.0	0.0	0FFFFFFFFF	12:56:01 PM	04:10:09 PM	03:14:08	12:56:04 PM	01:21:36 PM	00:25:32	EVDisconnected	1.512	0.388	0.0	0.0
09/21/2022	1532302599	B362-EVOCharge-Left	Port1	Bldg. 362	AC	14.789	0.0	0.0	9949eac9-f747-4223	12:23:09 PM	03:29:31 PM	03:06:22	12:23:14 PM	02:38:35 PM	02:15:21	EVDisconnected	7.861	2.017	0.0	0.0
09/21/2022	301442248	Chargion6D94	Port1	Bldg. 300 AC	AC	21.372	6.855	6.769	edb39656-83cc-4c07	12:01:55 PM	03:12:06 PM	03:10:11	12:02:02 PM	03:12:06 PM	03:10:04	EVDisconnected	11.360	2.914	0.0	0.0
09/21/2022	csCOWOE889	SCA-BF87-ECF4	Port 2	Bldg 300 SCA	AC	16.197	3.889	3.667		12:00:59 PM	05:33:29 PM	05:32:30	12:00:59 PM	04:26:22 PM	04:25:23	EVFullyCharged	8.609	2.209		
09/21/2022	802478845	Chargion6626	Port2	Bldg. 300 AC	AC	16.123	3.854	2.899	c839fb14-f224-44fe	12:00:49 PM	05:33:39 PM	05:32:50	12:00:57 PM	04:26:48 PM	04:25:50	EVDisconnected	8.570	2.199	0.0	0.0
09/21/2022	648870272	ChargionE3B7/MDL1	Port1	MDL	AC	23.536	5.934	4.57	5b76dd0d-6cc8-4de4	10:17:54 AM	03:30:51 PM	05:12:57	10:18:05 AM	03:30:51 PM	05:12:08	EVDisconnected	12.510	3.209	0.0	0.0
09/21/2022	148962710	ChargionBB28	Port1	Bldg. 300 AC	AC	31.602	6.926	4.495	fe441928-2863-4a66	10:07:56 AM	05:13:36 PM	07:05:40	10:08:05 AM	02:47:22 PM	04:39:16	EVDisconnected	16.797	4.309	0.0	0.0
09/21/2022	590656189	Chargion6626	Port1	Bldg. 300 AC	AC	17.068	6.921	6.84	19a559ae-4c1c-4f87	10:06:55 AM	12:37:28 PM	02:30:33	10:07:03 AM	12:37:28 PM	02:30:25	EVDisconnected	9.072	2.327	0.0	0.0

Showing 1 to 10 of 3,962 entries

Previous 1 2 3 4 5 ... 397 Next

EVrest

EV Driver Mobile App

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EV Driver app that integrates with Argonne's CSMS (iOS and Android)

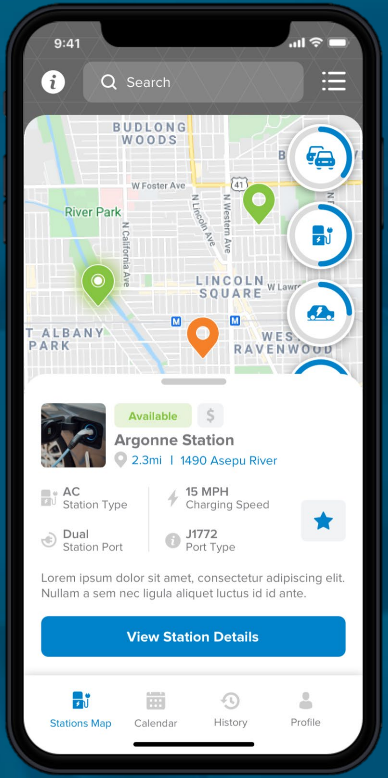
- Integrates the following types of EVSE:

OCPP AC single port
OCPP AC dual port
OCPP DC single Port
OCPP DC dual port (1 session allowed)
OCPP DC dual port (2 sessions allowed)

SCA single port
SCA dual port
Non-Networked single port
Non-Networked dual port

EVSE owner in web portal can configure stations:

- Default: with or without access control
- Reservation – Reserve a specific station and port for a specific duration of time
- Wait List – Group based wait list allows drivers to be added to a queue and notified when a port is available

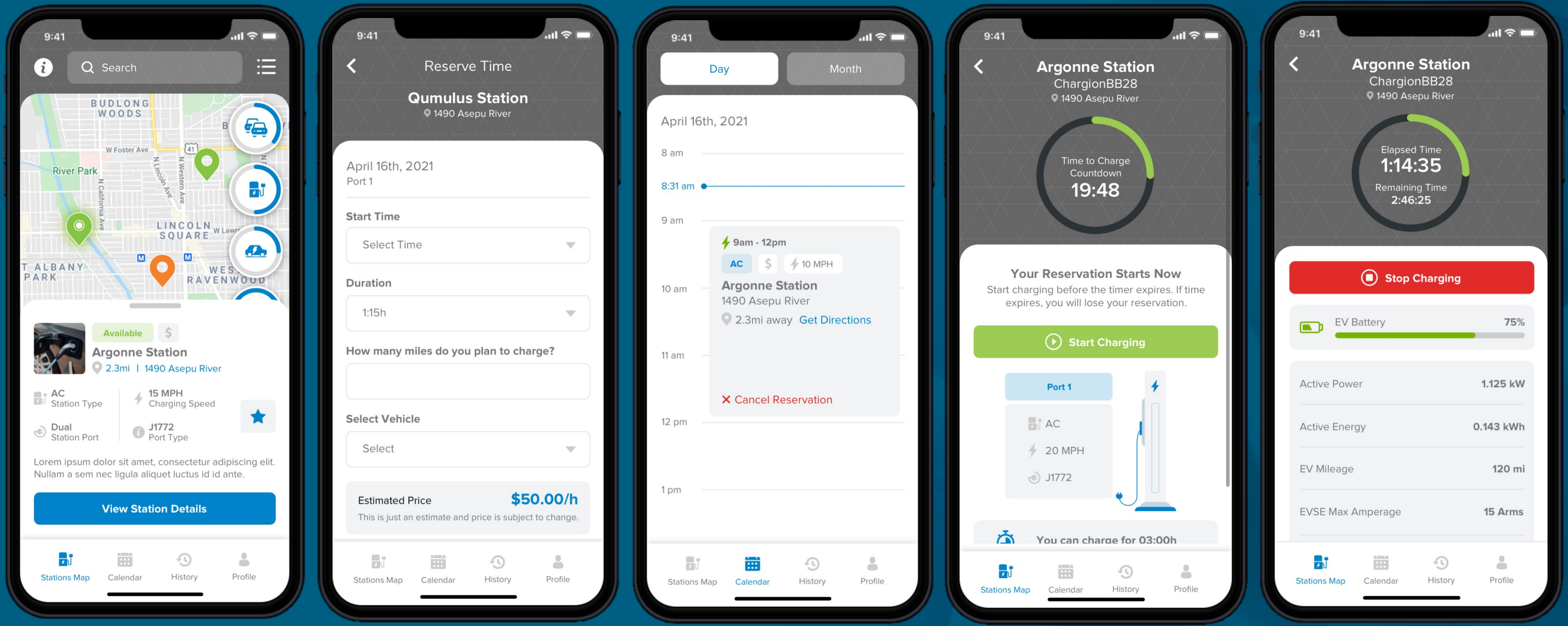


EVrest

EV Driver Mobile App

Platform will aggregate charging data and build profiles for each EV driver or EVSE for AC/DC charging as well as AC/DC scheduling

Profiles will be made available via 3rd party API for real-time machine learning that can provide forecasting and optimized scheduling. Platform also allows for integration of Charge Scheduler Bridge for non-ISO 15118 EVs



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OptiQ: Smart AC L2 EVSE

Smart Plugin EV Communication Controller (SpEC)

Gen I: Communication Controller for EV or EVSE

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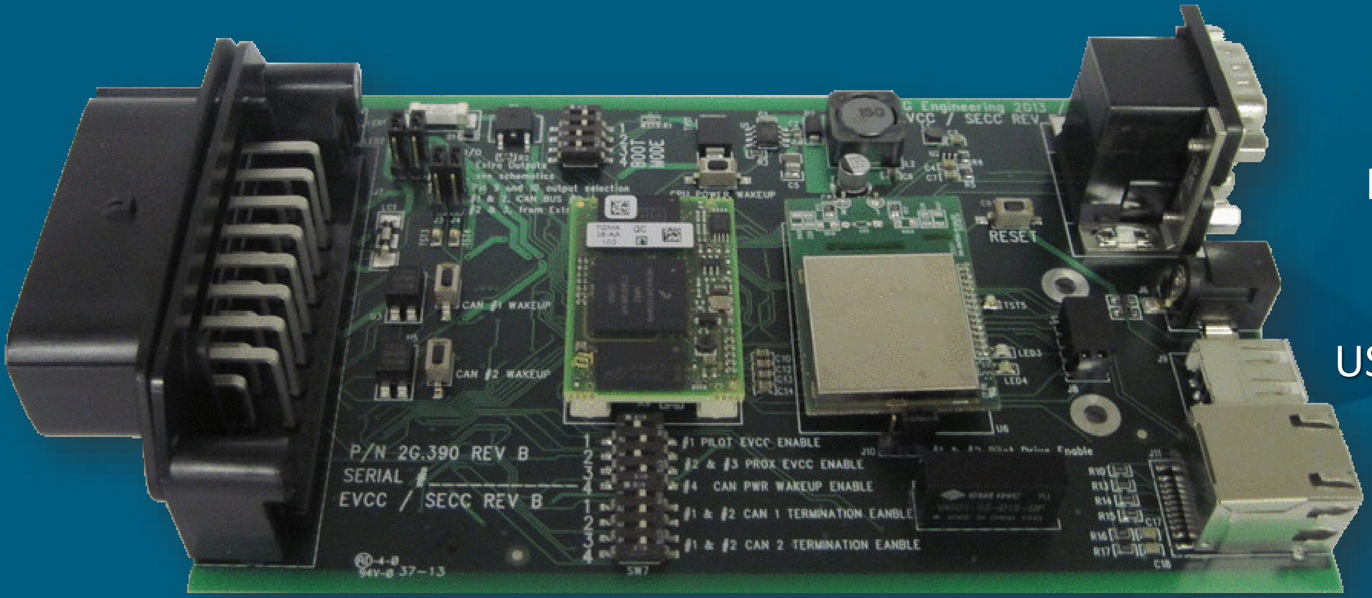
CAN
RS-232
PLC/Pilot
Proximity
Temp Sense
Coupler Lock



RS-232
USB
Ethernet

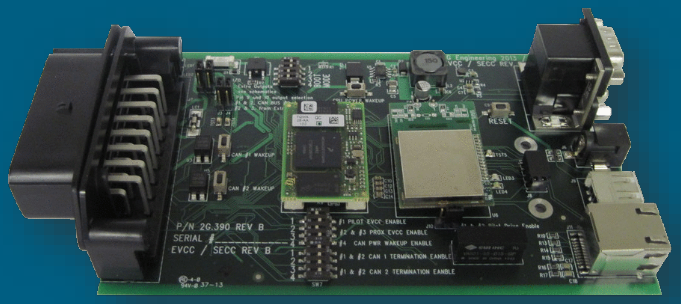
- Qualcomm Atheros QCA7000 HPGP IC
- ARM9 Freescale i.MX287 microprocessor
- J1772 Circuits
  - Pilot/Proximity
  - Coupler Lock
  - Coupler Temperature Sense

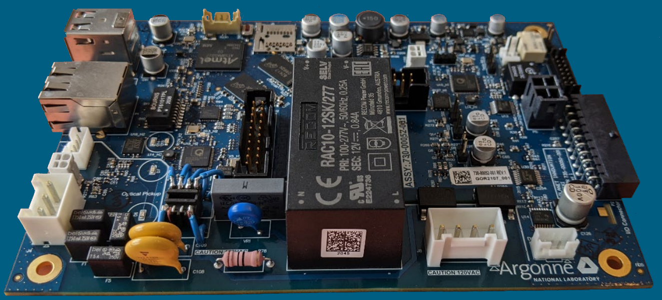
Interfaces:

