INCUBATENERGY LABS

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2022 DEMO DAY

October 26
Minneapolis
Minnesota

EPRI

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Central Hudson
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PowerNode / Electric Era Technologies

Supported/Hosted by:
Central Hudson Fortis, Fortis BC, Xcel Energy

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Over the course of 16 weeks, Electric Era, EPRI, Fortis Inc., and Xcel Energy engaged in a demo project to demonstrate the PowerNode™ battery energy storage system (BESS) and PowerNode Command Console (PNCC). This demo project vetted the PowerNode's capabilities as a non-wires solution to minimize costs and grid impacts to accelerate EV fast charging.

Project Mission

Electric Era is on a mission to make DC fast charging ubiquitous and affordable, and has partnered with EPRI to demonstrate the potential of doing so by operating a charging site in Knoxville, TN.

This charging site closely represented a basic station following the specification set out per National EV Infrastructure (NEVI) program guidelines.

Demonstration Overview

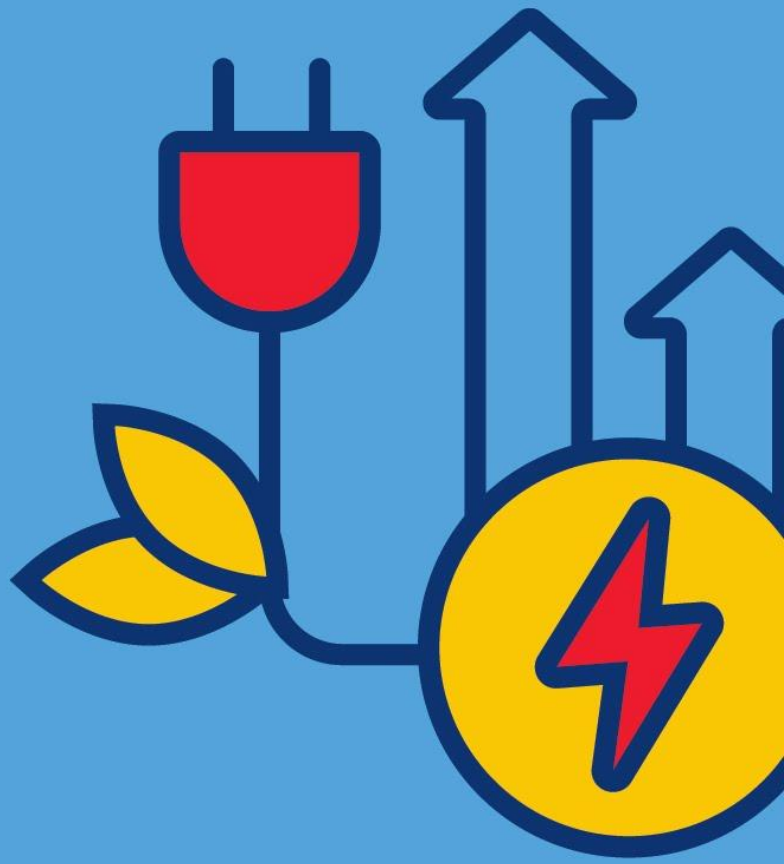
This slide deck will cover:

- Demonstration Site Information
- Test Results

We will cover results from operating the PowerNode system at EPRI in Knoxville:

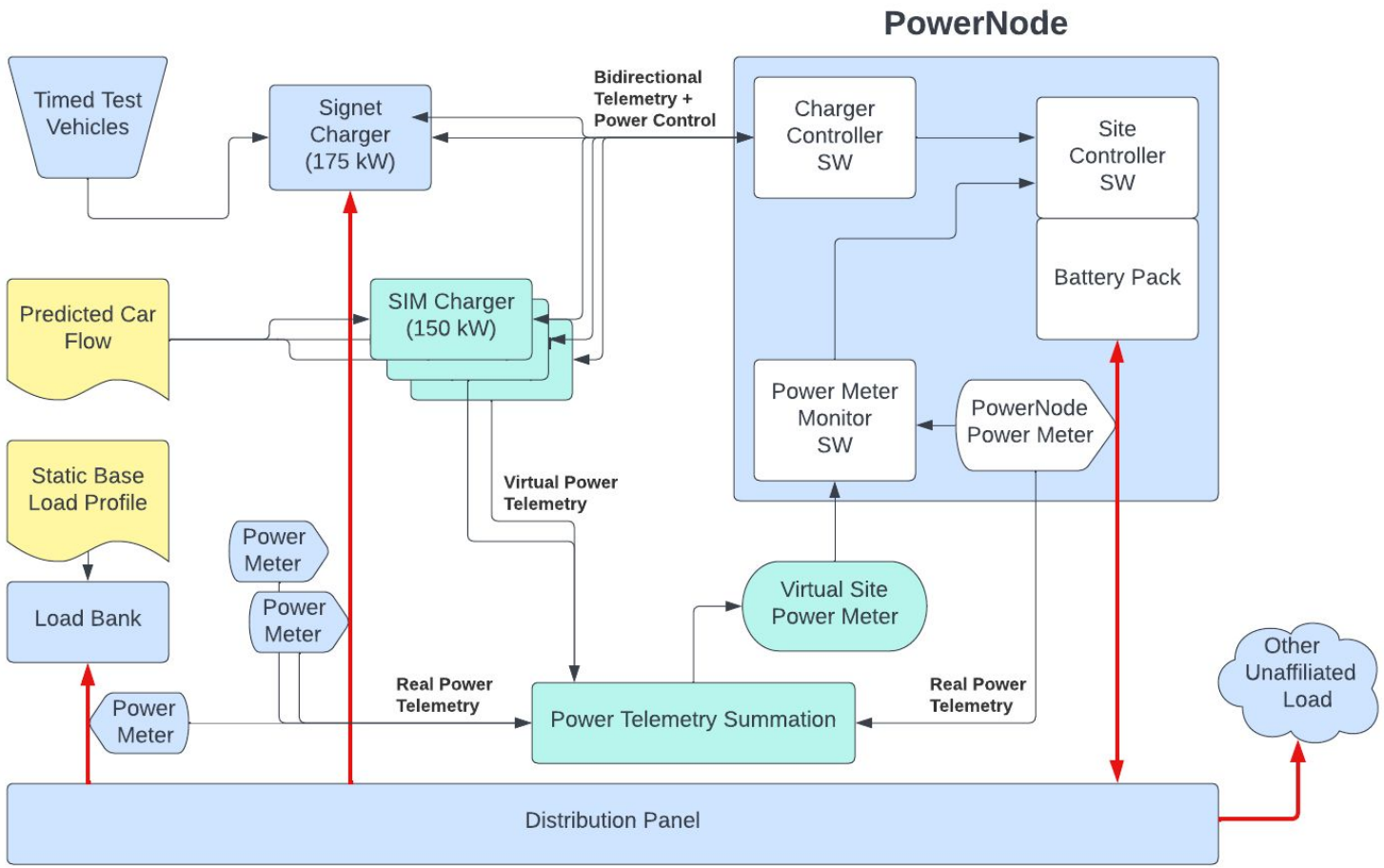
- Ribbon Cutting Live Demo Day
- Low Utilization Site Operation
- High Utilization Site Operation
- ESIC Testing
  - Full Cycle Testing and System Performance
  - Low Energy Testing
  - Connect/Disconnect Function

