NARUC Electric Vehicles State Working Group

APRIL MEETING

APRIL 28, 2020

AGENDA

3:00 PM	**Welcome and Introductions (10 minutes)** • Agenda review • Roll call, by state
3:10 PM	**Presentation: The Brattle Group (15 minutes)** • Ryan Hledik, Principal, and Tony Lee, Consultant, will present on managed charging of EVs.
3:25 PM	**Presentation: Avista Utilities (15 minutes)** • Mike Vervair, E-Mobility Engineer, will present on Avista's EV managed charging pilot program.
3:40 PM	**Presentation: Electric Power Research Institute (15 minutes)** • Dan Bowermaster, Program Manager for Electric Transportation, will present on vehicle-to-grid (V2G) technology and capabilities.
3:55 PM	**Closed Door Discussion (30 minutes)** • Working group members will discuss their own views and the actions their states have taken to date.
4:25 PM	**Next Steps and Announcements (5 minutes)**
4:30 PM	**Adjourn**

Roll Call – Read from Webinar

Working Group Members

States:

- Arizona
- California
- Colorado
- Connecticut
- D.C.
- Florida
- Georgia
- Hawaii
- Illinois
- Maryland
- Massachusetts
- Michigan
- Minnesota
- Missouri
- Nevada
- New Jersey
- New York
- North Carolina
- Ohio
- Oregon
- Puerto Rico
- South Dakota
- Texas
- Vermont
- Washington
- Wisconsin

National/Federal Partners:

- NARUC
- U.S. DOE
- U.S. EPA

Managed Charging and V2G

Preparation Questions

- Does your state have any programs for the active management of EV charging?
- If so, how is charging managed? How are customers compensated?
- Has your commission or any utility in your state explored V2G?

Pre-Read Materials

- NARUC's *Electric Vehicles: Key Trends, Issues, and Considerations for State Regulators* (bit.ly/EVKeyTrends)
  - Managed Charging: *p. 35-36*
  - Vehicle-to-Grid: *p. 38*

Electric Vehicle Managed Charging

CONSIDERATIONS FOR AN EMERGING OPPORTUNITY

PRESENTED TO
NARUC EV Working Group

PRESENTED BY
Ryan Hledik
Tony Lee

April 28. 2020

THE Brattle GROUP

Why managed charging?

Unmanaged charging is expensive

- 20 million EVs = approx. **$100 billion** in infrastructure investment
- Need for new power plants, transmission and distribution infrastructure, customer hardware…

Consumers will benefit

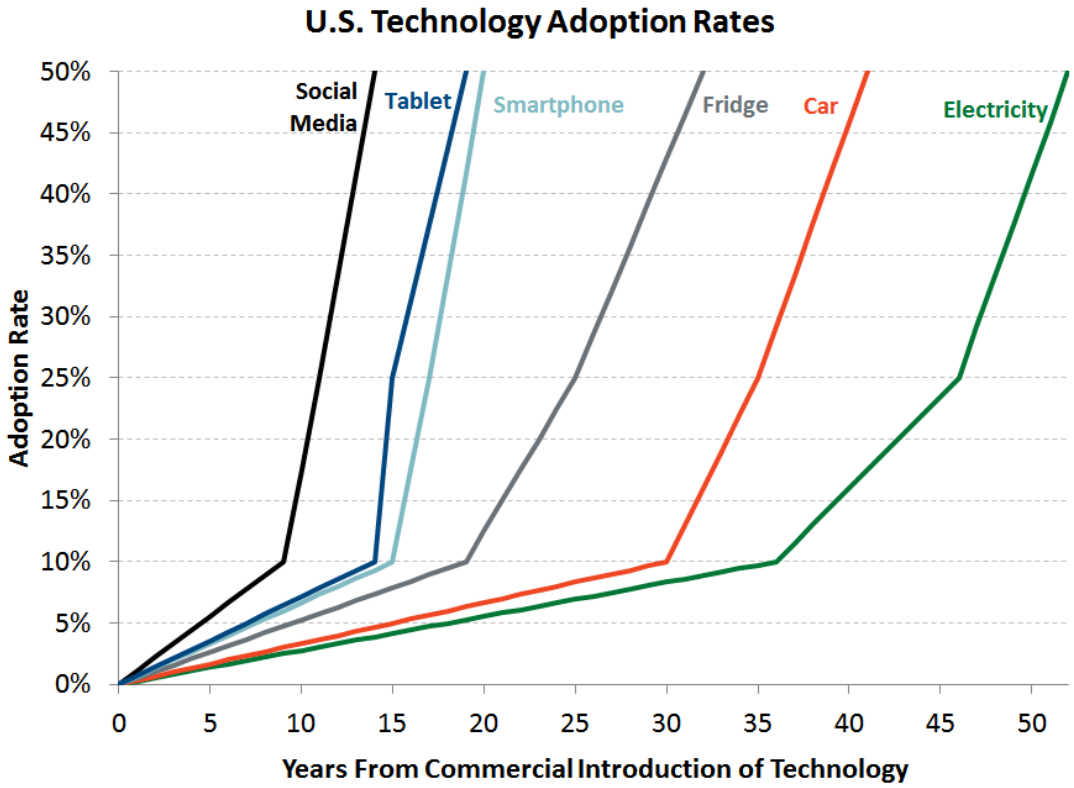
- Reduced charging costs
- Streamlined home charger installation

The environment can also benefit

- If charging is scheduled to reduce renewables curtailment and avoid hours supplied by high-emitting resources

There are only 1.5 million EVs on the road… so why worry about managed charging now?

Technological disruption can happen quickly



EV share of new vehicles sold in Santa Clara County, CA in 2018:

>20%

Sources: https://www.linkedin.com/pulse/part-2-megaproject-paradox-what-chances-barrel-oil-being-john-noonan, https://theicct.org/sites/default/files/publications/CA-cityEV-Briefing-20180507.pdf and Brattle analysis

There are only 1.5 million EVs on the road… so why worry about managed charging now?

Advantages of EVs	Advantages of ICE vehicles
– Lower fuel cost – Minimal maintenance – Clean – Quiet – Fun to drive – Can fuel at home	– Lower up-front purchase price – Dependable fueling infrastructure (no range anxiety) – Consumer confidence in reliable, proven technology – Diverse model availability
All of these advantages are permanent	***How long will these advantages last?***

“Active” vs “passive” managed charging: **What’s the difference?**

Active Managed Charging	Passive Managed Charging
– Automated dispatch signal	– Time-varying retail rates
– “Direct load control”	– Peak time rebates
– Vehicle-to-grid or vehicle-to-home (backup power)	– Timer-based charging

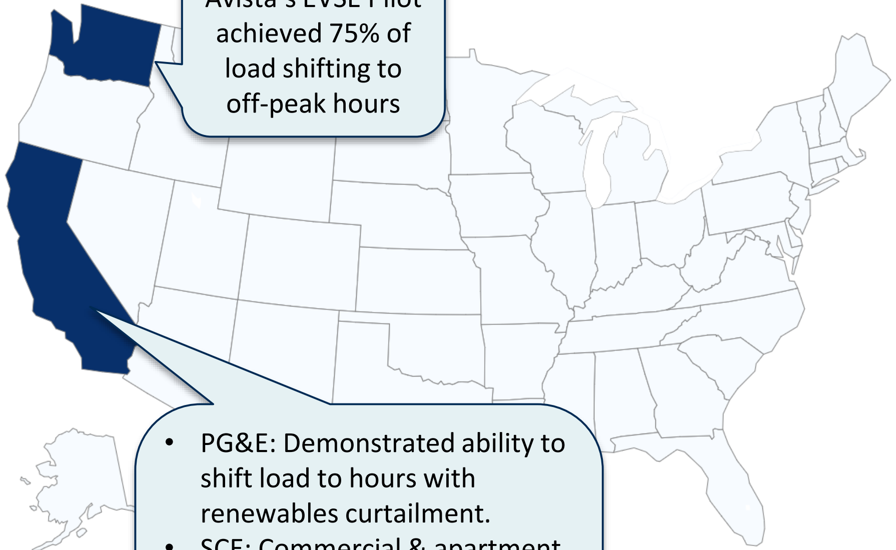
"Active" vs "passive" managed charging: **Advantages of each**

Active Managed Charging	Passive Managed Charging
– Flexibility and precision in managing load	– Lower deployment cost (if AMI has been adopted)
– Real-time control of individual chargers across system	– Greater customer control
– More value through wider variety of grid services	– Significant industry experience with TOU rates, and demonstrated ability to significantly shift EV load

“Active” vs “passive” managed charging: **Current landscape**

Active Managed Charging

Utility Managed Charging Pilots



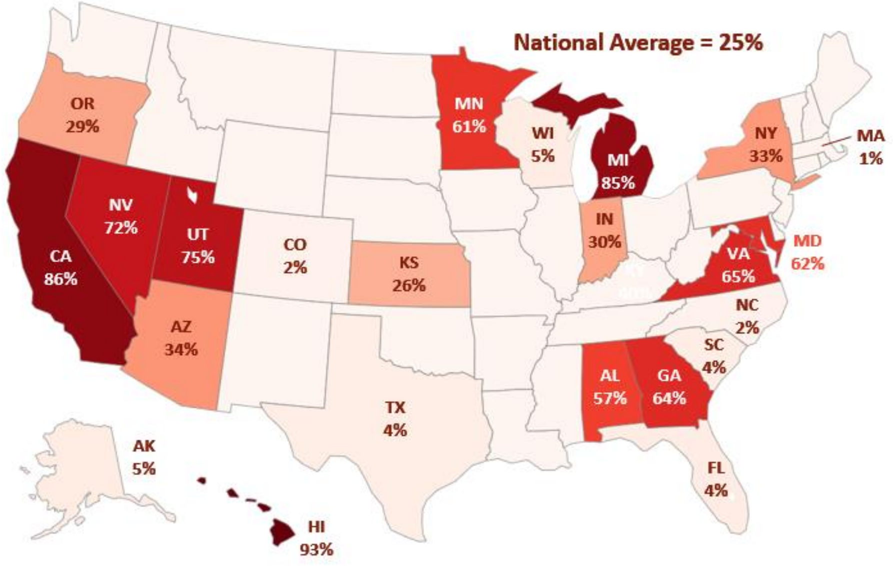
Avista’s EVSE Pilot achieved 75% of load shifting to off-peak hours

- PG&E: Demonstrated ability to shift load to hours with renewables curtailment.
- SCE: Commercial & apartment EV charging loads reduced by 42% during DR events.
- SMUD: Managed charging reduces charger integration costs by avoiding transformer upgrades

Passive Managed Charging

Share of Residential Customers Offered Time-Varying EV Rate

Offered by 50 utilities across 26 states



Source: Smart Electric Power Alliance & The Brattle Group, “Residential Electric Vehicle Rates That Work”, 2019.