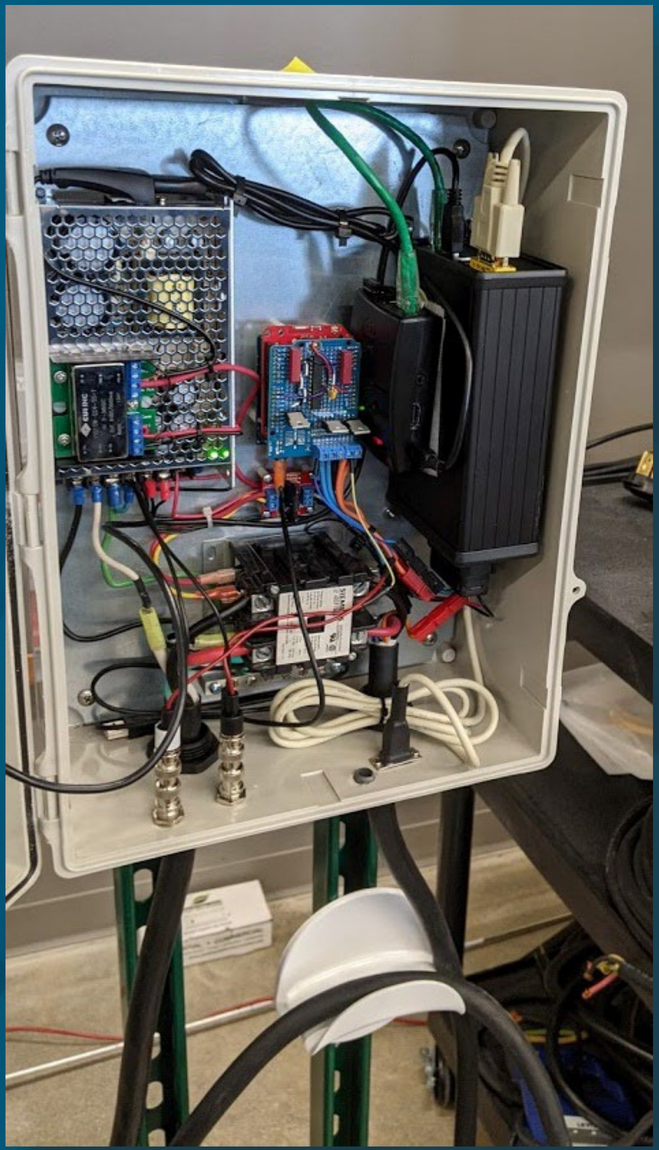
- Ethernet
- USB
- RS-232
- SPI
- CAN
- GPIO

ISO 15118-2 AC EVSE

SMART VGI project

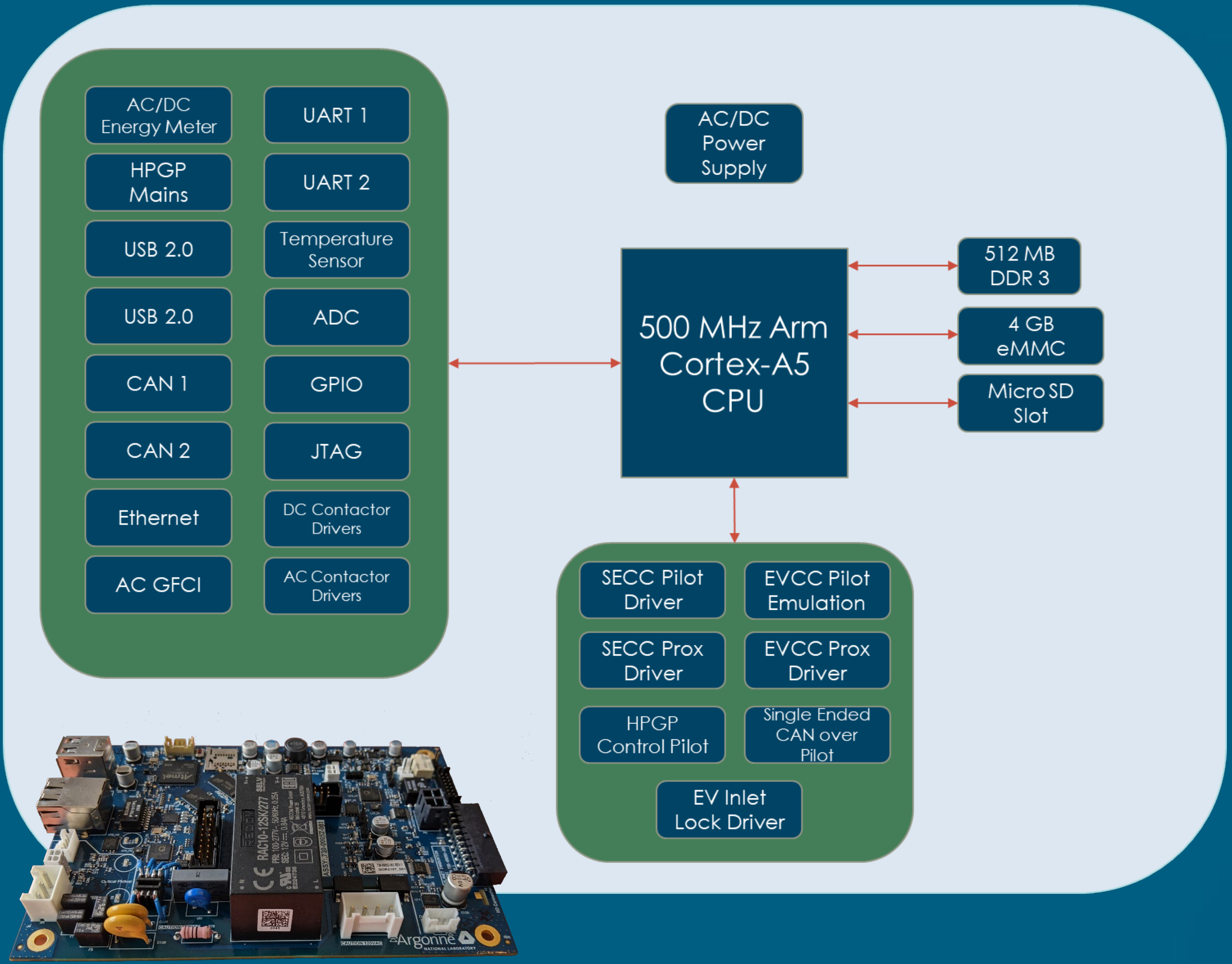






SpEC II

Hardware Overview



Environmental	Operating Temperature	-40°C to +85°C.
	Storage Temperature	-40°C to +105°C.
Memory and Storage	SDRAM Memory	512 MB DDR3 @ 166MHz
	Flash Memory	4 GB eMMC Flash onboard with additional external micro SD card slot
Interfaces	Power Line	HomePlug Green PHY: AC Mains
	Communication	HomePlug Green PHY: Control Pilot
	USB 2.0	2 HOST controllers
	Ethernet	RJ-45 10/100 Ethernet interface
	Control Pilot	Generation (EVSE) and Emulation (PEV)
	Proximity	Monitoring and Generation
	CAN	2 CAN interfaces
	Tesla (Single Ended Can)	Rx/Tx Single Wire Can over Pilot
	AC Current	Input for CT to measure AC current (AC charging)
	DC Current	Input for DC current sensor to measure DC current (DC charging)
	AC Voltage	Input for AC Voltage for AC meter
	DC Voltage	Input for DC Voltage for DC meter
	12VDC Switches	Dual 2A, 12VDC switches for contactors
	DPDT AC Relays	Quad SPST SSR's for driving external AC contactors
	EV Inlet Lock Driver	12VDC Driver for EV inlet lock
	Temperature Sensor	external input and onboard temperature sensor
	GFCI	Ground Fault Interrupt CT input
	GPIO	5 externally accessible GPIO
	ADC	4 externally accessible ADC
	JTAG	JTAG for Debugging
	UARTS	2 UARTS for serial communication
Power	AC Input Voltage	85-265 VAC
	DC Input Voltage	9-24 VDC
	Quiescent Current	< 200µA in ultra-low power mode
Modes of Operation	EVCC	Electric Vehicle Communication Controller
	SECC	Supply Equipment Communication Controller

SpEC II

Software Overview

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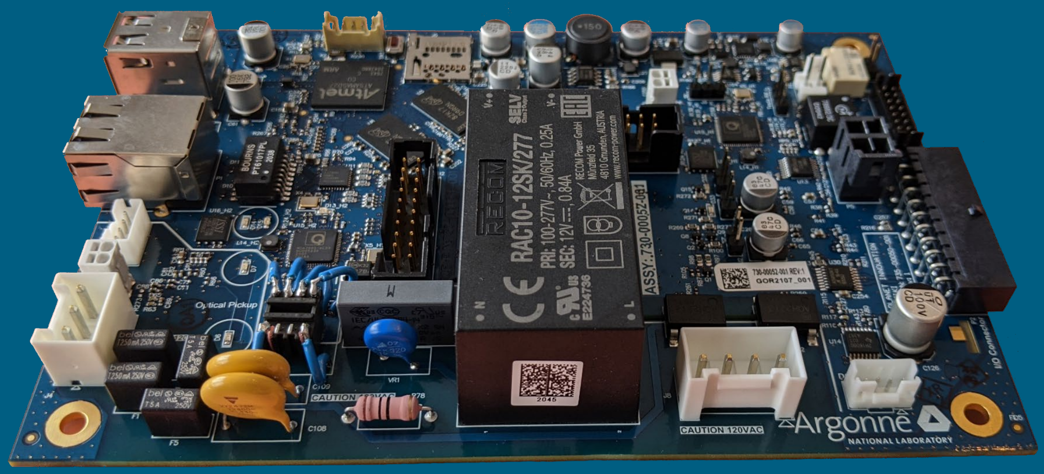
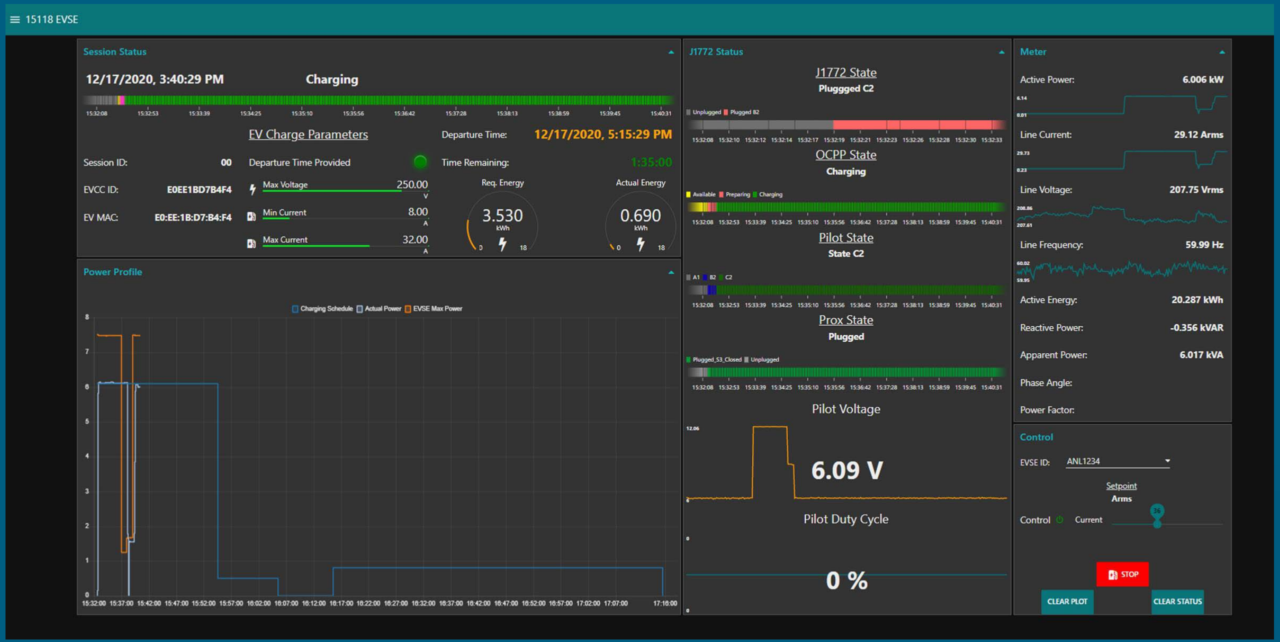