Demonstration Site Information



Demonstration Site Components

- PowerNode BESS and site controller
- 3x simulated 175 kW chargers
- 1x 175 kW Signet charger installed on site (limited to 150 kW)
- 125 kW distribution panel
- Load bank for demonstration testing



Demonstration Site Simulations

- Simulated chargers allow us to quickly and efficiently impart realistic, high-utilization charging load on PowerNode, which responds in real time using real power/energy
  - Many different types of vehicles charging with configurable durations and states-of-charge are possible
- All simulated components are highly representative
  - Simulated power meters communicate via Modbus-TCP
  - Simulated chargers communicate over OCPP 1.6

Demo (Ribbon Cutting) Day

Background

Electric Era launched a functioning PowerNode-backed station for demonstration: Link

Numerous vehicles were charged:

- Mustang Mach-E
- Tesla Model S
- Rivian R1T
- Kia EV6
- Polestar 2

Results

Criteria for Success:

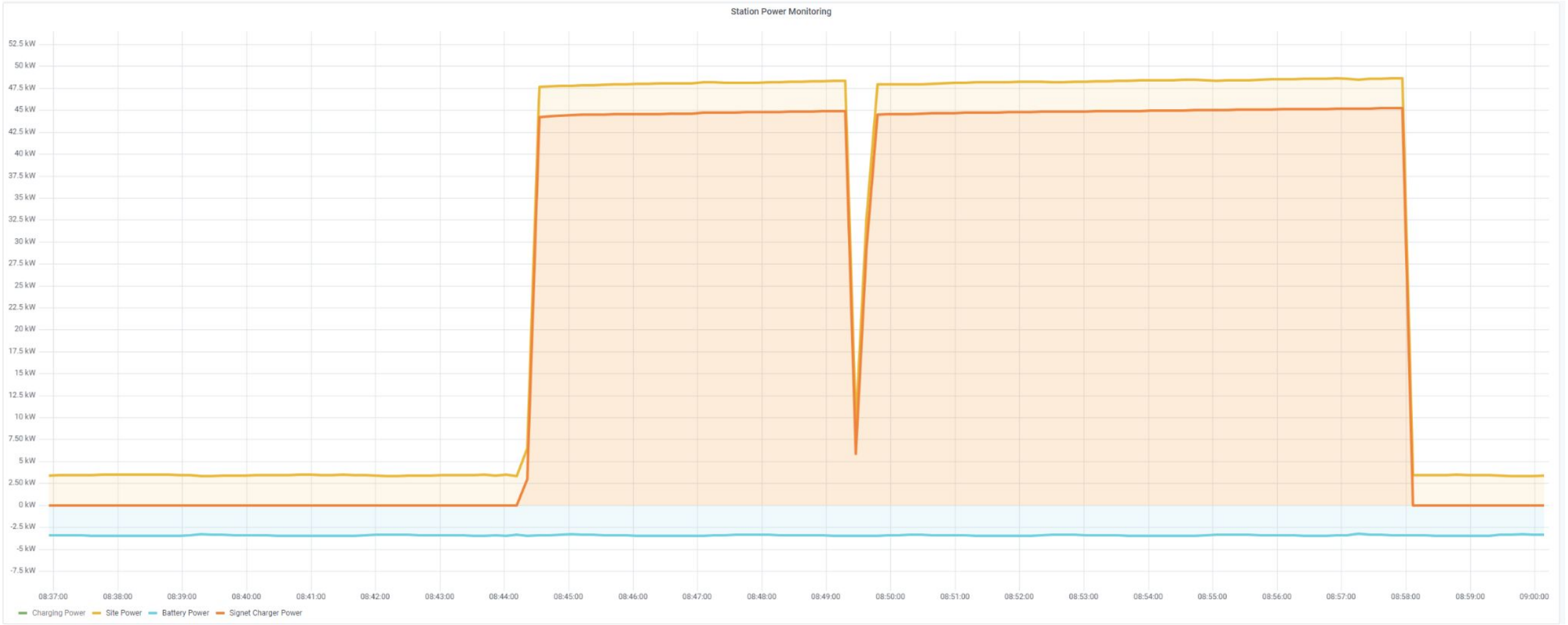
- Allow vehicles to charge at will at the Signet charger at up to 150 kW
- Do not materially exceed the 90 kW strict grid limit throughout demo day

Results:

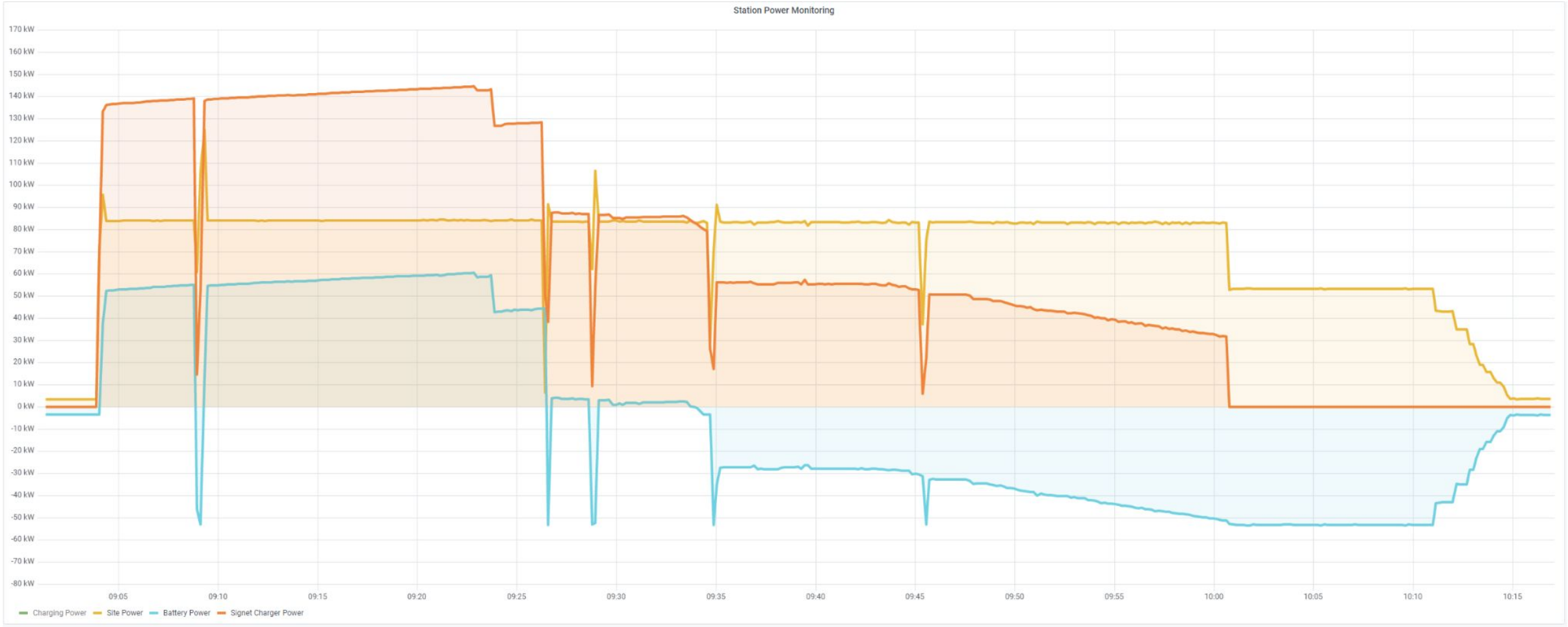
- All vehicles charged with a maintained 90 kW grid limit
- No throttling of vehicles under the 150 kW offered by the charger - PowerNode handled all site electrical request > 90 kW!
- Minimum of 37% battery SoC observed during back-to-back charging