What should happen next?

Two no-regrets opportunities:

Utility-specific EV load flexibility potential studies

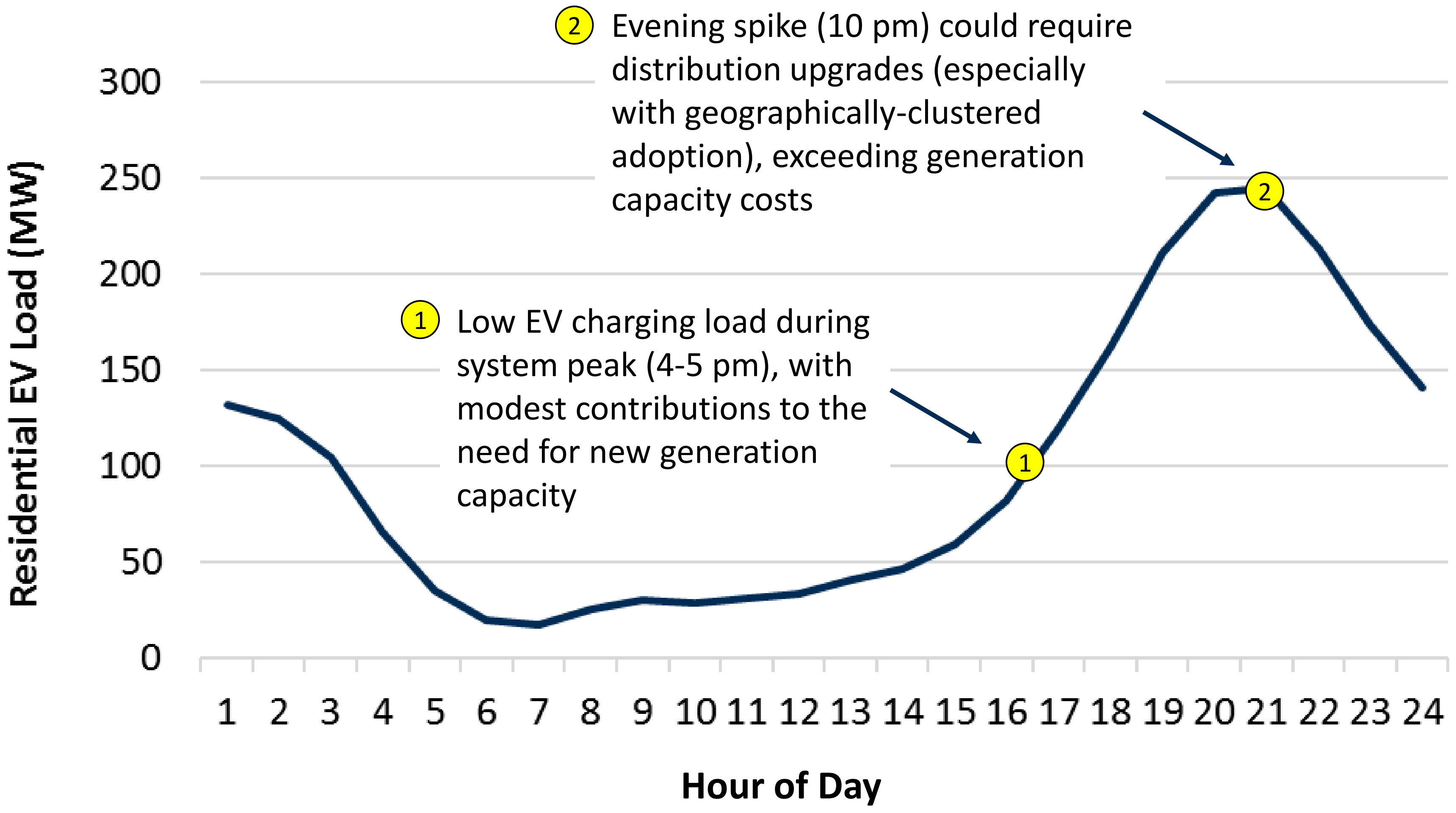
- What are the incremental system costs of EV adoption?
- What are the options for avoiding these costs?
- Which managed charging options are most cost-effective?

Managed charging pilots

- Address significant gaps in research and technology
- Do it while there’s still time

Illustrating the benefit of EV managed charging potential studies

What is the ideal way to manage charging on this system?



Additional Brattle research in this area…

Presenter Information

RYAN HLEDIK

Principal | San Francisco, CA

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Ryan Hledik specializes in regulatory and planning matters related to the emergence of distributed energy technologies.

Mr. Hledik has consulted for more than 50 clients across 30 states and 9 countries. He has supported his clients in matters related to energy storage, load flexibility, distributed generation, electrification, retail tariff design, energy efficiency, and grid modernization.

Mr. Hledik's work has been cited in regulatory decisions establishing procurement targets for energy storage and demand response, authorizing billions of dollars in smart metering investments, and approving the introduction of innovative rate designs. He is a recognized voice in debates on how to price electricity for customers with distributed generation. He co-authored Saudi Arabia's first Demand Side Management (DSM) plan, and the Federal Energy Regulatory Commission's landmark study, A National Assessment of Demand Response Potential.

Mr. Hledik has published more than 25 articles on retail electricity issues and has presented at industry events throughout the United States as well as in Brazil, Belgium, Canada, Germany, Poland, South Korea, Saudi Arabia, the United Kingdom, and Vietnam. His research on the "grid edge" has been cited in *The New York Times* and *The Washington Post*, and in trade press such as *GreenTech Media*, *Utility Dive*, and *Vox*. He was named to *Public Utilities Fortnightly's* Under Forty 2019 list, recognizing rising stars in the industry.

Mr. Hledik received his M.S. in Management Science and Engineering from Stanford University, where he concentrated in Energy Economics and Policy. He received his B.S. in Applied Science from the University of Pennsylvania, with minors in Economics and Mathematics. Prior to joining Brattle, Mr. Hledik was a research assistant with Stanford's Energy Modeling Forum and a research analyst in Charles River Associates' Energy Practice.

Presenter Information

TONY LEE

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Tony Lee is a Consultant in The Brattle Group's San Francisco office. He specializes in wholesale market design, environmental policy analysis, resource planning, and economic analysis of generation, transmission, and demand-side resources. He has extensive experience developing and operating economic models of electricity systems. Mr. Lee holds a B.A. in Economics and a B.S. in Engineering, both from Swarthmore College.

Bibliography

- Hledik, Ryan, Erika H. Myers, Jacob Hargrave, Richard Farinas, and Lauren Burke. "Residential Electric Vehicle Time-Varying Rates That Work: Attributes That Increase Enrollment." Prepared for the Smart Electric Power Alliance (SEPA), November 2019.
- Hledik, Ryan, Ahmad Faruqui, Michael Hagerty, and John Higham. "The Total Value Test: A Framework for Evaluating the Cost-Effectiveness of Efficient Electrification." Prepared for the Electric Power Research Institute (EPRI), August 8, 2019.
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- Weiss, Jürgen, Ryan Hledik, Michael Hagerty, and Will Gorman. "Electrification: Emerging Opportunities for Utility Growth." Prepared by The Brattle Group, January 2017.