Linux Kernel: 5.4.81

Custom Device Tree Overlay

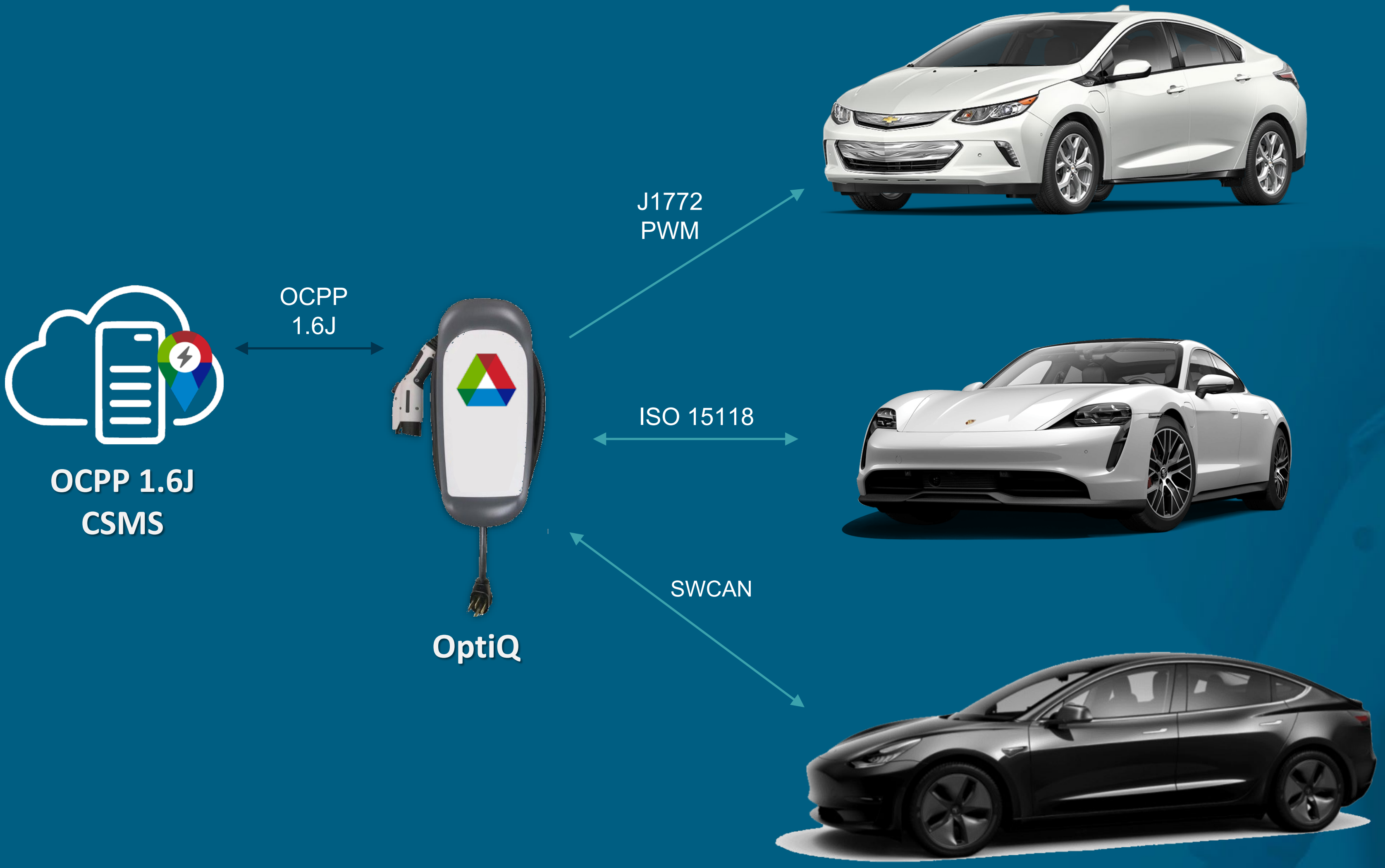
OCPP 1.6J Client

Custom C/C++ Applications

- DIN 70121
- ISO-15118-2
- ISO-15118-20

OptiQ

Smart AC L2 EVSE Overview



- Revenue Grade AC Submeter
- Uniqueness:
  - Tesla SWCAN
  - ISO-15118
  - J1772 (PWM)
- Configurable PHY interfaces:
  - Wi-Fi, Ethernet, Cellular, or PLC over mains
- OCPP 1.6J to CSMS
- Enables Smart Charge Scheduling

OptiQ

Proof of Concept

Thank You

Jason D. Harper

jharper@anl.gov

Stakeholder Feedback
(10 minutes)

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U.S. Department of Energy

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.

10-minute break

Please take a 10-minute break and plan to return at 12:15 p.m. ET

Session 2 - VGI Demonstration and Codes & Standards

EVs@Scale
U.S. Department of Energy

12:15 p.m. – 12:45 p.m. ET	**Demonstration Plans**
Presentation (20 min)	Jason Harper, Myungsoo Jun
Q&A (10 min)	
12:45 p.m. – 1:15 p.m. ET	**Codes & Standards**
Presentation (20 min)	Ted Bohn
Q&A (10 min)	

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U.S. Department of Energy

EVs@Scale Deep Dive - SCM/VGI

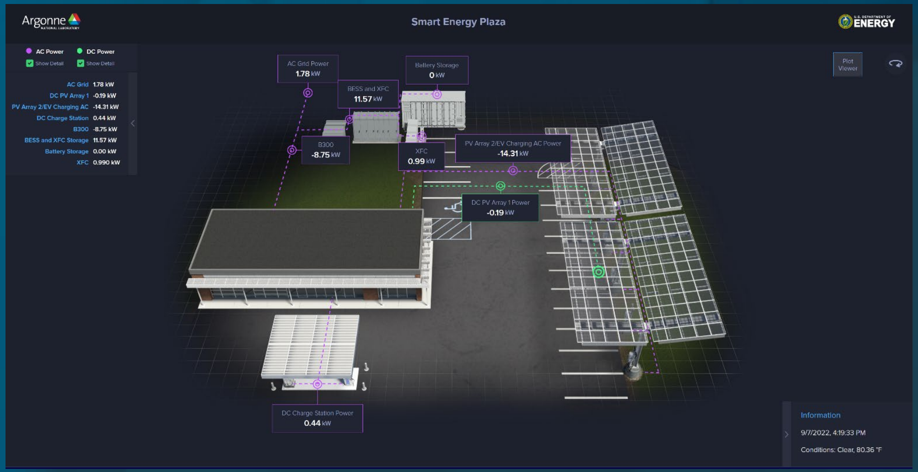
Next Steps and Demonstration Plans

Jason Harper (ANL),
Myungsoo Jun (NREL)

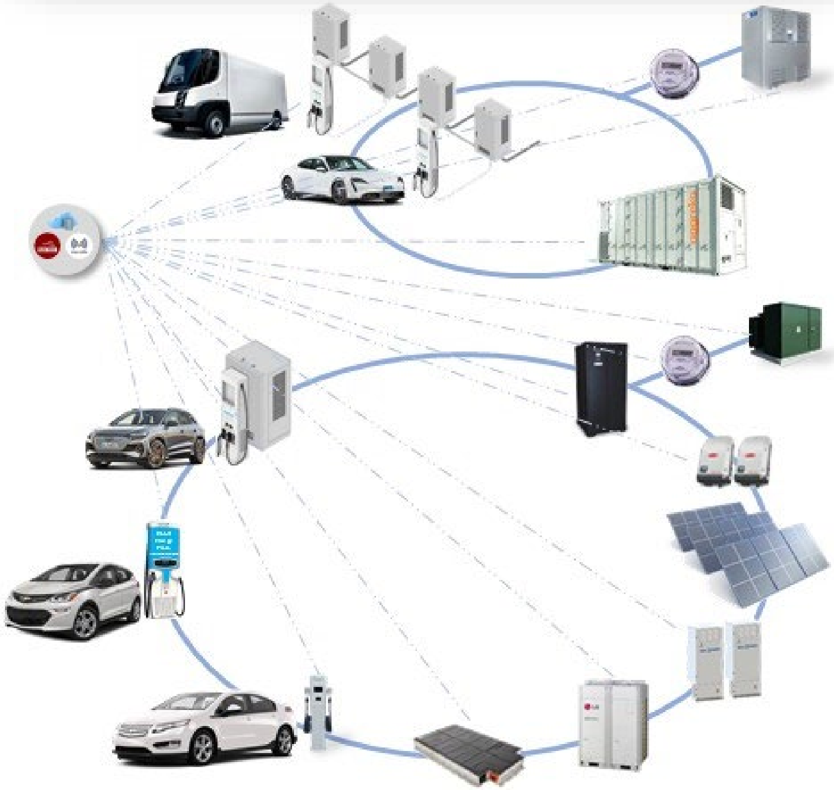
September 29, 2022

Argonne Smart Energy Plaza

- 80 kW PV Solar Canopies
- 12 AC L2 EV Charging Ports
- Second-use BMW i3 battery
- Grid isolation switch
- 200 kW DC xFC
- 2x350 kW DC xFC
- 660 kWh Li-ion battery



https://iot.ioc.anl.gov/



EVrest: Further Development

- **Develop OCPP 2.0.1 in ANL CSMS**
  - Allows integration of OCPP 2.0.1 stations into ANL CSMS
- **Integrate Charge Scheduler application into ANL CSMS**
  - Allows for ISO-15118 based EVs to participate in charge scheduling
- **Further Develop Charge Scheduler Bridge**
  - Allows for non-ISO-15118 based EVs to participate in charge scheduling
- **IoT Parking Sensor Integration**
  - Combats EV drivers from being "ICED": arriving at a parking spot set aside for EV charging only to find it blocked by an internal combustion engine vehicle, also known as an ICE
  - Provides status of parking spot + port status

EVrest Demonstration Plans

- **FY23 Q1 (Jan 2023) Demonstration Milestone:**

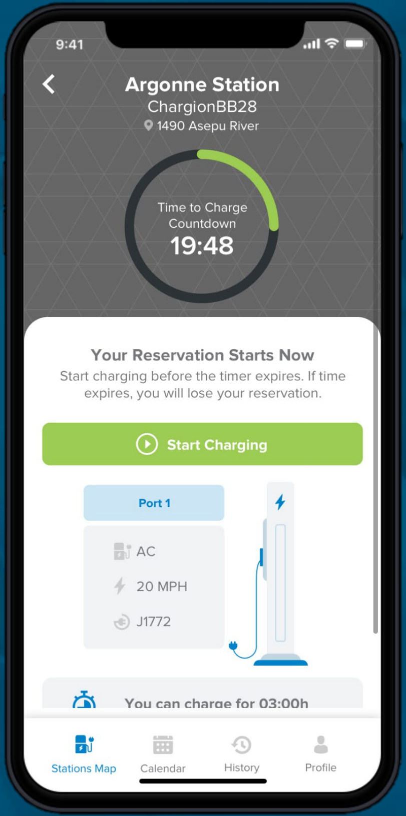
  Finalize EVrest internal testing and prepare for Alpha Pilot of EVrest at Argonne