Results: Mustang Mach-E Charging Session

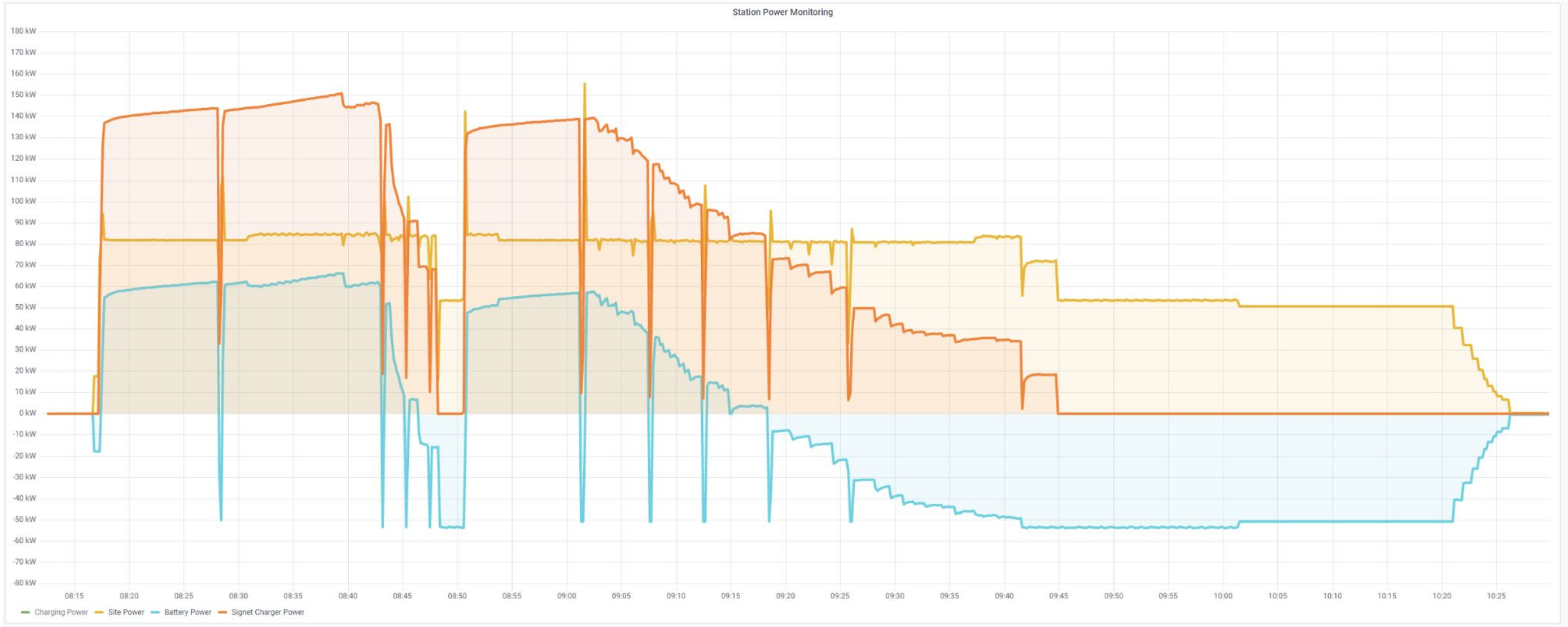
Results: Tesla Model S Charging Session



Results: Rivian R1T Charging Session



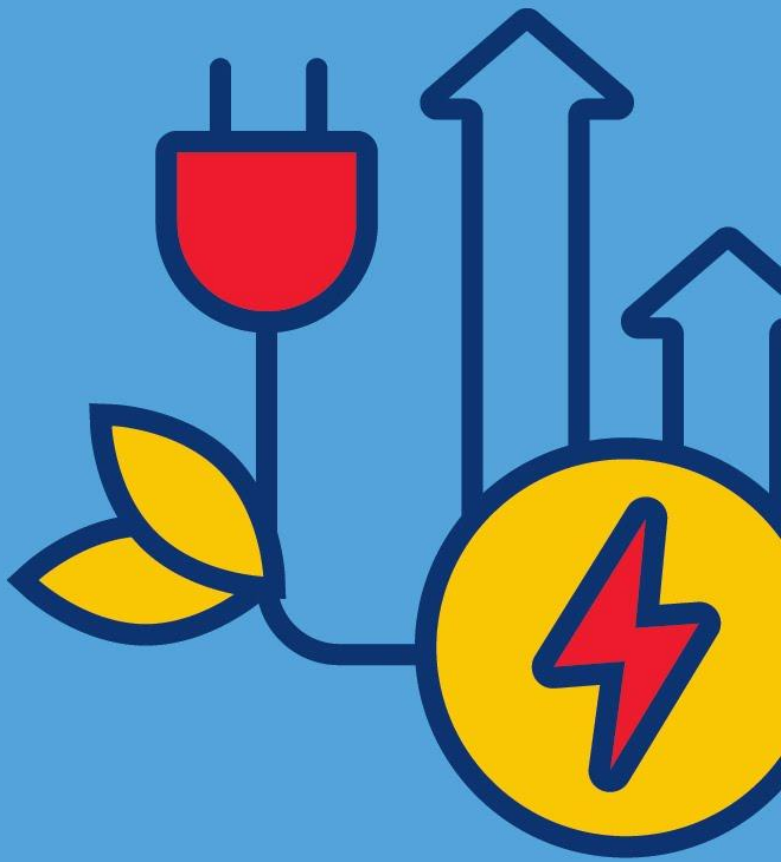
Results: Kia EV6 & Polestar 2 Charging Session



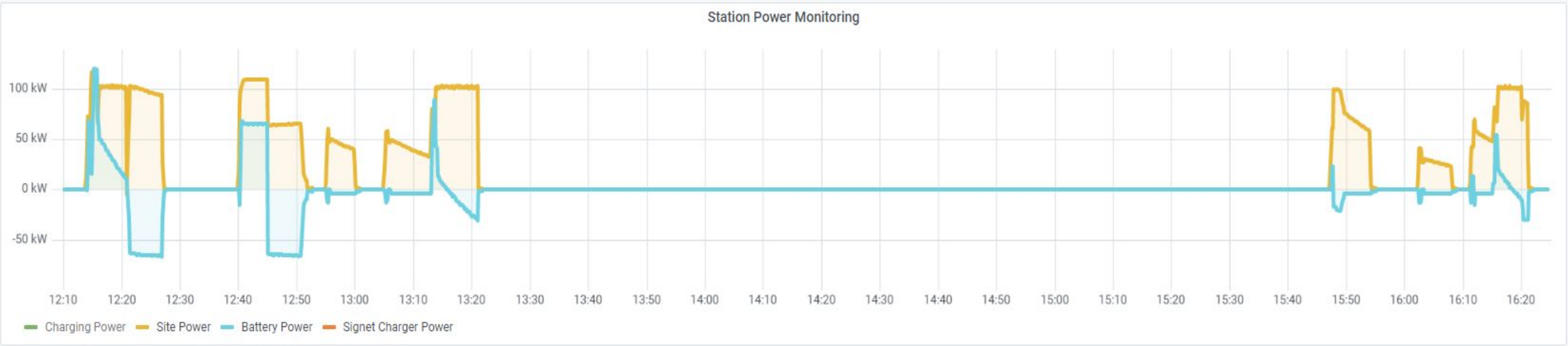
Conclusion

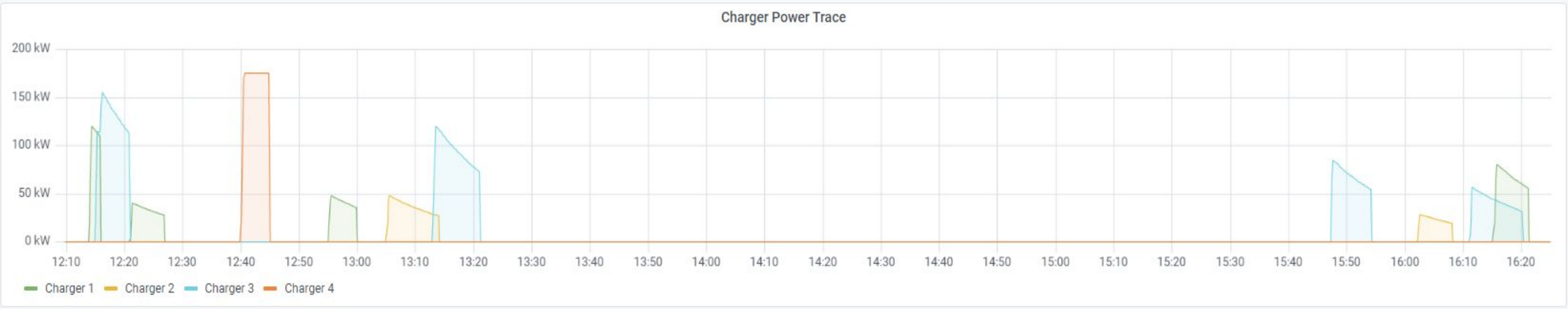
- PowerNode operated a site successfully, allowing public fast charging above the grid limit
- Charging experience to the EV driver in ALL circumstances was indistinguishable from that of a non-grid-constrained site

Low Utilization Demonstration



Low Utilization Testing Data





Low Utilization Testing Parameters

- Test Parameters
  - 20 sessions per day
  - 4 simulated 175 kW chargers with 1 port each
  - Run from 12 noon to 5 pm ET on the test day
  - Simulating a C-store / gas station driver behavior, with short sessions
- EPRI personnel observed the first hour of testing live

Low Utilization Testing Conclusions

- 11 sessions occurred during the test window
  - Remaining 9 sessions were not simulated because they occur outside the test window.
  - All sessions hit within acceptable parameters of desired maximum power
- Conclusions
  - No throttling of vehicle sessions
  - Light battery usage by system
  - Overall highly operable low-utilization site