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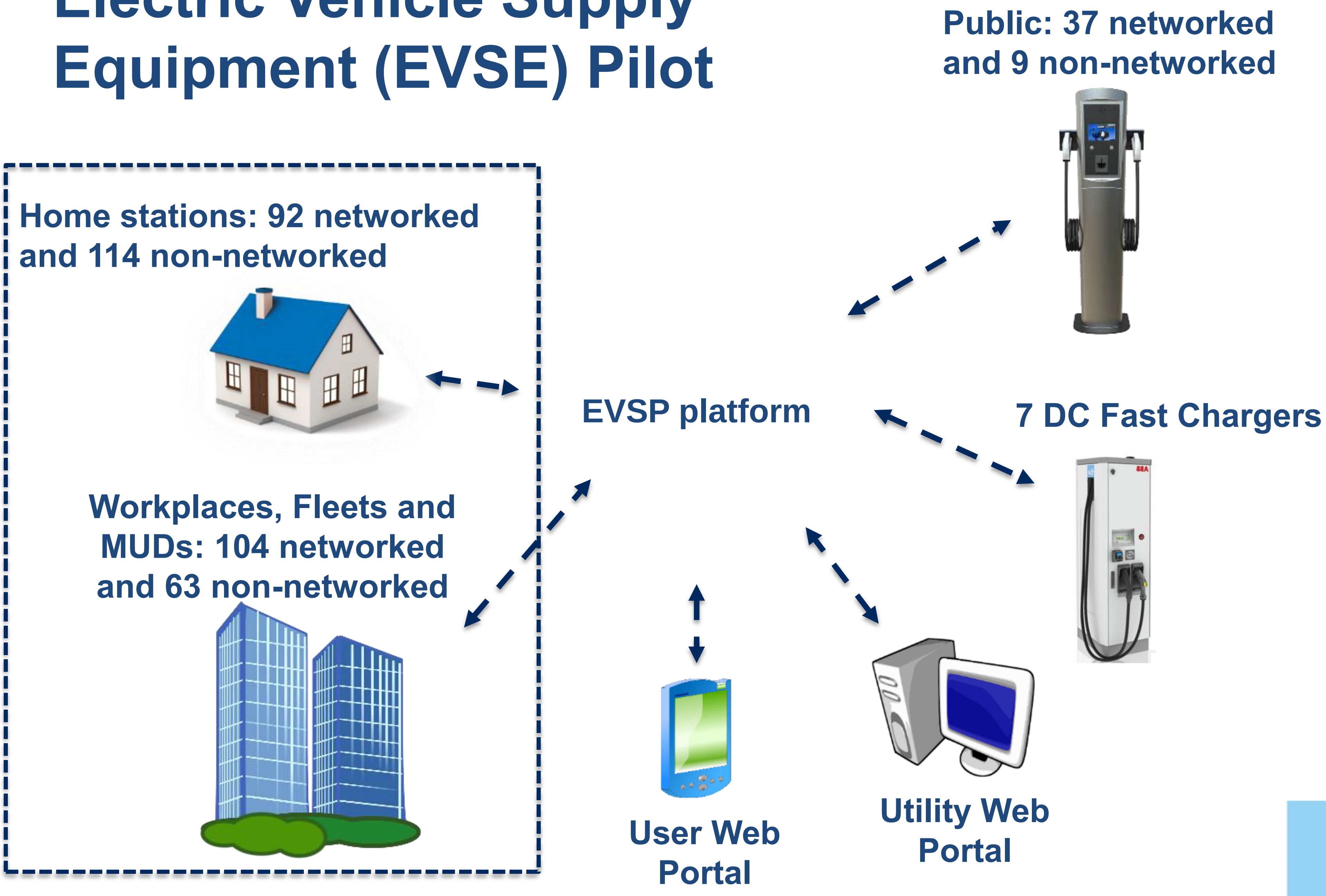
Avista Managed Charging Review

Mike Vervair
Engineer
April 28, 2020

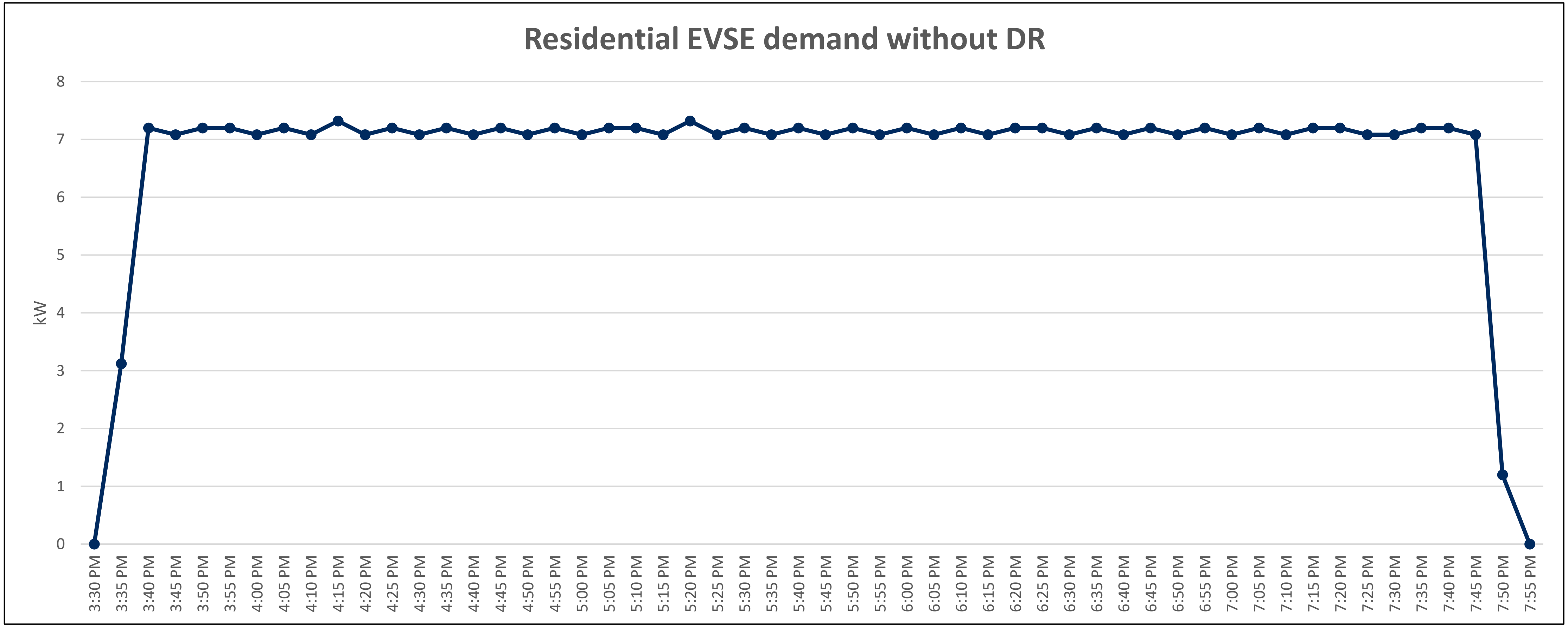
Avista Service Territory

AVISTA

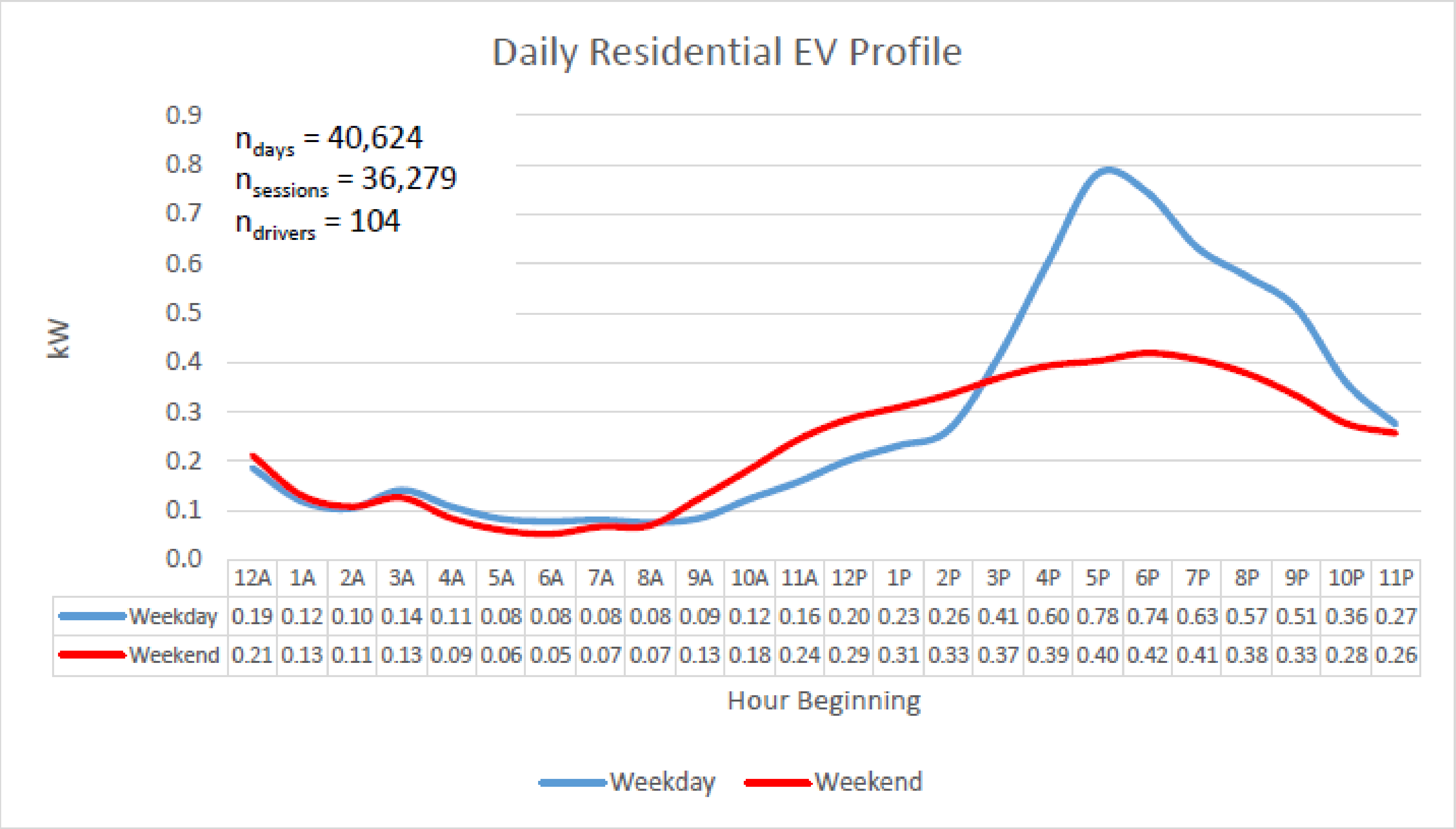
Electric Vehicle Supply Equipment (EVSE) Pilot