  - Partnered with ANL Sustainability Group
  - On track to meet this milestone
  - Launch Alpha Pilot at ANL FY23 Q2/Q3 (DOE IRB HSR Approved)

- **FY24 Q1 (Jan. 2024) Milestone:**

  Complete Workplace EV Charge Reservation System (EVrest) ANL Alpha Pilot

Interested in Multi-Family Dwelling and other Public/Semi-Public Pilot Opportunities

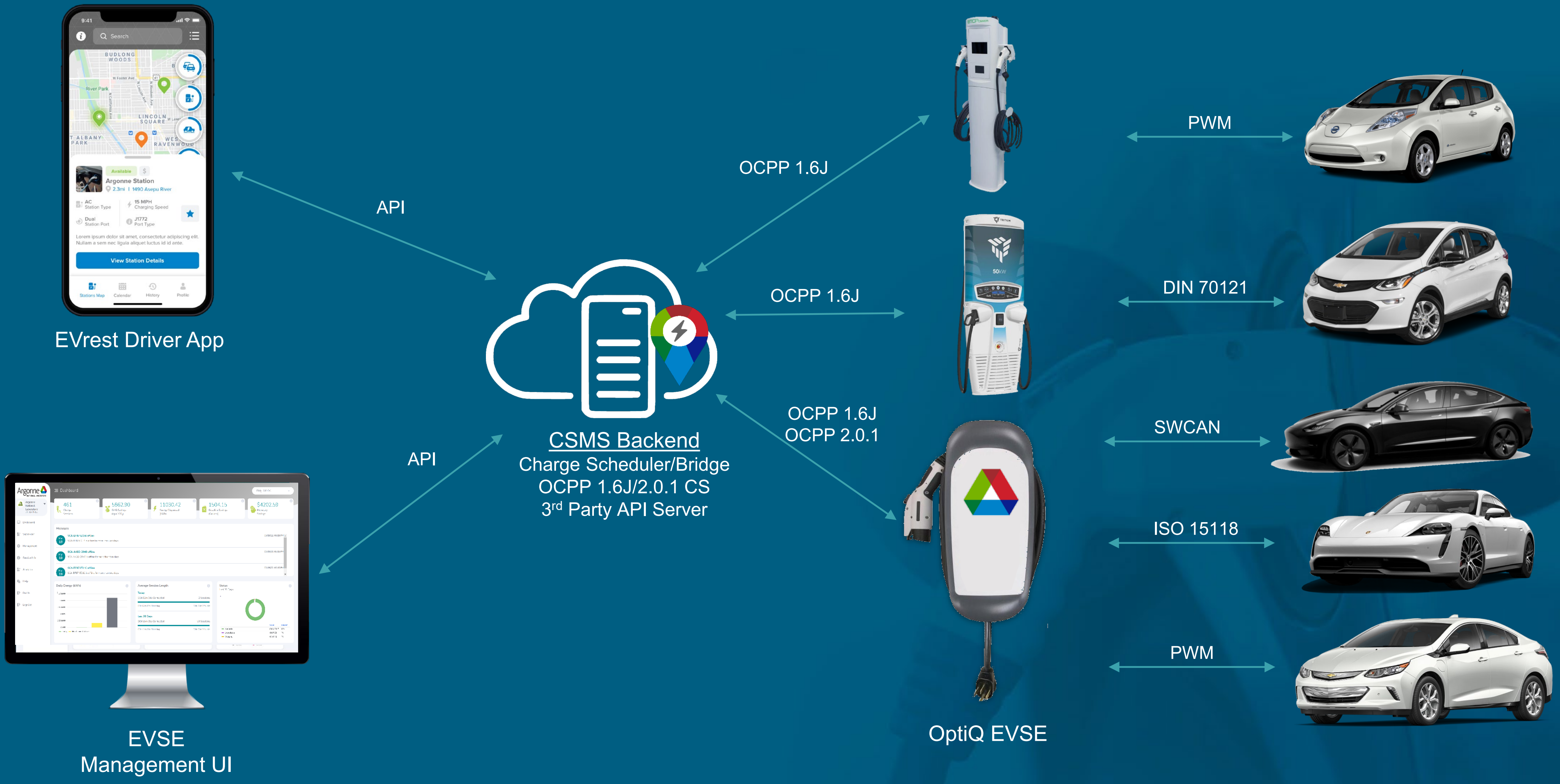


OptiQ Further Development & Demonstration Plans

- **Develop of Mk I OptiQ Prototype**
  - Board Design Update
  - Custom Enclosure
  - OCPP 2.0.1 Client development
- **FY22 Q3 (Oct. 2022) Demonstration Milestone:**
  - Deploy POC OptiQ at Argonne
    - Update FW to support ISO 15118 and Tesla SWCAN over next Quarter
- **FY24 Q1 (Jan. 2024) Milestone:**
  - Deploy Mk I Prototypes around campus or with Industry partner by FY23 Q4
  - Complete ANL Mk I Prototype Pilot at ANL

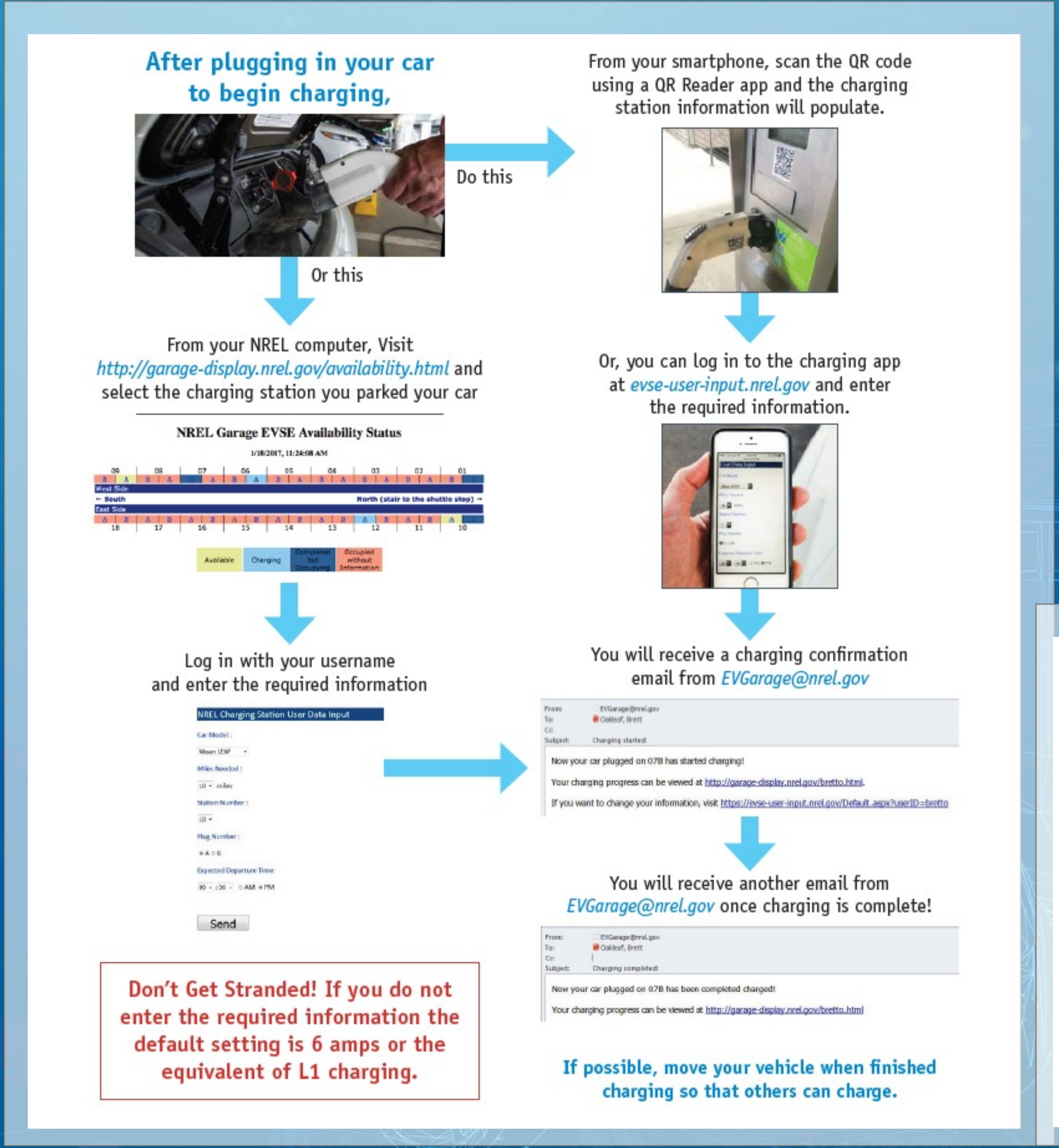
Looking for commercialization partners and pilot demonstration partners

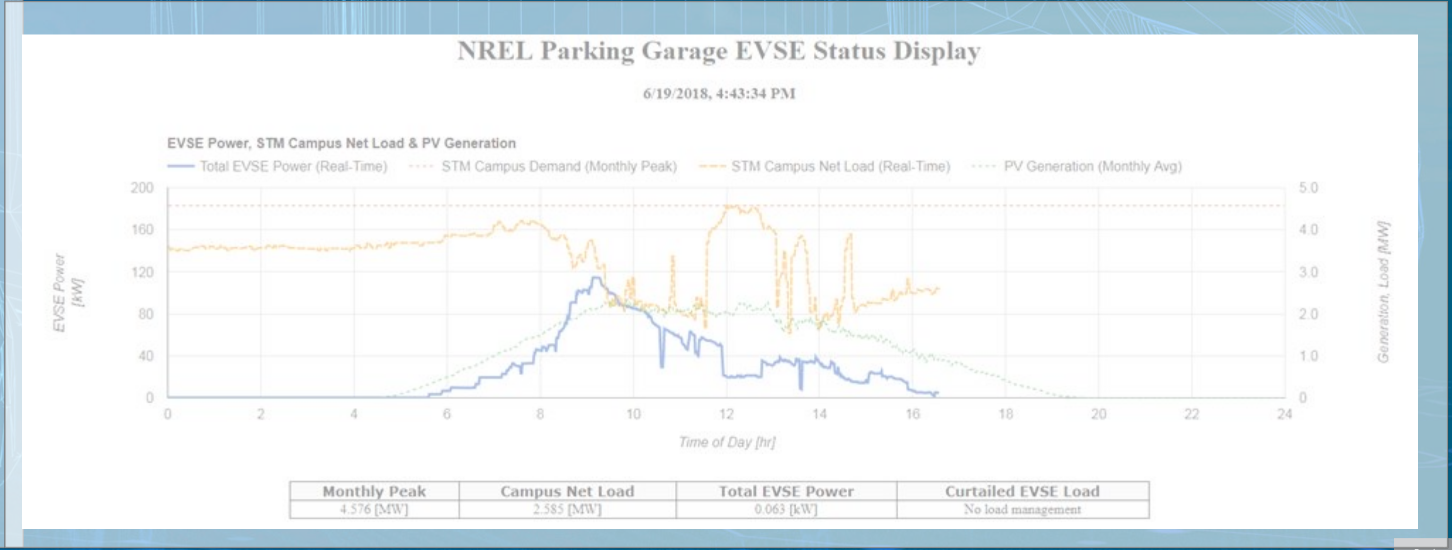
Argonne Smart Charging Ecosystem



Previous SCM at NREL

- **Deployed NREL proprietary SCM at NREL parking garage**
- **Objective is to reduce campus net peak load**
- **Lesson learned**
  - Credibility of user-provided information
  - Campus load forecast
  - Machine-learning based user usage pattern analysis
  - Expandibility