Low Utilization Testing Session Data

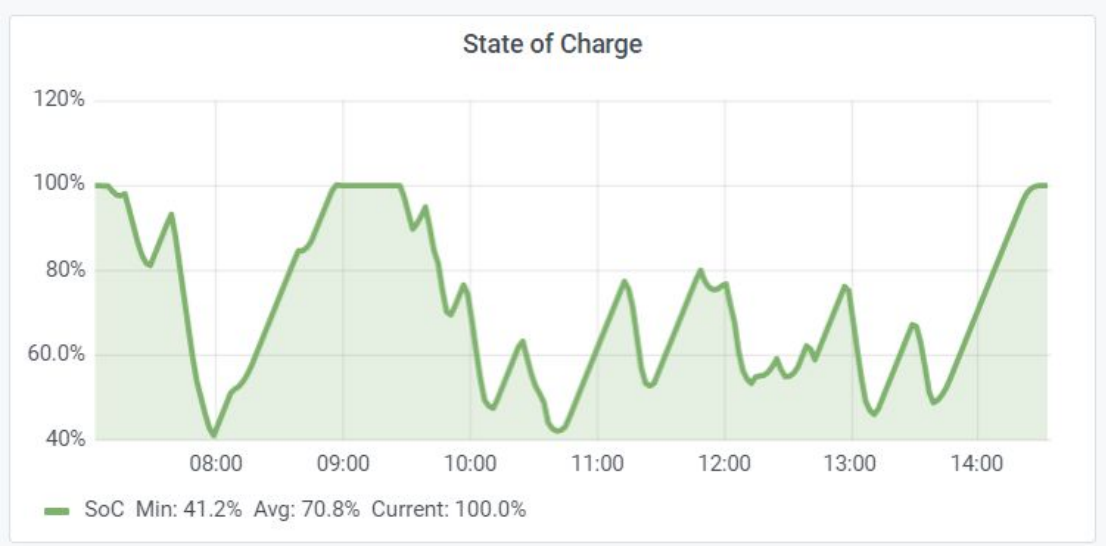
Session ID	Vehicle	Starting Vehicle SoC	Charging Time	Charger ID	Desired Power	Received Power	% Peak Power
		Percent	Minutes		kW	kW	Percent
0	model3	60.70%	2	0	122.5	120	97.96%
1	model3	47.70%	6	2	163.3	156	95.53%
2	model3	86.90%	6	0	40.8	39.7	97.30%
3	model3	15.00%	5	3	175	175	100.00%
4	model3	84.30%	5	0	49	48.2	98.37%
5	model3	84.30%	9	1	49	47.6	97.14%
6	model3	60.80%	8	2	122.5	120	97.96%
7	model3	72.50%	7	2	85.7	84.8	98.95%
8	model3	90.80%	6	1	28.6	28.2	98.60%
9	model3	81.60%	9	2	57.1	56.8	99.47%
10	model3	71.30%	6	1	81.7	80.3	98.29%

High Utilization Demonstration

High Utilization Testing Data

High Utilization Testing Conclusions

- 30 sessions were performed successfully in the testing window
  - 28 sessions hit within acceptable parameters of desired maximum power
  - 2 sessions hit above 60% desired maximum power, 93% SLA achieved
- Observations
  - Battery SoC was NOT the limiting factor (we were dropping at most to ~40%)
  - Impacted sessions were largely due to instantaneous power limits
- This level of operation/utilization represents the beginning of when the site is ready to “scale up”



High Utilization Testing Session Data (Pg. 1)

Session ID	Vehicle	Starting Vehicle SoC	Charging Time	Charger ID	Desired Power	Received Power	% Peak Power
		Percent	Minutes		kW	kW	Percent
0	model3	68.4	8	1	129	124	96.12%
1	ioniq5	50	14	2	175	175	100.00%
2	model3	54.4	9	3	164	162	98.78%
3	model3	55	9	1	160	110	68.75%
4	model3	52.4	7	2	169	165	97.63%
5	r1t	50	10	3	175	175	100.00%
6	model3	82.4	9	1	94	90	95.74%
7	model3	80.8	7	2	98	97	98.98%
8	ioniq5	46.4	5	3	175	175	100.00%
9	model3	87.6	9	1	81	80	98.77%
10	r1t	50.2	8	2	175	175	100.00%
11	model3	76.8	6	3	108	104	96.30%
12	model3	26.8	15	1	175	175	100.00%

High Utilization Testing Session Data (Pg. 2)

Session ID	Vehicle	Starting Vehicle SoC	Charging Time	Charger ID	Desired Power	Received Power	% Peak Power
		Percent	Minutes		kW	kW	Percent
13	model3	65.4	8	2	142	86	60.56%
14	bolt	34	4	3	55	51	92.73%
15	model3	35.8	12	1	175	175	100.00%
16	model3	67.2	12	2	132	132	100.00%
17	r1t	54	9	3	175	175	100.00%
18	model3	71.2	10	1	122	120	98.36%
19	bolt	30.2	5	2	55	52	94.55%
20	model3	59.2	13	3	152	149	98.03%
21	model3	43	13	1	175	175	100.00%
22	model3	87.2	4	2	82	82	100.00%
23	model3	76.8	11	3	108	108	100.00%
24	model3	72.8	9	1	118	118	100.00%
25	ioniq5	29	3	2	175	175	100.00%
26	ioniq5	36.4	14	3	175	175	100.00%

High Utilization Testing Session Data (Pg. 3)