Typical residential driver session (Dx level impact)



Avista baseline residential profile (system capacity impact)

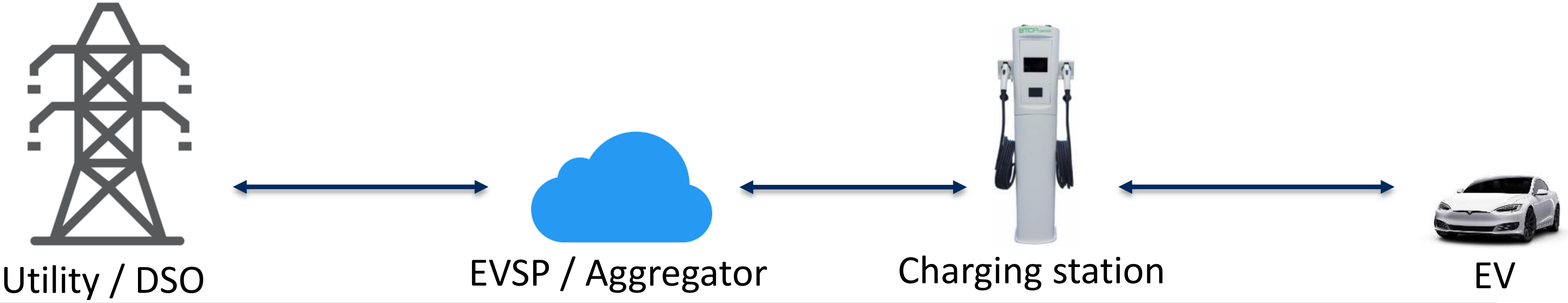


	12A	1A	2A	3A	4A	5A	6A	7A	8A	9A	10A	11A	12P	1P	2P	3P	4P	5P	6P	7P	8P	9P	10P	11P
Weekday	0.19	0.12	0.10	0.14	0.11	0.08	0.08	0.08	0.08	0.09	0.12	0.16	0.20	0.23	0.26	0.41	0.60	0.78	0.74	0.63	0.57	0.51	0.36	0.27
Weekend	0.21	0.13	0.11	0.13	0.09	0.06	0.05	0.07	0.07	0.13	0.18	0.24	0.29	0.31	0.33	0.37	0.39	0.40	0.42	0.41	0.38	0.33	0.28	0.26

Residential DR goals and path

Objective	Method
Determine how much load, energy can be shifted to off peak	Send curtailed load profiles during peak hours via OCPP, track meter data
Maintain high customer satisfaction levels	Maintain transparent communications and roll out in phases to ensure kinks worked out
	Conduct period surveys and interviews and adjust based on feedback
	Give customers ability to opt out of DR events via phone app and track opt outs
Use information in cost-benefit analysis for future program	Add data to Ratepayer Impact Measurement and Regional Perspective Cost models

AVISTA

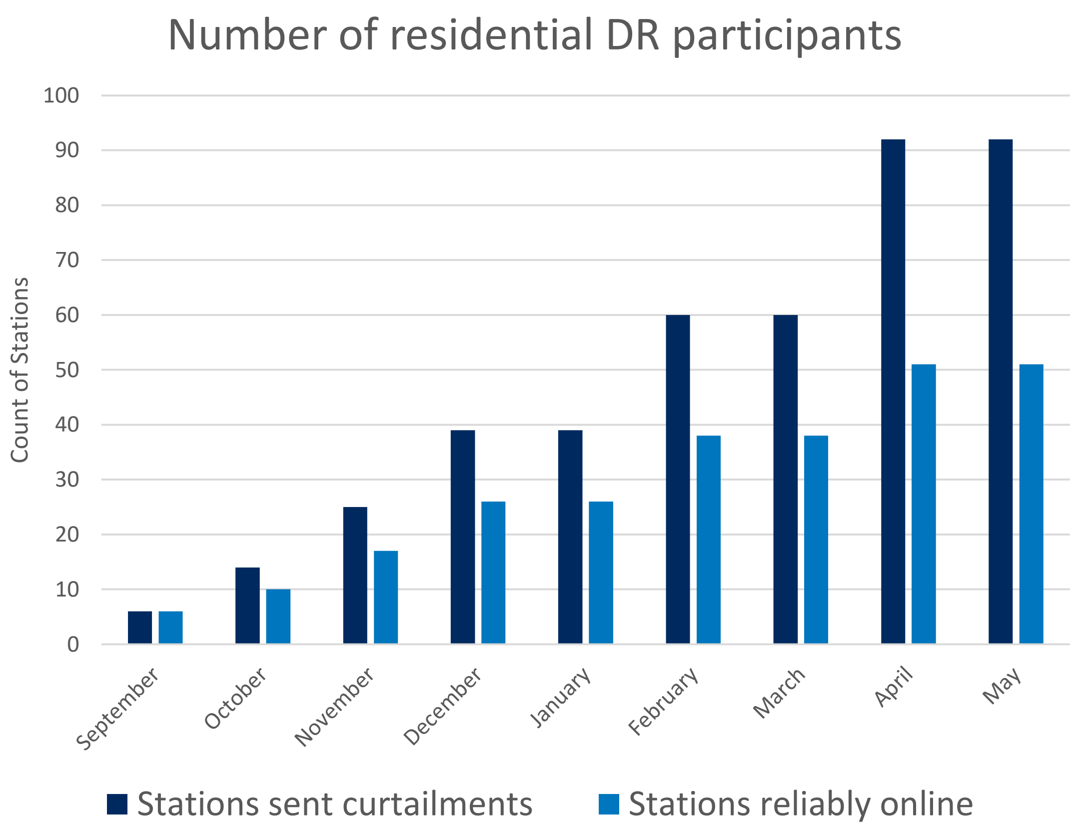


Communications framework	OpenADR ISO 15118 IEEE 2030.5 Web portal (manual)	OCPP OCPI Proprietary	SAE J1772
Communications pathways	Pathway agnostic	Wi-Fi Ethernet PLC Cellular	PLC
State of market solutions	Few pilots Early stages Development req’d	Many pilots Basic “turn key” solutions EVSP-to-EVSP developing	Established