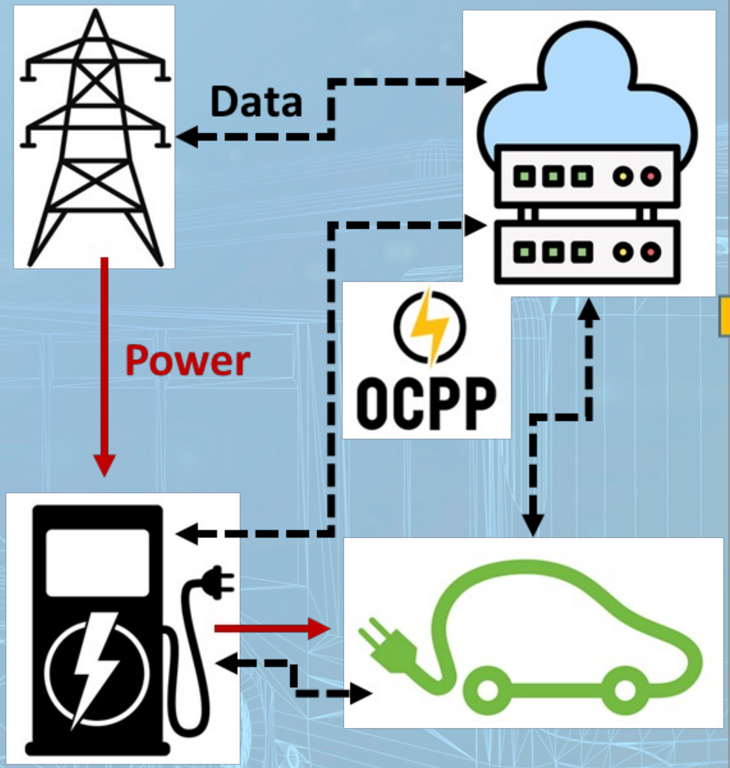




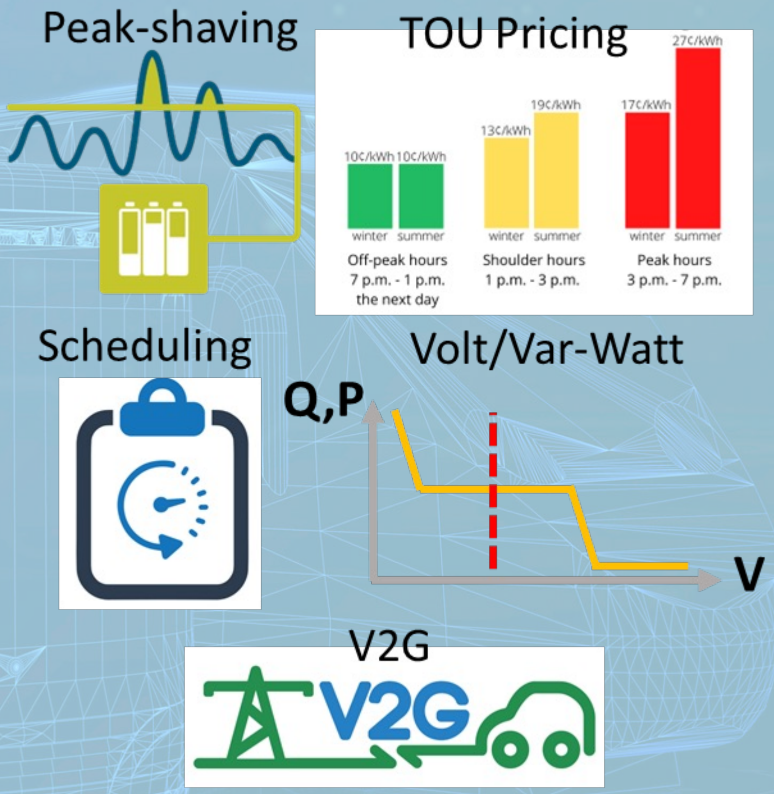
Demonstration Plan

Market Research

Testing and Verification for SCM Capabilities



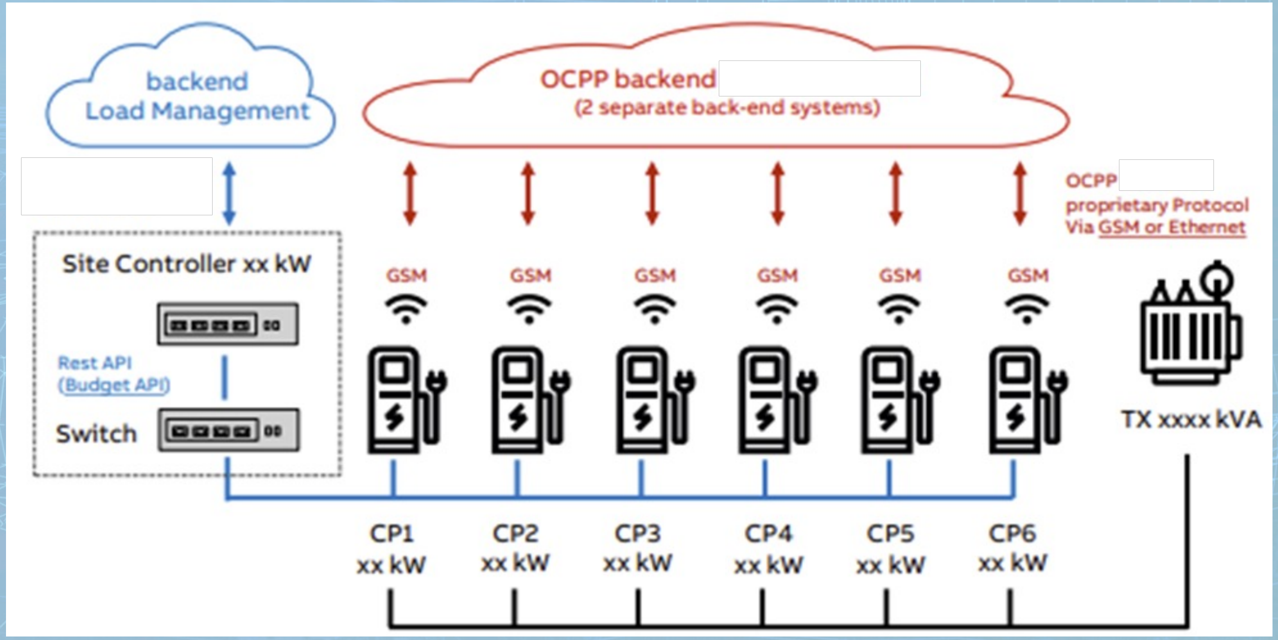
Demonstrating SCM Under Different Strategies



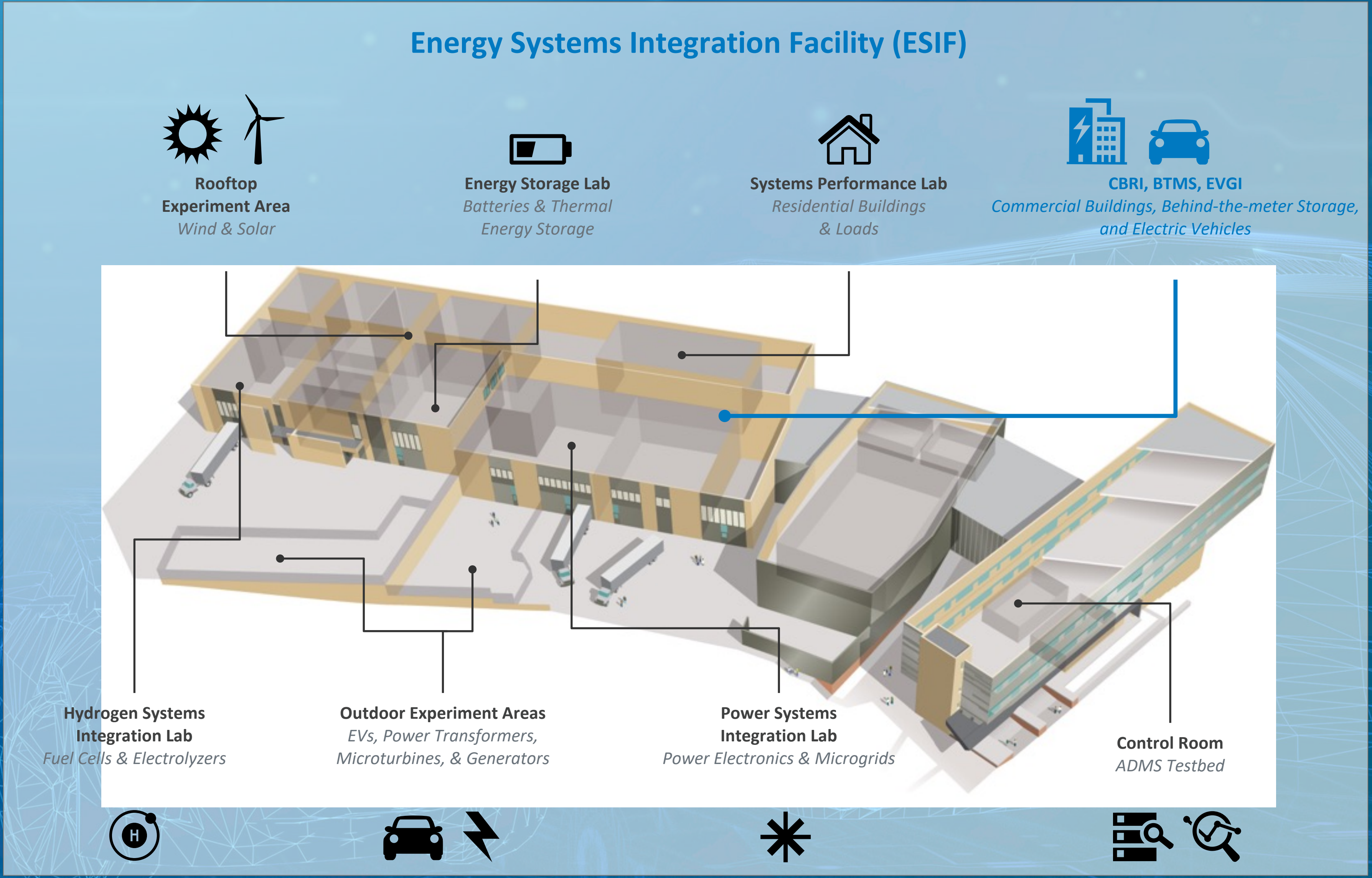
Market Research

- **SCM Availability:**
  - EVSE Vendors
    - ABB, Schneider, Siemens, Eaton, Wallbox, Enel X, ChargePoint, etc.
    - Traditional EVSE vendor has the advantage of combining hardware and software to deliver a full range of smart charging control solutions
  - Third-party Charging Management Company:
  - ChargeLab, Ampcontrol, Driivz, VIRTA, MOEV, PowerFlex, WeaveGrid, AMPLY, etc.
  - With the Open Charge Point Protocol (OCPP), a number of third-party startups offer cloud-based EV smart charging platforms as software as a service (SaaS)
- **SCM Gaps:**
  - Existing SCMs focus on site or household level, such as avoiding demand charges and coordinating with renewables.
  - There is a lack of interoperability between existing SCM platforms and the power system. Smart charging control is not available on a large scale with advanced functions like price-responsive smart charging, volt-var control, or V2G functionality.
  - EVs' flexibility and controllability are rarely exploited to mitigate their impacts on the power system, which is critical for EV@Scale

- **EVSE's in the market that support SCM:**
  - EVSE management with proprietary ways
  - EVSE's compatible with OCPP
    - Mostly 1.6j compatible. 2.01 is being on a way to the market
    - Flexibility of OCPP server connection varies
  - Proprietary communication interface between a site controller and load management backend or OCPP cloud backend (REST API, etc.)