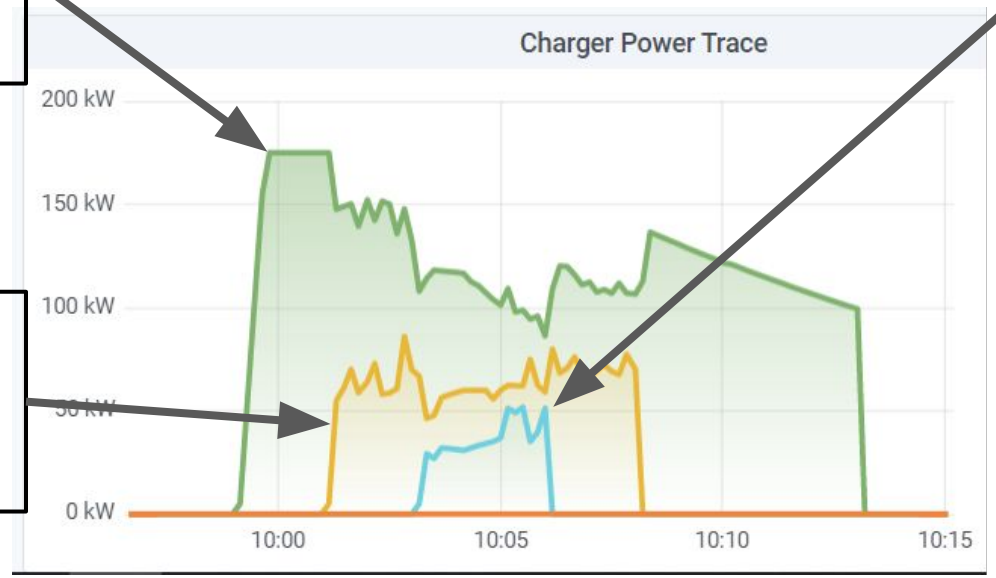
Session ID	Vehicle	Starting Vehicle SoC	Charging Time	Charger ID	Desired Power	Received Power	% Peak Power
		Percent	Minutes		kW	kW	Percent
27	model3	79.6	9	1	101	100	99.01%
28	model3	31.2	8	2	175	175	100.00%
29	model3	75.2	12	3	112	109	97.32%

High Utilization Coincident Charging Analysis

First vehicle received rated power and throttled back as station filled up to avoid exceeding grid limit.

Second vehicle was at reasonably high SoC and didn't need to charge at >100 kW, so received less power.

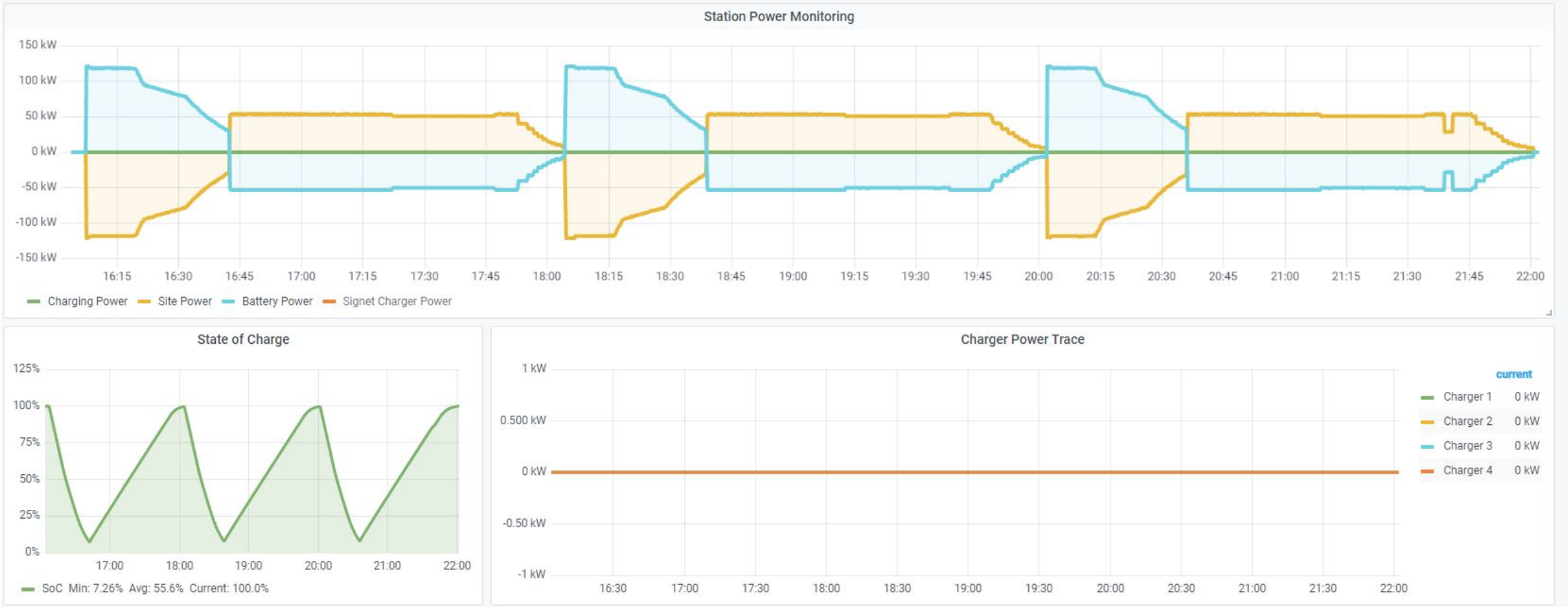
Third vehicle was a Bolt and didn't need more than 50 kW.