Used in Avista DR pilot

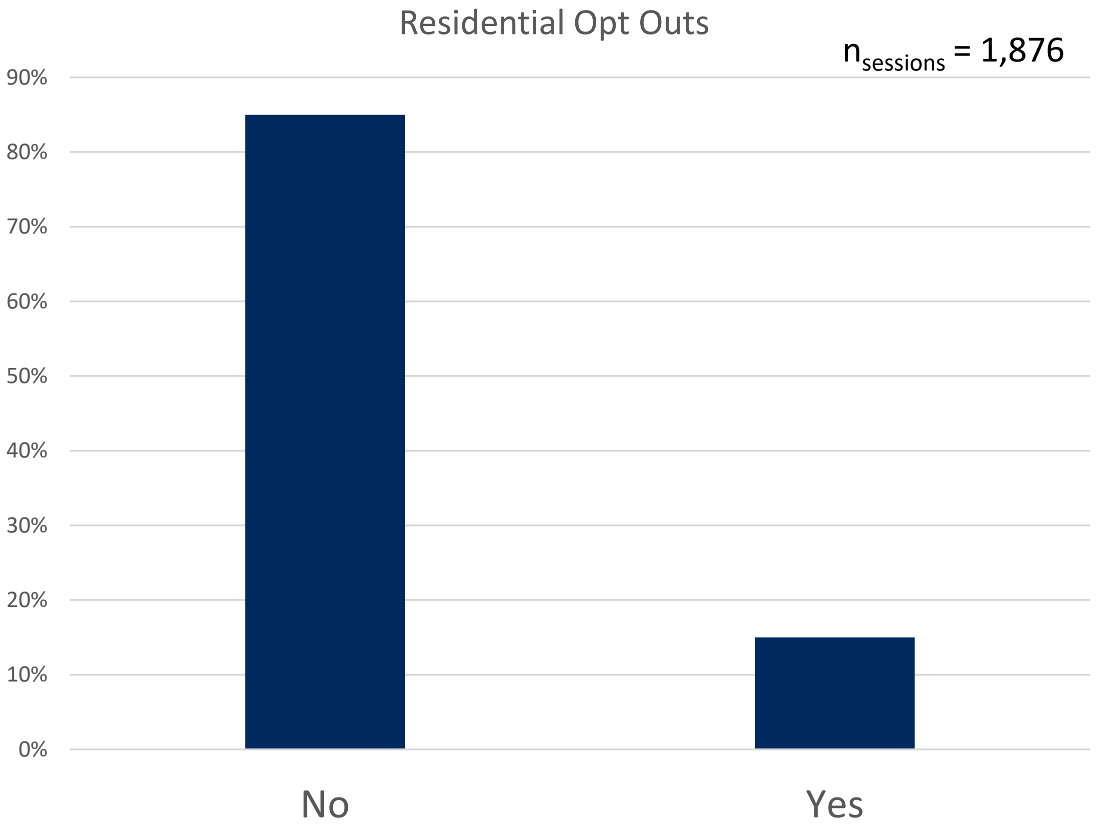
AVISTA

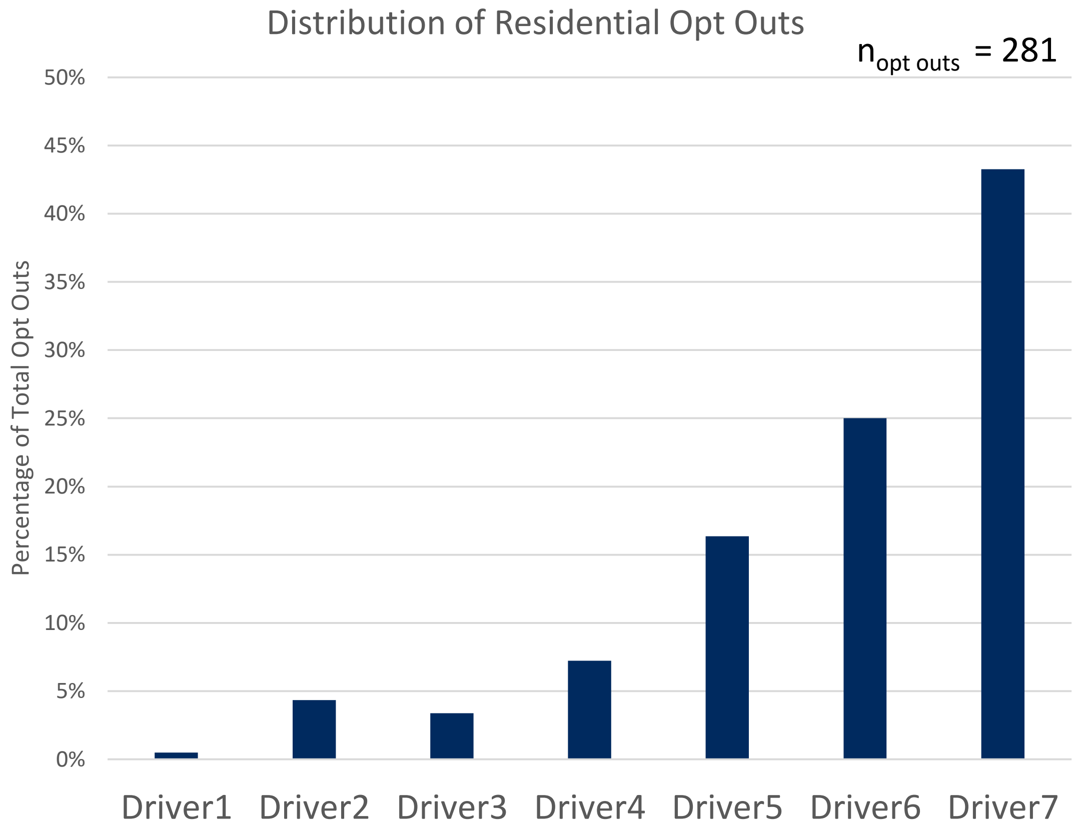
Residential DR rollout



- Customers rolled out in multiple waves
- Minor delays experienced due to changes in station messaging
- 92 residential networked EVSEs were sent DR requests daily, although not all requests received due to connectivity challenges
- Small scale DR testing at workplace and fleet locations during winter mid-morning peak

Opting out of residential DR events





Individual residential DR session impact

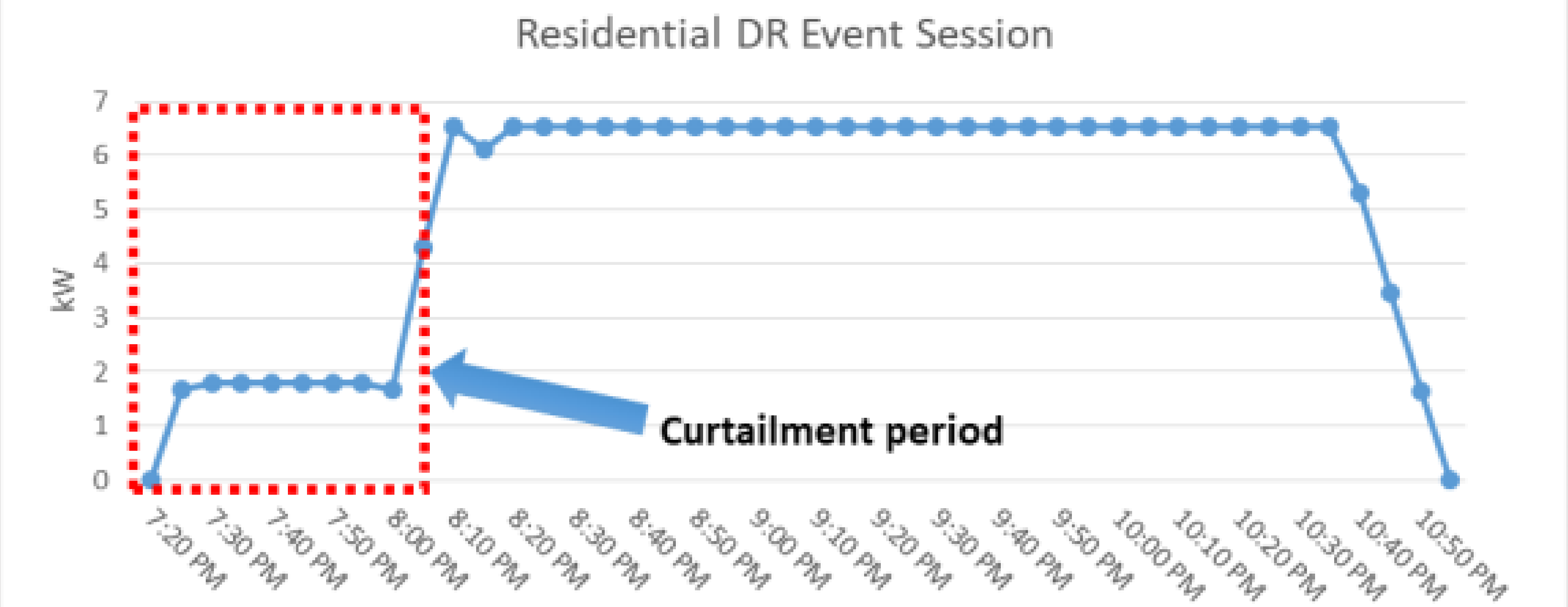


Figure 3: Example DR charging session with 75% peak load reduction

Baseline:

n_{days} = 15,715

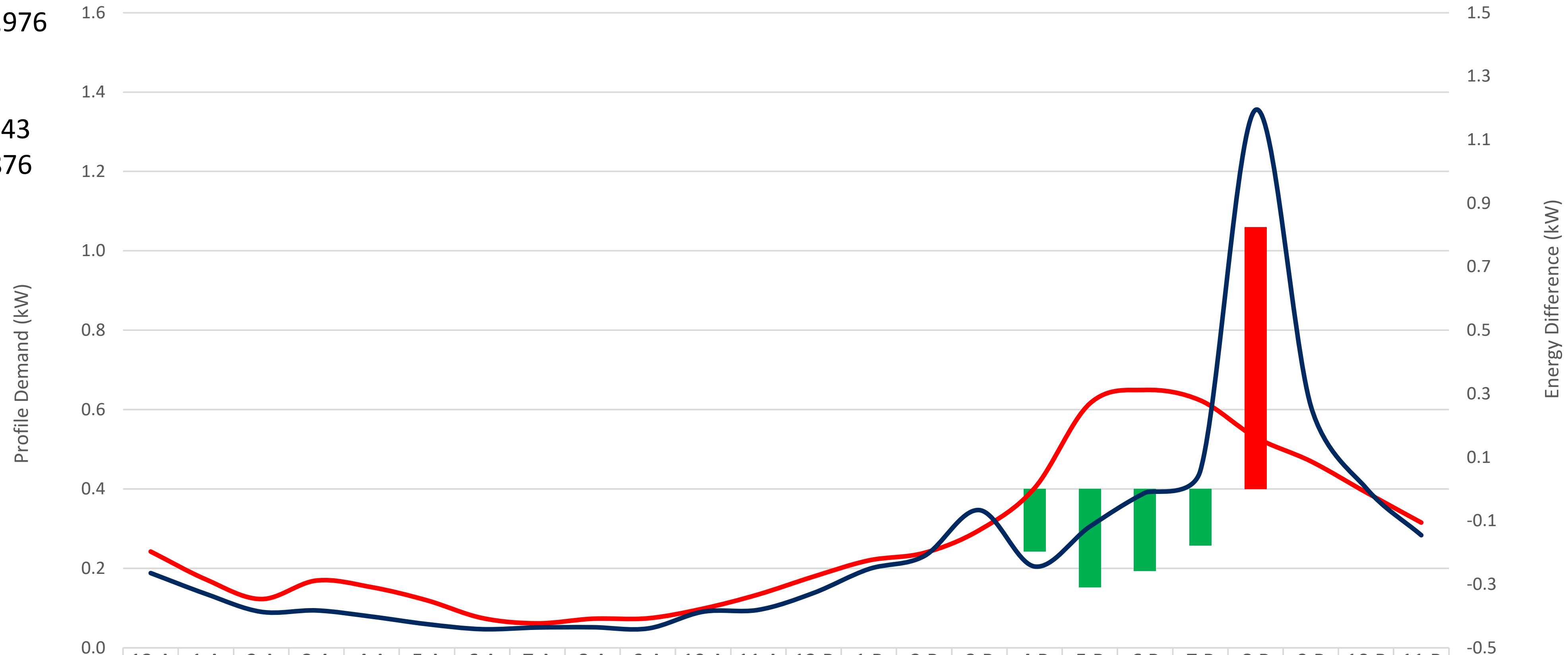
$n_{sessions}$ = 12,976

DR:

$n_{days,DR}$ = 3,143

$n_{sessions}$ = 1,876

Residential Base and DR Daily Profile Comparison With Difference



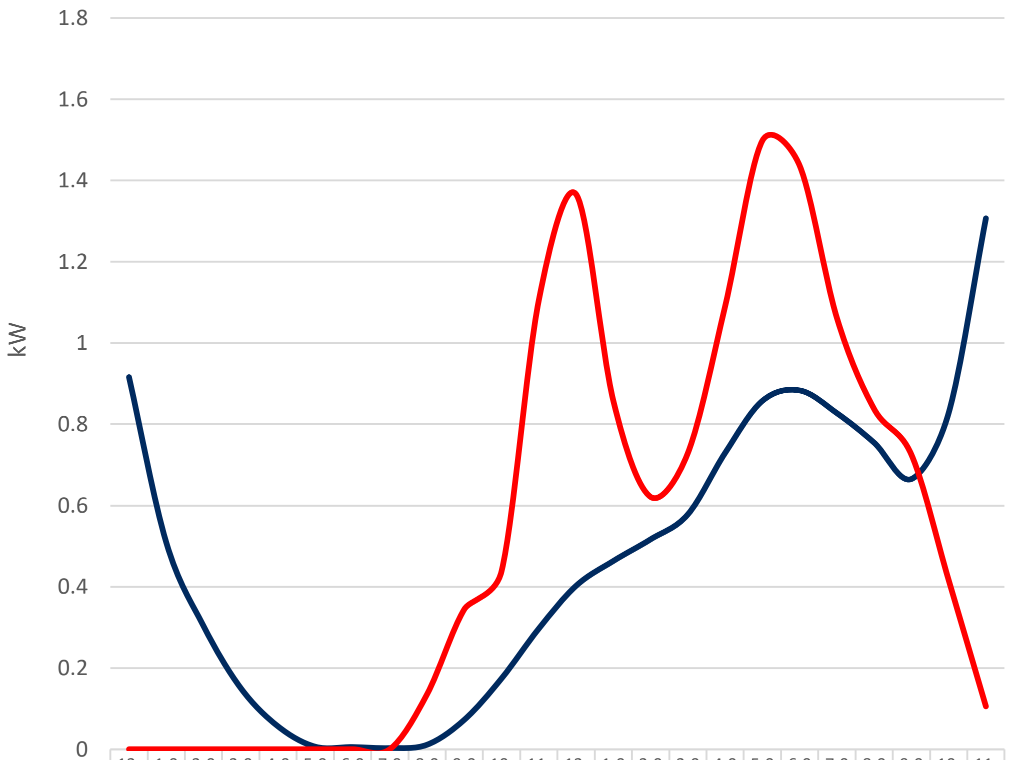
	12 A	1 A	2 A	3 A	4 A	5 A	6 A	7 A	8 A	9 A	10 A	11 A	12 P	1 P	2 P	3 P	4 P	5 P	6 P	7 P	8 P	9 P	10 P	11 P
Difference	-0.1	0.0	0.0	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	-0.2	-0.3	-0.3	-0.2	0.8	0.1	0.0	0.0
Base Profile	0.2	0.2	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.4	0.6	0.6	0.6	0.5	0.5	0.4	0.3
DR Profile	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.2	0.3	0.4	0.4	1.4	0.6	0.4	0.3

Hour Beginning

Fleet DR and Baseline Profile Comparison

DR:
n_{days} = 398
$n_{sessions}$ = 1614
n_{ports} = 4

Baseline:
n_{days} = 91
$n_{sessions}$ = 202
n_{ports} = 4

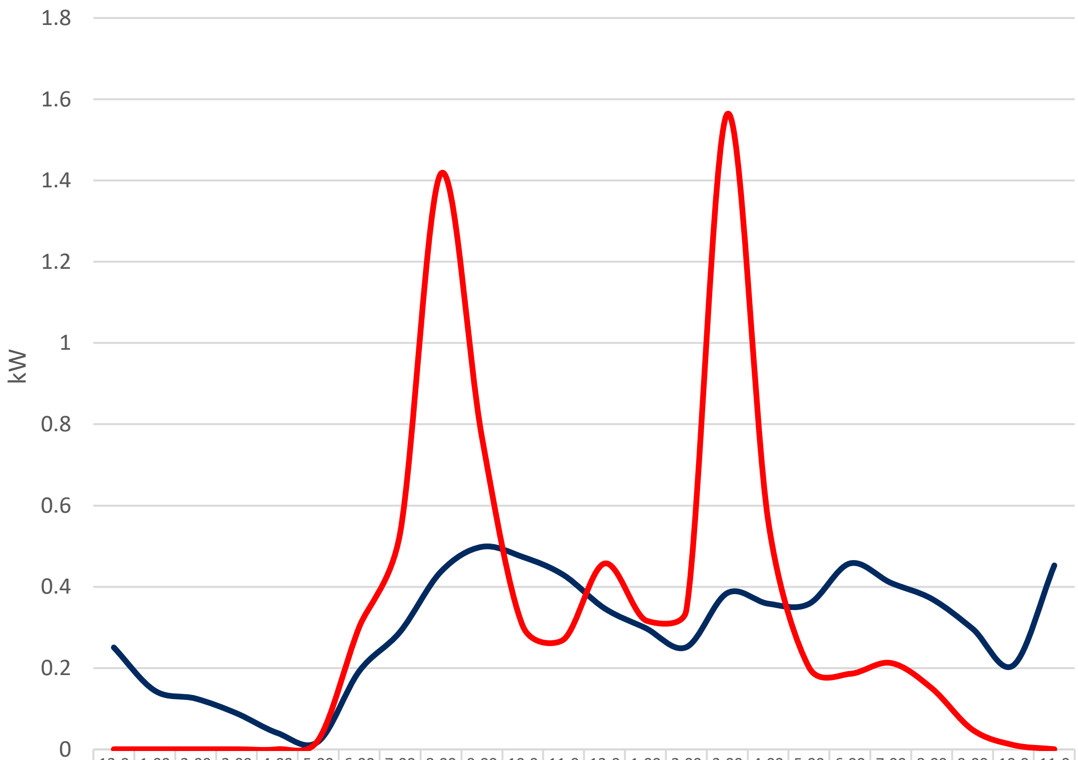


	12:00:00 AM	1:00:00 AM	2:00:00 AM	3:00:00 AM	4:00:00 AM	5:00:00 AM	6:00:00 AM	7:00:00 AM	8:00:00 AM	9:00:00 AM	10:00:00 AM	11:00:00 AM	12:00:00 PM	1:00:00 PM	2:00:00 PM	3:00:00 PM	4:00:00 PM	5:00:00 PM	6:00:00 PM	7:00:00 PM	8:00:00 PM	9:00:00 PM	10:00:00 PM	11:00:00 PM
DR Profile	0.9	0.5	0.3	0.2	0.1	0	0	0	0	0.1	0.2	0.3	0.4	0.5	0.5	0.6	0.7	0.9	0.9	0.8	0.8	0.7	0.8	1.3
Baseline Profile	0	0	0	0	0	0	0	0	0.1	0.3	0.4	1.1	1.4	0.9	0.6	0.7	1.1	1.5	1.4	1.1	0.8	0.7	0.4	0.1

Workplace DR and Baseline Comparison

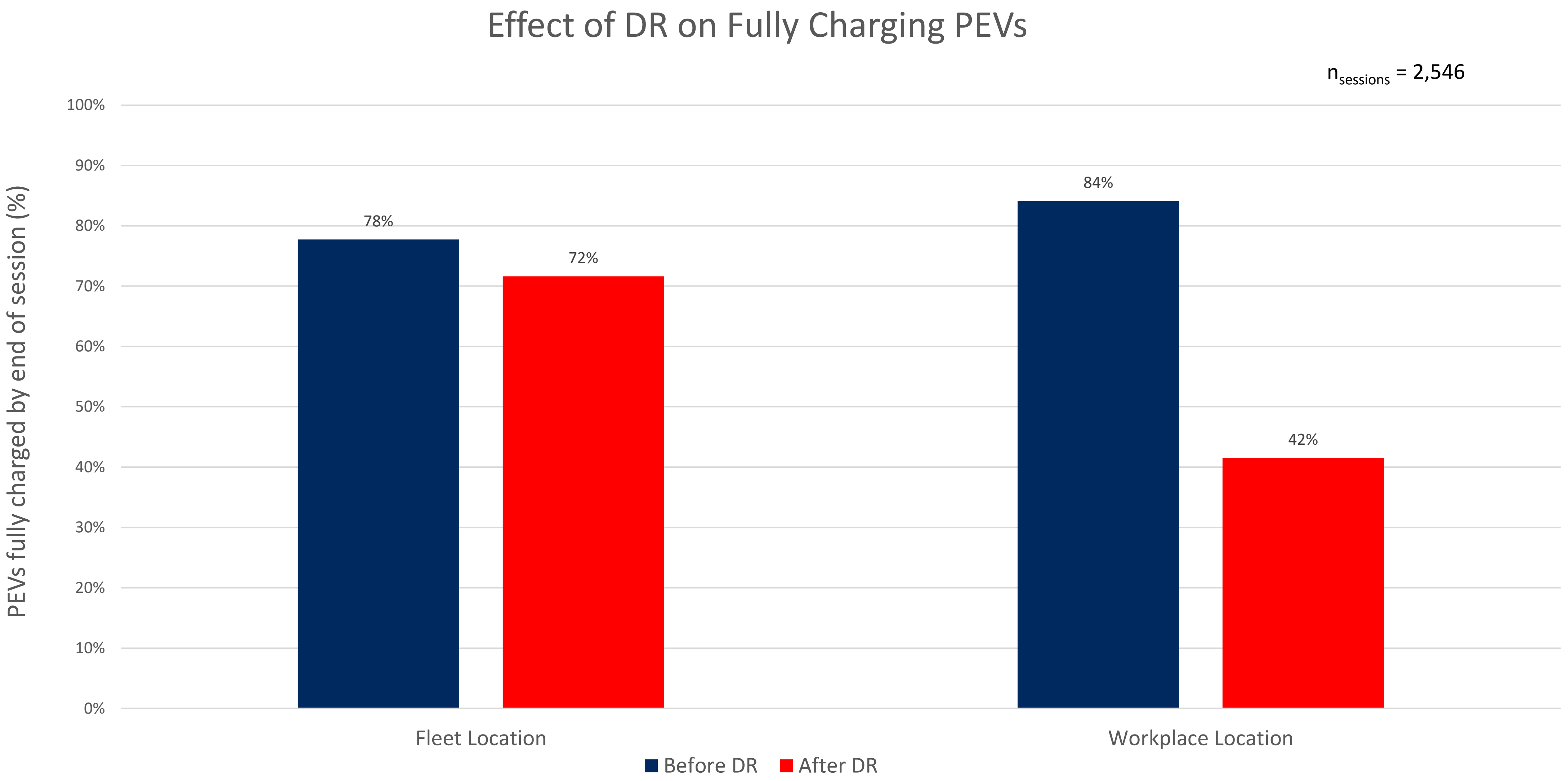
DR:
n_{days} = 478
$n_{sessions}$ = 453
n_{ports} = 4