Resources at NREL



EVRI Capabilities

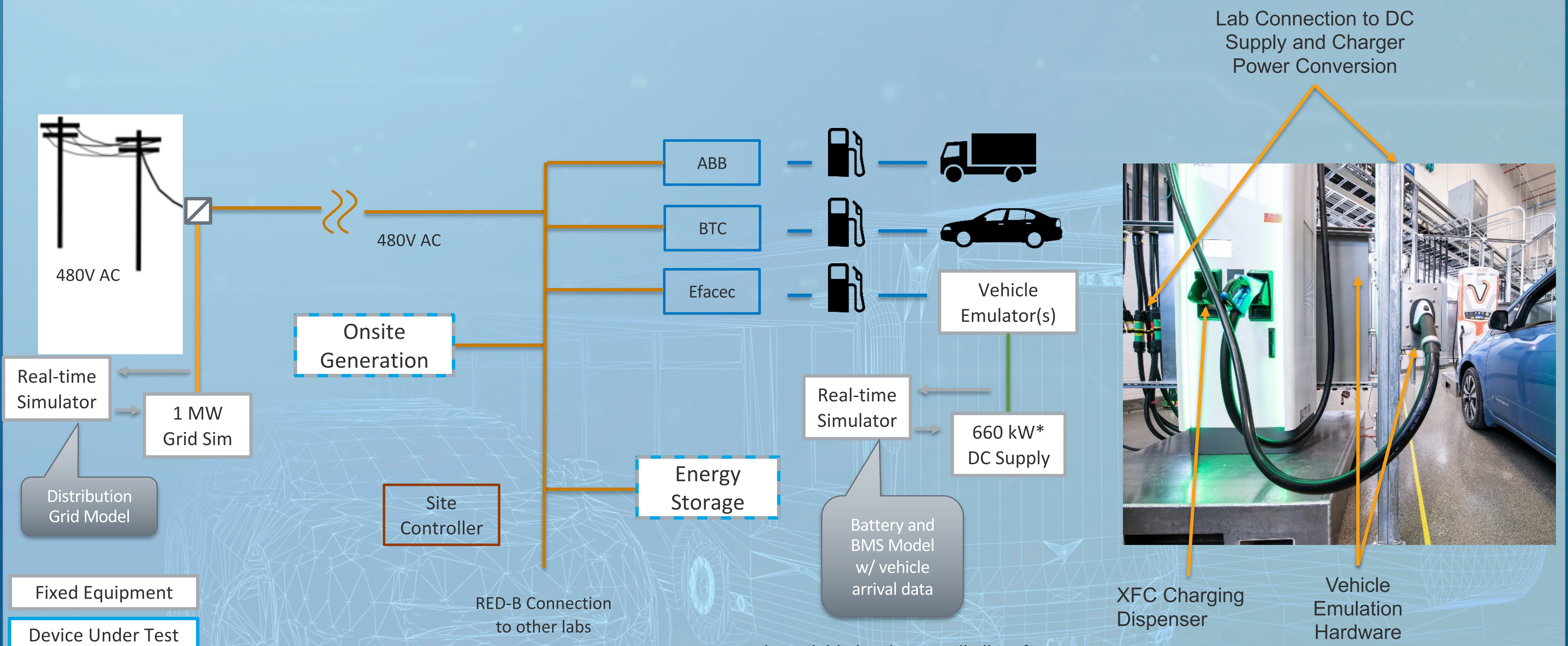
Electrical infrastructure includes two 480 V sites with 208/120 V or 240/120 V transformer and panels

Charging Equipment supports connections for 100 kW and 30 kW DC charging as well as AC level 2 and 1 at four stalls

Distributed Energy Resources with directly integrated 30 kW/kWh stationary storage and 30 kW PV

HIL network includes AC-side grid emulation capability through ESIF RED-B 1 MW or 200 kW systems and DC-side vehicle emulation capability through 500 kW or 250 kW systems

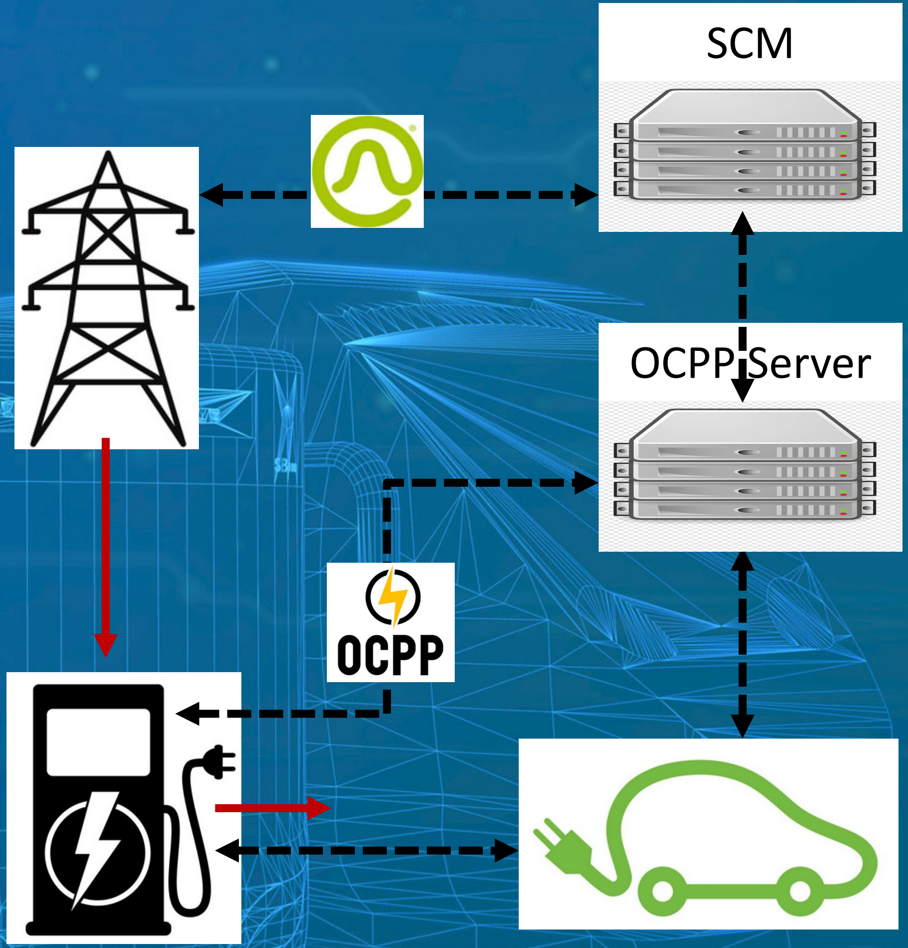
EVRI Capabilities



* Available hardware will allow for two DC supplies to provide up to 500A

Testing/Verification and Demonstration of SCM

- **Goals:**
  - Identify limitations and future requirements of EVSE's in the market for SCM
- **Plans**
  - Integrated SCM with a commercial EVSE
    - Set up an OCPP server
    - Determine a communication protocol between the OCPP server and SCM
    - Set up OpenADR VTN/VEN for DR signals from the utility
  - Collect data (power quality, power factor, etc.) with different SCM strategies
  - Identify the things that should be addressed when SCM is deployed



Thank You

Jason D. Harper
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Myungsoo Jun
myungsoo.jun@nrel.gov

Stakeholder Feedback
(10 minutes)

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U.S. Department of Energy

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.

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U.S. Department of Energy

Standards Discussion on HPC Vehicle Grid Interaction and Smart Charging Management

Theodore Bohn
Argonne National Laboratory

FUSE Deep Dive, September 29, 2022

Outline

- EVS at Scale Standards Pillar Overview, Prioritization Criteria
- EVSP Standards Roadmap Catalog of Standards/Gaps
- Vehicle Grid Integration Codes and Standards; ISO 15118, Open ADR, Open FMB, OCPP
- Measurement System Standards for Commercial EV Charging Transactions for VGI
- VGI/SCM as part of SAE J3271 MCS Charging System Functions
- Energy Services Interface (ESI) Implementation Pilot Demonstration of IEEE P2030.13
- 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 O'Neil
- Richard Pratt

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)

ANSI EVSP EV Charging Roadmap Process/Overview

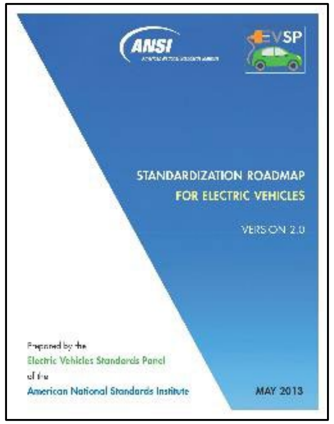
Roadmap Overview

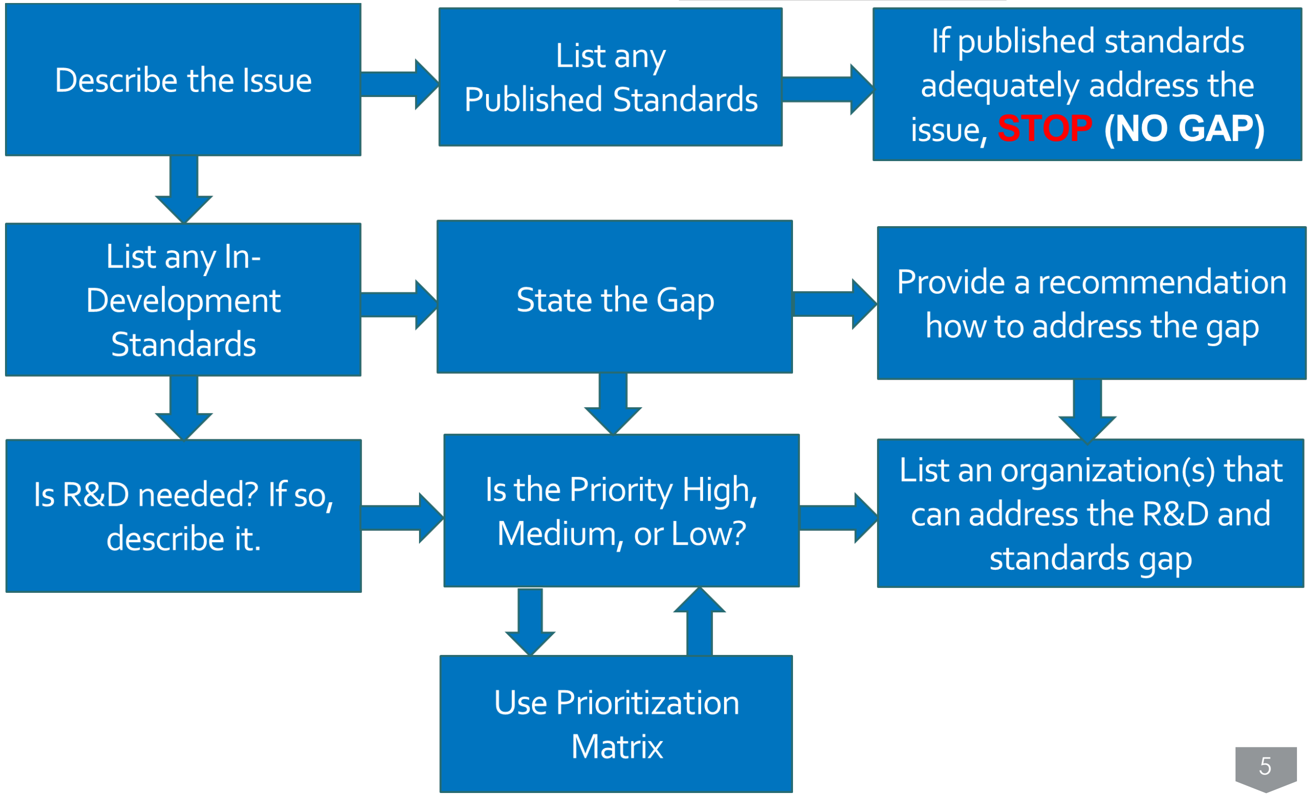
- Identifies issues as well as standards, codes, and regulations that exist or are in development to address those issues

- 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





Alphabet Soup-TLA Overload; SAE Battery Standards List/Diagram (50+)

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Thermal Management & Adhesives: J3073, J3178