ESIC Testing

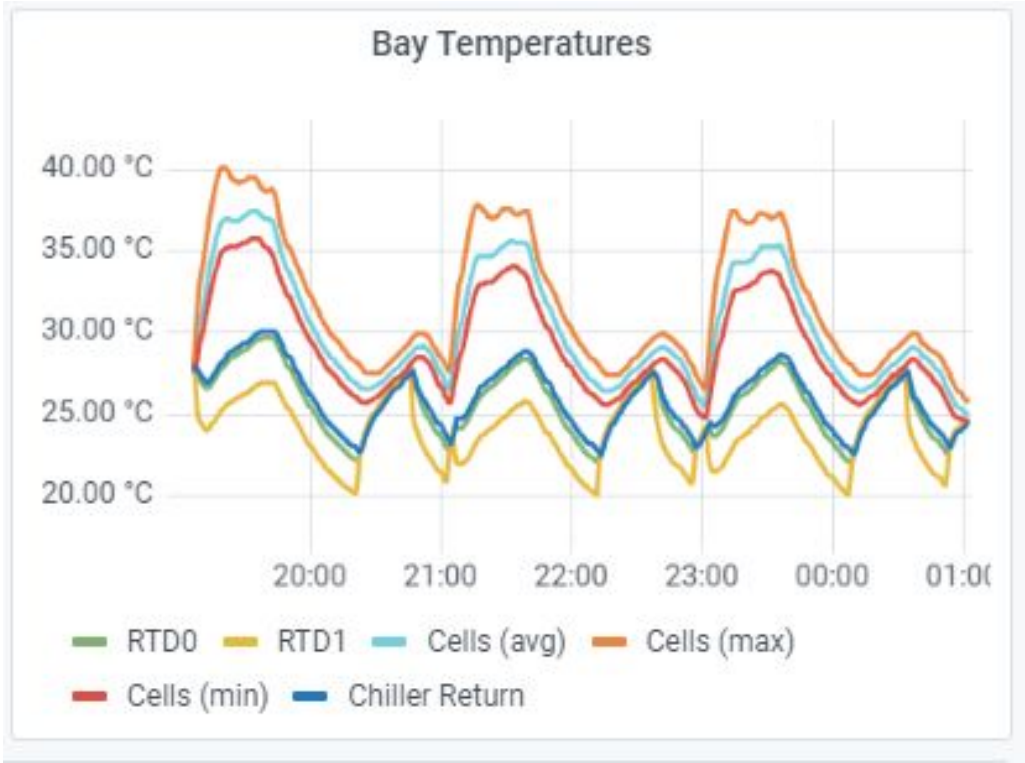
Charge/Discharge Cycle Testing

- A full system cycling (x3) was performed in accordance with ESIC Testing guidelines
- For these tests, 2 of the 16 battery modules within PowerNode were disconnected



Charge/Discharge Cycle Testing

- Power Over Time
  - 40% energy capacity delivered at 120 kW
  - Next 10% delivered at >100 kW
  - Next 25% delivered at >75 kW
  - Last 25% delivered at ~linear derate from 75 kW to 30 kW
- Max temperature hit 40 degC, well within bounds of operational temperature
  - Ambient during the day was about 81 degF
  - Ambient is not overly important due to high thermal resistance of the enclosure
  - Heat rejection derate would only begin at >105 degF to about 80% of rated max power at 122 degF



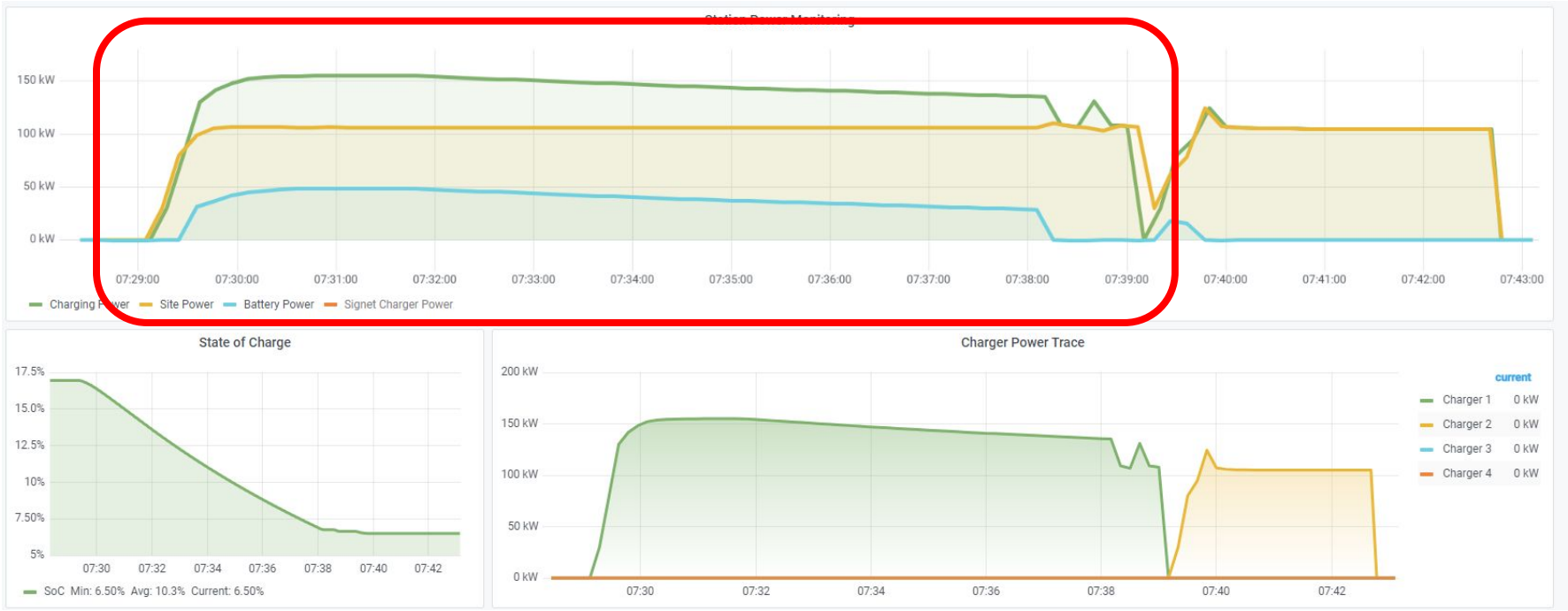
System Performance Measurements

- A full system discharge was performed in accordance with ESIC Testing guidelines
- For these tests, 2 of the 16 battery modules within PowerNode were disconnected

- Delivered DC energy
  - 58.96 kWh start energy (via Coloumb counter)
  - 6.02 kWh end energy (via Coloumb counter)
  - = 52.94 kWh delivered through standard discharge
- Maximum Power Observed
  - 117-119 kW AC
  - 122-123 kW DC
- Discharge Time
  - Full power 12 minutes
  - Full discharge 35 minutes