Baseline:
n_{days} = 289
$n_{sessions}$ = 277
n_{ports} = 4

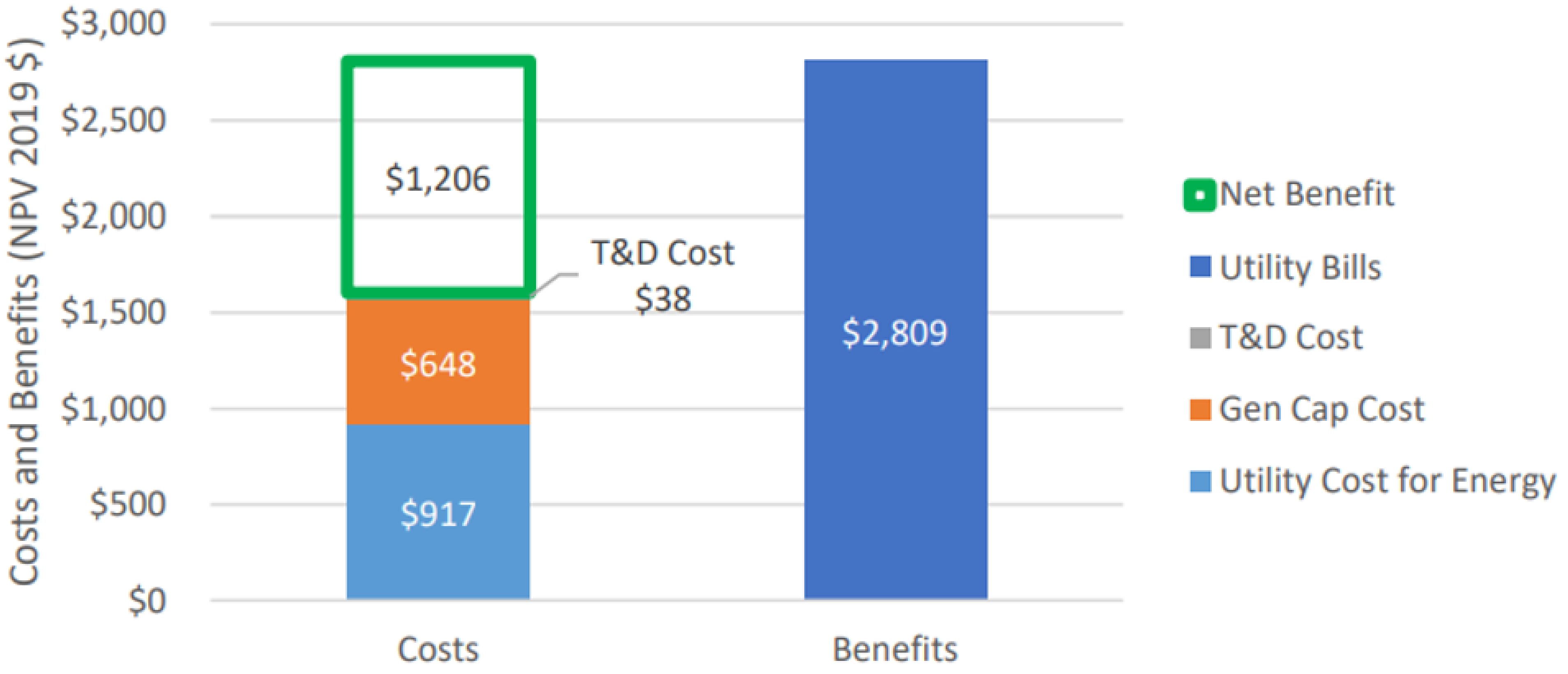


	12:00:00 AM	1:00:00 AM	2:00:00 AM	3:00:00 AM	4:00:00 AM	5:00:00 AM	6:00:00 AM	7:00:00 AM	8:00:00 AM	9:00:00 AM	10:00:00 AM	11:00:00 AM	12:00:00 PM	1:00:00 PM	2:00:00 PM	3:00:00 PM	4:00:00 PM	5:00:00 PM	6:00:00 PM	7:00:00 PM	8:00:00 PM	9:00:00 PM	10:00:00 PM	11:00:00 PM
DR Profile	0.25	0.14	0.12	0.09	0.04	0.02	0.19	0.29	0.44	0.5	0.47	0.43	0.35	0.3	0.25	0.38	0.36	0.36	0.46	0.41	0.37	0.3	0.21	0.45
Baseline Profile	0	0	0	0	0	0.02	0.3	0.53	1.42	0.77	0.3	0.27	0.46	0.32	0.34	1.56	0.56	0.2	0.19	0.21	0.15	0.05	0.01	0

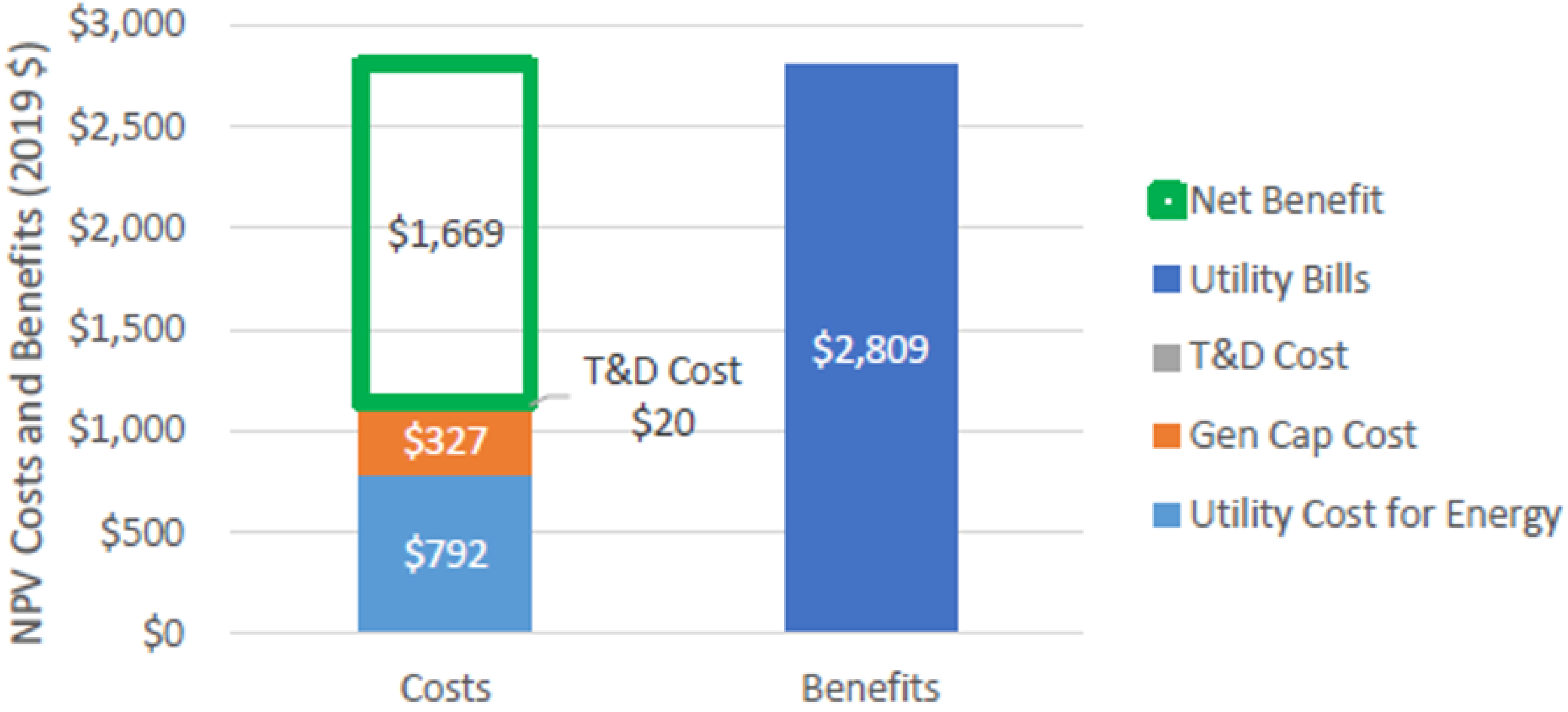
AVISTA


Effect of DR on Fully Charging PEVs
$n_{sessions}$ = 2,546
PEVs fully charged by end of session (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
78%
72%
84%
42%
Fleet Location
Workplace Location
Before DR
After DR