Battery Labeling: J2936

Battery Testing Methodologies: J2758, J2380

Battery Materials Testing: J2983, J3021, J3042, J3159

Battery Secondary Use: J2997

Battery Vibration: J2380, J3060

Battery Transport: J2950

Battery Recycling: J3071, J2974, J2984

Starter & Storage Batteries: J1495, J2185, J240, J2801, J2981, J3060,J537, J930

Battery Life Assessment Testing: J240, J2185, J2288, J2801

Electric Drive Battery Systems Functional Guidelines: J2289

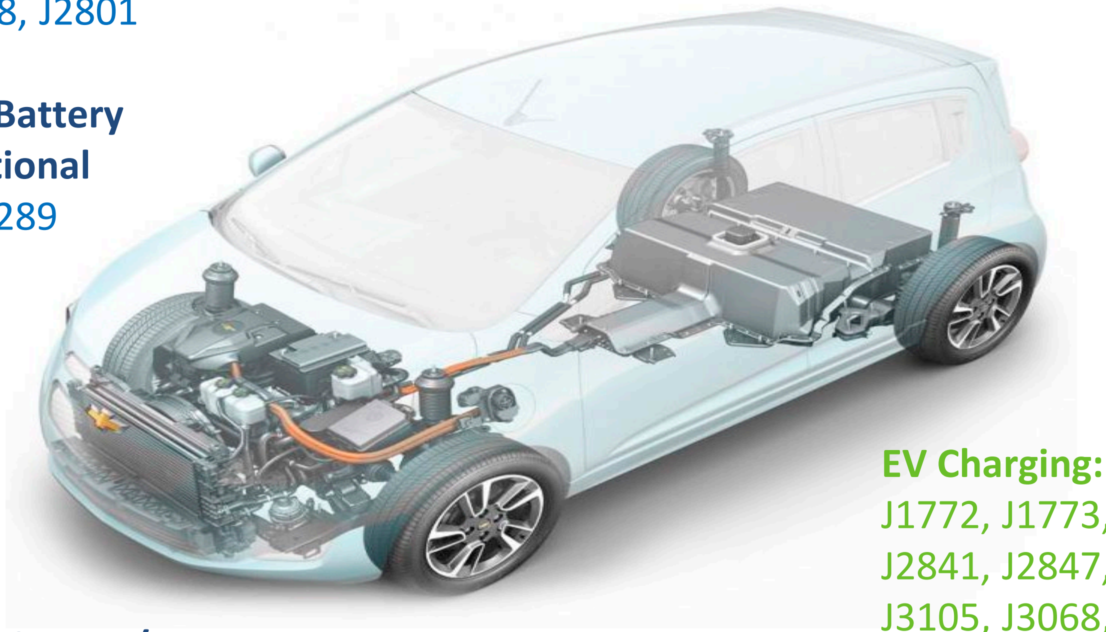
Capacitive Energy & Start/Stop: J3012, J3051

Battery Terminology: J1715/2

Truck & Bus Batteries: J3004, J3125,

Battery Safety: J2929, J2464, J3009

Battery Size, Identification & Packaging: J1797, J3124, J2981, J3004



EV / Battery Fuel Economy & Range: J1634, J1711, J2711

EV Charging: J1772, J1773, J2293, J2836, J2841, J2847, J2894, J2931, J3105, J3068, J3271, AIR7357

EV Battery Safety: J1766, J2344, J2910, J2990

Battery Performance & Power Rating: J1798, J2758

EV Charging Safety: J1718, J2953/1, J2953/2, J2953/3, J2953/4, J2953/5 (CSRP)

Battery Electronic Fuel Gauging & Range: J2946, J2991

ANSI C12.32 DC Meter Standard; VGI relies on AC metering; Telematics?

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EV charging requires meters w/ 1% net accuracy (w/cable errors), 16-80A AC, 350A-3000A DC

DC distribution/utility regulated markets require certified DC meters, C12.32 now published
https://webstore.ansi.org/Standards/NEMA/ANSIC12322021 ($147) {no known ANSI C12.32 certified meters available today}

ANL Benchmark DC meter examples

	Manufacturer	Model
1	AccuEnergy	AcuDC 243
2	EVoke	EUMD6m
3	Isabellenhuette	IEM-DCC
4	LEM	DCMB
5	Lumel	PH30
6	MeasurLogic	DTS DC
7	Porsche Engineering Services	DCEM 100
8	Rish	Alpha EM DC
9	Satec	PM130-PLUS-DC
10	Tritium	integrated DC

NIST Handbook 44-3.40 Commercial Transaction Code (National/State level)

High accuracy sensor and meters for AC/DC charging 30A-3000A Testing Solutions

- HB44 for commercial DC EV charging will be adopted as permanent code nationwide January 2023
- Simple, affordable accurate test solutions developed under EV@S, based on 6ppm sensors 20ppm meters
- Pass through measurement cable (CCS now, MCS soon), have been field test w/ Labview GUI

500A, 1000A, 3000A Sensors

Tesco T4000 w/7kW load

Vehicle Grid Integration Codes and Standards- Overview

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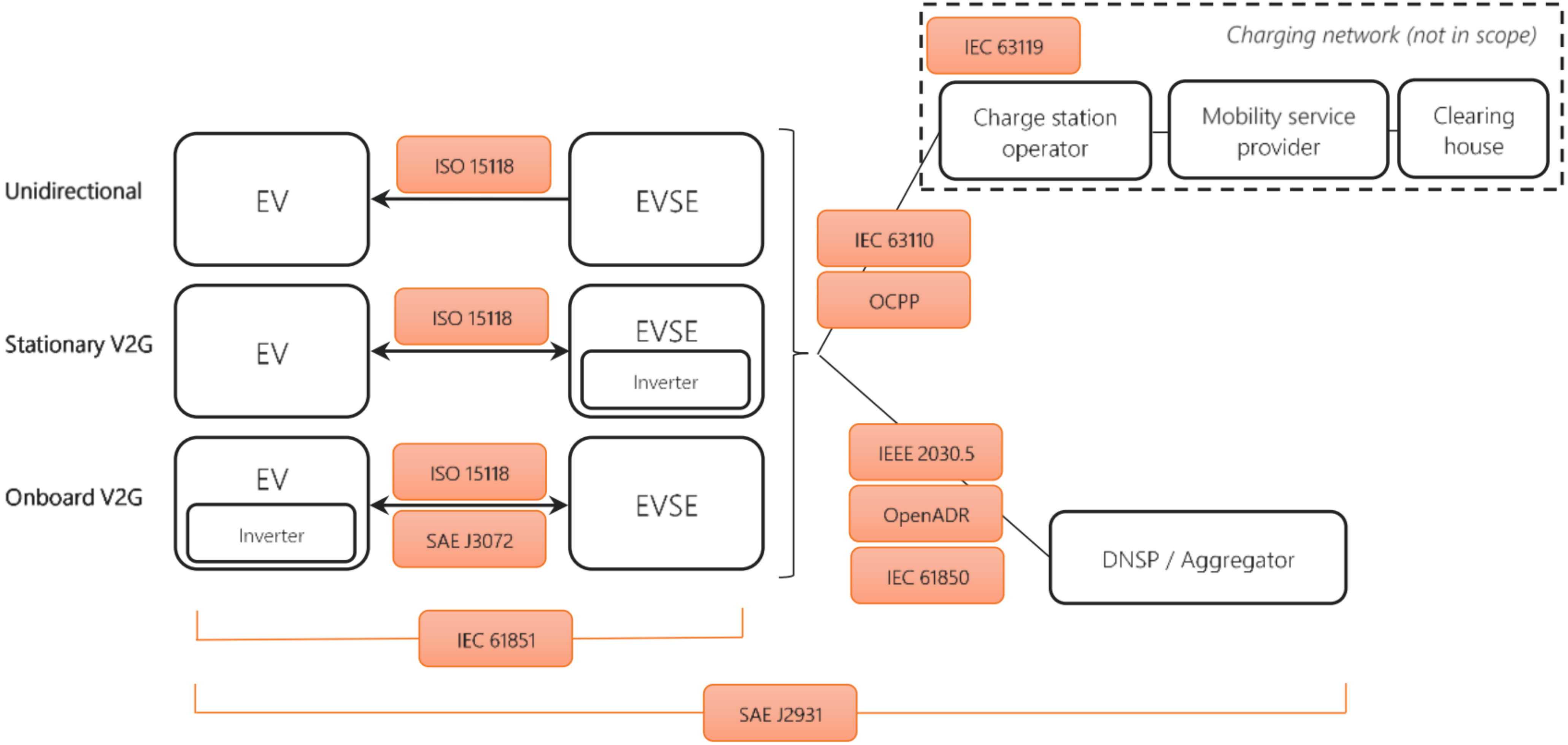
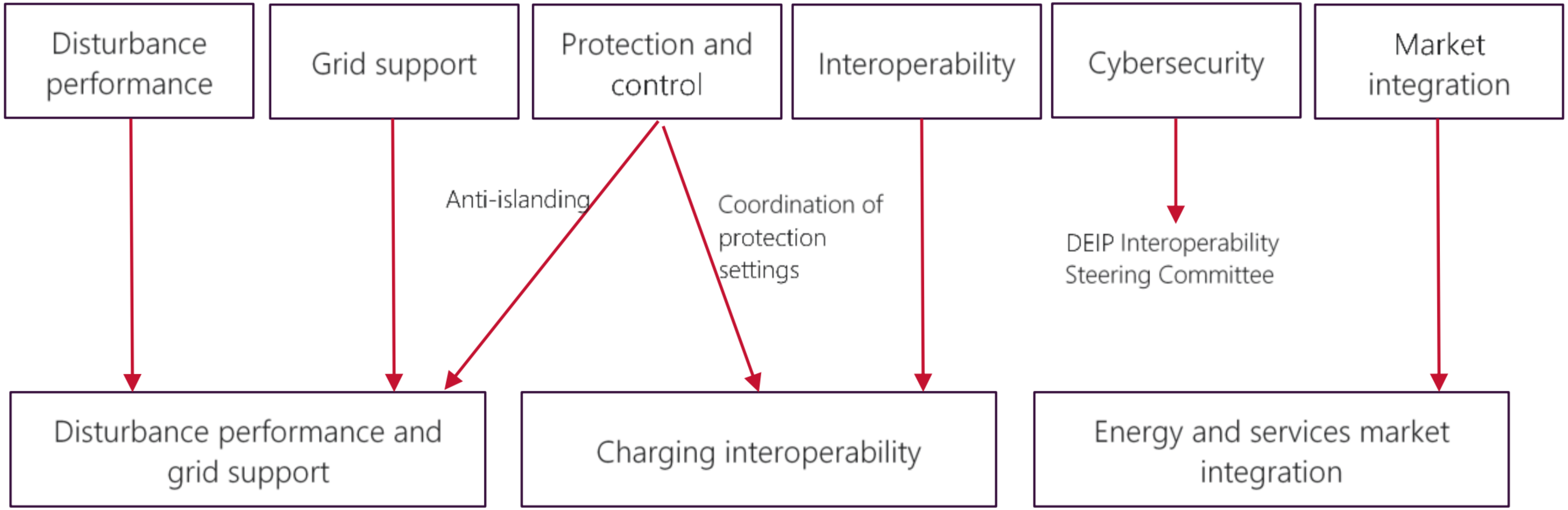
SAE J1772/IEC61851-23 uses digital communication (PLC) with ISO15118-2, or more commonly DIN 70121; ISO15118-20 going forward (SAE J2847/2 equivalent); Other VGI related standards



https://aemo.com.au/-/media/files/stakeholder_consultation/working_groups/der-program/deip-ev/2021/deip-vgi-standards-report.pdf?la=en

VGI Standards Focus Areas:

- Charging Interoperability
- Energy Services Market Integration
- Disturbance Performance and Grid Support



Vehicle Grid Integration Codes and Standards; Testing Events/Validation

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Testing Events Validate Standards Specifications/Implementation and Support Iteration