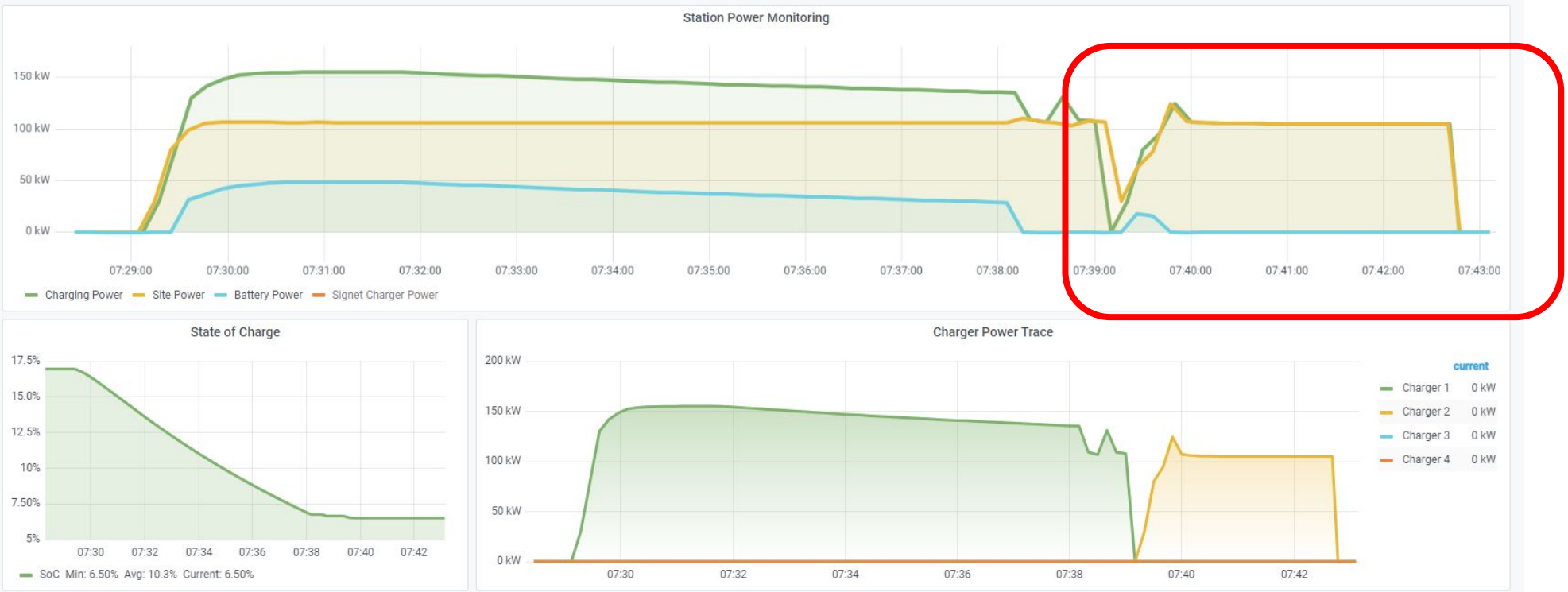
Low-Energy Charging

- A charging session was initiated at low battery energy to verify station/charger management was in effect
- The battery was disconnected during a second session per ESIC Testing guidelines on connect/disconnect behavior
- No exceedances during low energy charging session
- Session respected limited battery power capacity, including drop when battery was fully discharged



Connect/Disconnect

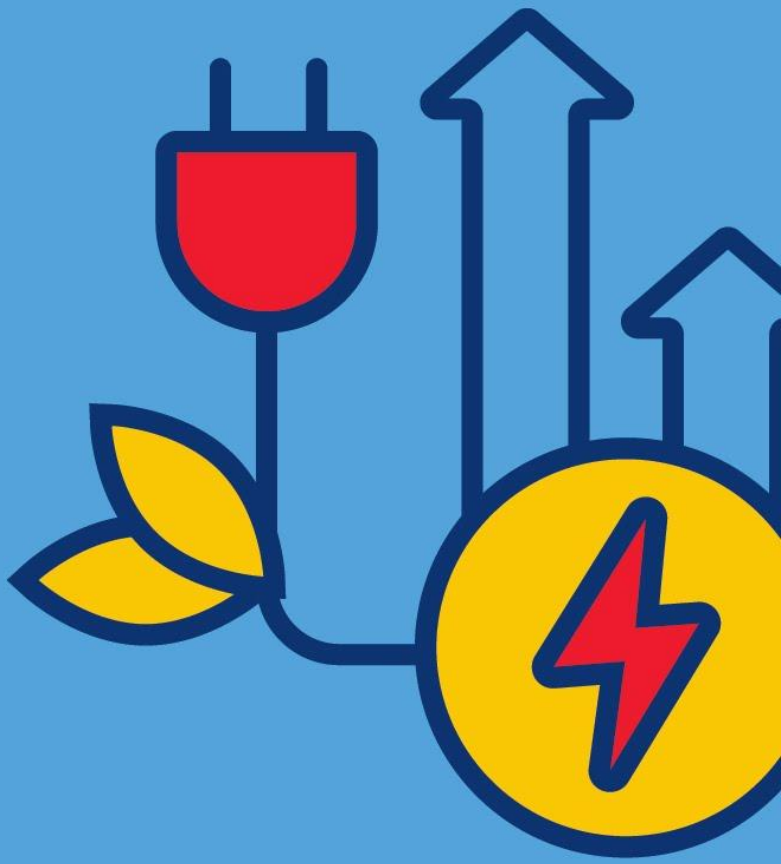
- Same test initiated a second charging session where the battery was placed into maintenance mode, per ESIC testing guidelines
- Second session operated using grid only, as battery was in maintenance mode



Conclusion

- System Performance
  - Battery does not overheat when presented with repeated cycles, and is capable of sourcing 120 kW in a reasonably hot climate with thermal margin
- Low Energy Charging
  - Site operated successfully as battery approached depletion, showing that the site resilient to “corner cases” of operation
- Connect/Disconnect
  - Site operated successfully with the battery disconnected, charging a vehicle within the grid limit (at reduced power)
  - Site is resilient to a battery failure (for any reason)

Conclusions



Conclusion

- PowerNode can provide battery-backed DC fast charging operation in grid-constrained scenarios
- PowerNode has demonstrated:
  - Direct management to the specified grid limit when charging EVs as shown on the demonstration (ribbon cutting) day
  - Operation in low- and high-utilization DC fast charging stations with high performance meeting 90+% of desired simulated vehicle charging requests
- PowerNode can be remotely managed to operate an EV charging site, with automatic reporting of any issues
- PowerNode demonstrates operation robust to various corner cases of operation, ensuring the site operates even in fault conditions

Attribution and Thanks

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- Morgan Smith
- Dennis Turner

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Host Utilities

and collaborators

Thank You

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