- CharIN, CEC and other organizations host 'Testing Symposium' events (or Testival, PlugFest)
- Latest event will be at Electric Island, Portland OR Oct 4-7th, focused on CCS vehicles, subsystems for MCS, along with evaluating EVCC/SECC control modules and test tools.
- SAE J2953 (EV-EVSE Interoperability) is being restarted and expanded for 2022 level functions, including VGI functions (called Tier 3/optional features in 2012 version of J2953)
- Testing tool scripts (Scienlab/Keysight, Comemso, Vector, Iotecha, etc) drive testing/results, insights. OCPP testing events also use OCA test tool; https://www.openchargealliance.org/protocols/test-tool/

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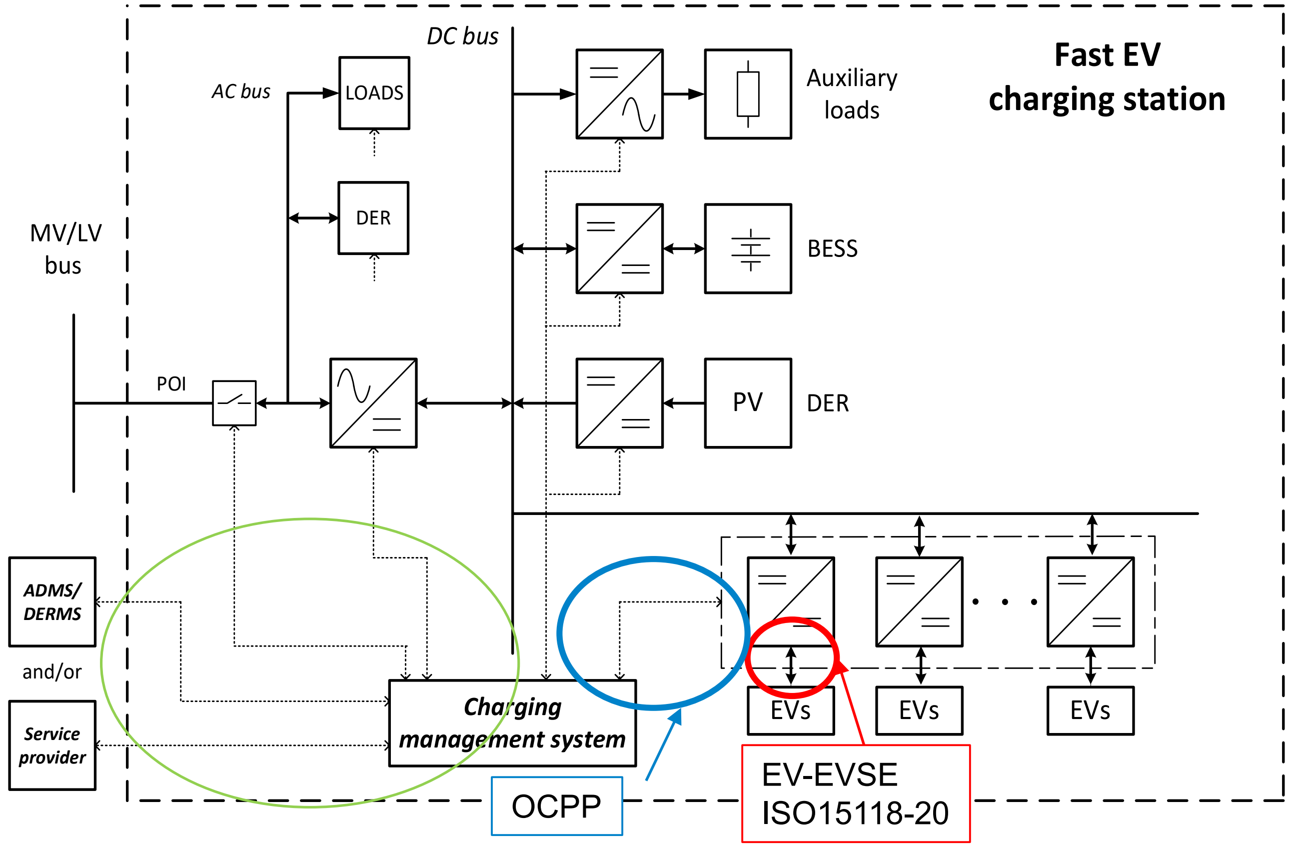
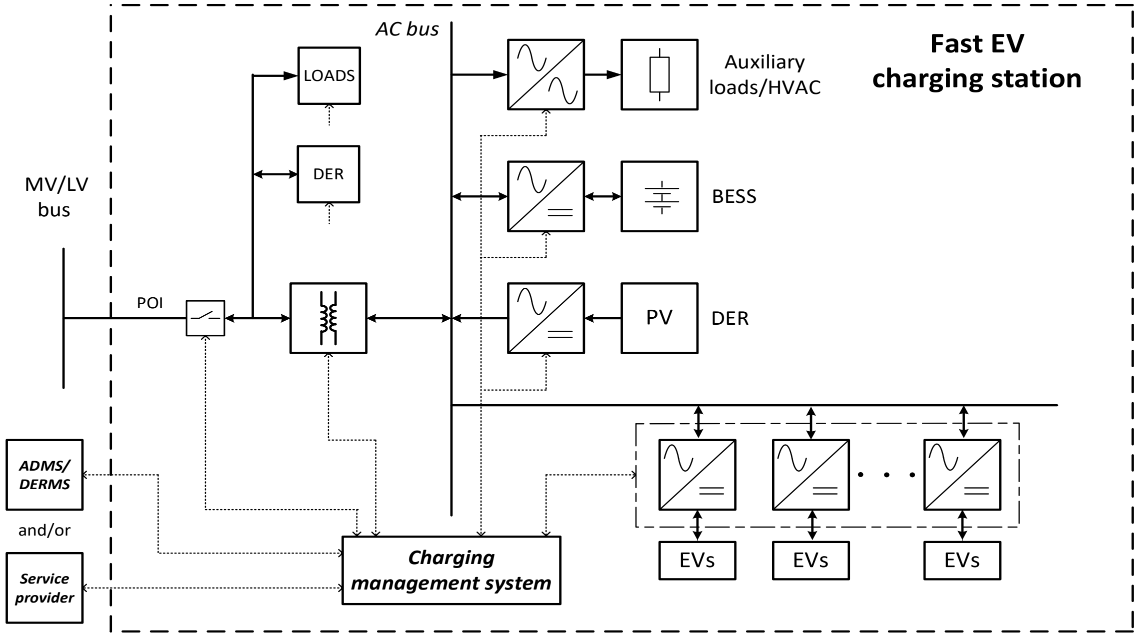
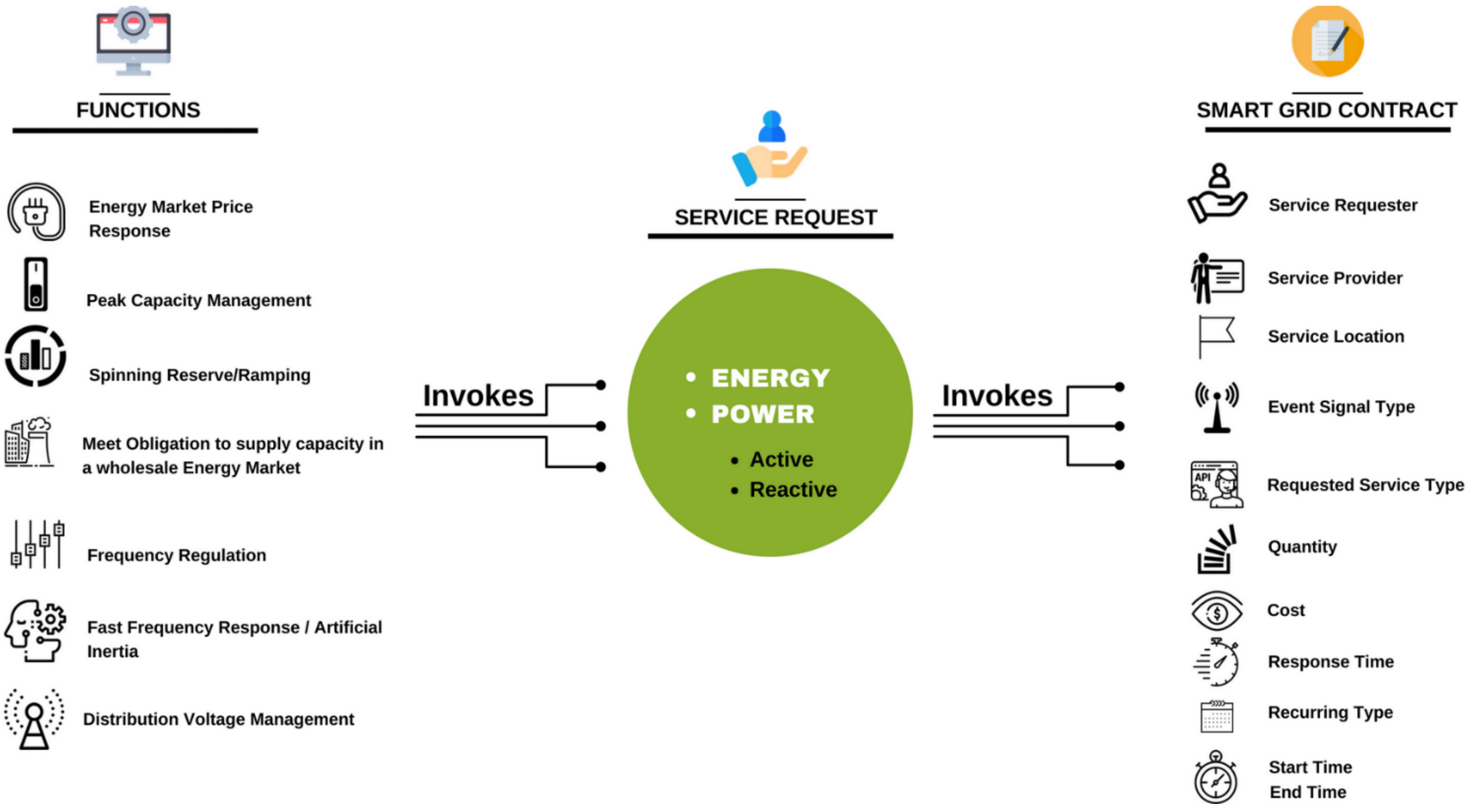
- ***"Guide for Electric Transportation Fast Charging Station Management System Functional Specification"***
- DC and AC bus system diagrams in P2030.13, Dotted lines represent protocols between components/subsystems and for the most part, the charging management system 'block'.





Ability to Communicate with all the ‘pieces’ of an HPC installation, sell Energy Services, Implementation with industry/utility partners



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) meeting to TIR goal in October 2022
- Continued monthly standards work group participation; drafting standards, etc
- Progress to milestones are studies support WPT and P2030.13 standards
- Engagement in tentative Interoperability (Testival) events in 2022

Cross-cutting wrap-up discussion and feedback gathering

EVs@Scale
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1:15 p.m. – 1:25 p.m. ET	**Wrap-up**
	Jesse Bennett
1:25 p.m. – 1:35 p.m. ET	**Addressing Biannual Meeting feedback**
	FUSE Team
1:35 p.m. – 2:00 p.m. ET	**Open-mic feedback**
	Attendees

Addressing Bi-Annual Meeting Feedback

- **Explore more VGI options, in addition to SCM**
  - Sandia has shared some of their progress and plans for a concentrated charging VGI approach
- **Broaden the scope of what will be managed**
  - Concentrated charging VGI analysis will shift charging spatially, as opposed to the temporal shifting from SCM controls
  - Energy analysis in FY23 will include M/HDV charging needs
- **Review current industry offerings and expand SCM analysis to include new capabilities**
  - SCM market review was conducted to determine demonstration options for measurement and verification
  - Expanded SCM SCM controls will be pursued to accommodate LDV and M/HDV needs for EVs@Scale

Open-mic Feedback

- **Open discussion for all attendees to share feedback with the FUSE Team on progress and next steps**

EVs @ Scale

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Thank you!