Avista customer perspective costs and benefits without managed charging (2019-2038)

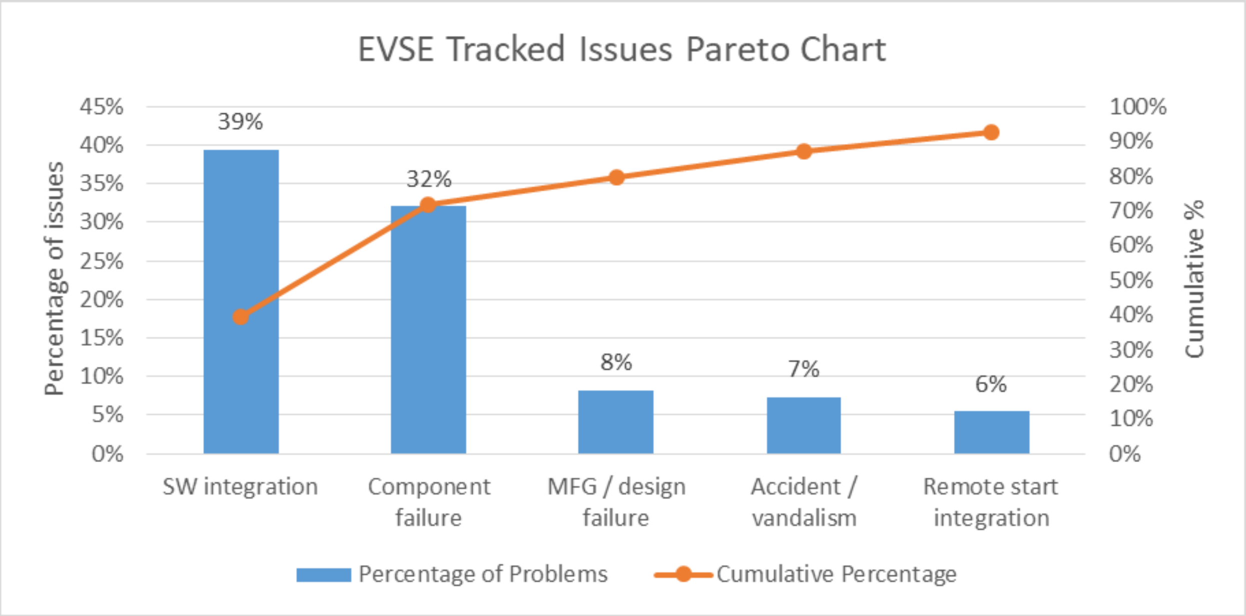


Avista customer perspective costs and benefits with managed charging (2019-2038)



Opportunities for improvements: O&M and reliability

	Installation cost per port	Annual O&M per port	% uptime	% online
Residential AC Level 2 - networked	$2,445	$370	98%	66%
Commercial AC Level 2 - networked	$6,035	$600	86% - 93%	76% - 86%
DC fast charging site	$128,084	$1,550	87%	87%
Residential AC Level 2 – non-networked	$1,766	$5	100%	NA
Commercial AC Level 2 – non-networked	$4,472	$185	99%	NA



Network switching

- To avoid “vendor lock” and to verify interoperability capabilities, Avista switched EVSP networks on L2 stations
- A total of 15 commercial L2 stations changed networks without swapping stations
- Tiered approach: some stations had HD, modem and / or SIM card swapped
- Worked with EVSP and HW manufacturer to switch 2 stations completely OTA

Questions?

Get a copy of Avista's EVSE pilot project report by Googling "Avista EVSE report" or at www.myavista.com

Contact me at Michael.Vervair@avistacorp.com for further questions

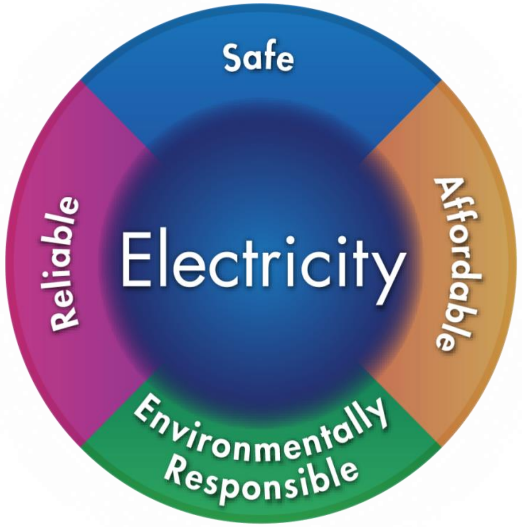
Electric Transportation

State of the EV market and Vehicle-Grid Integration

Dan Bowermaster
Sr. Program Manager, Electric Transportation
dbowermaster@epri.com

NARUC Webinar
April 28, 2020

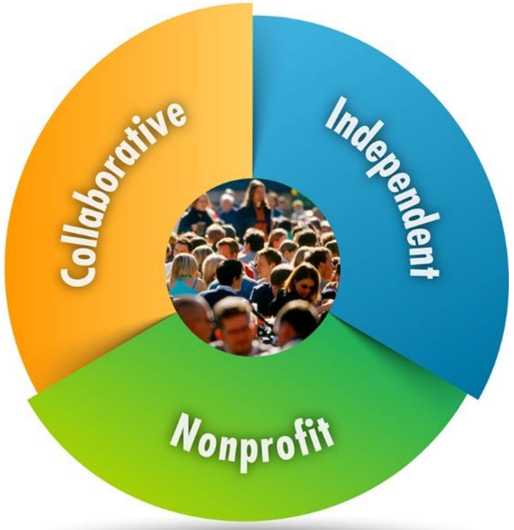
About EPRI, www.epri.com



- EPRI conducts **research and development** relating to the **generation**, **delivery** and **use of electricity** for the benefit of the public.

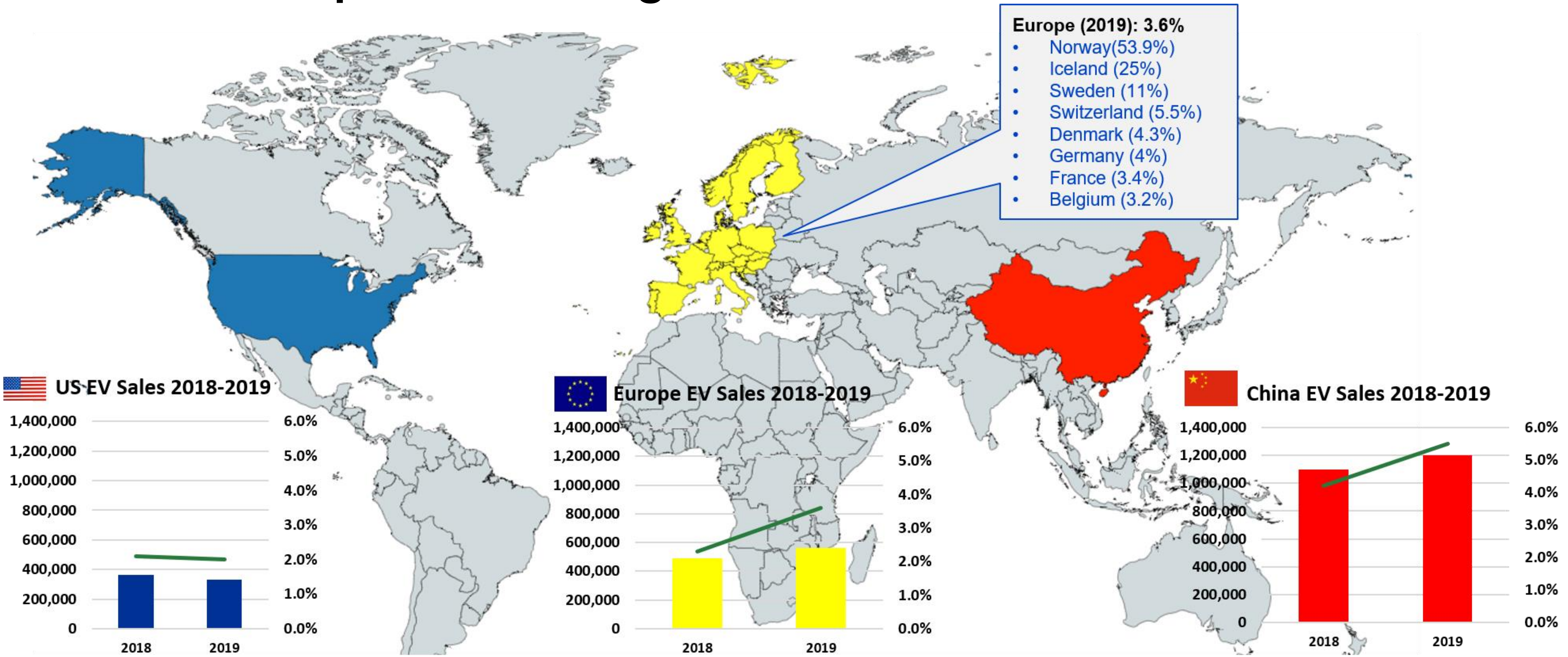
- EPRI brings together its scientists and engineers as well as experts from academia and industry to help address challenges in electricity, including **reliability**, **efficiency**, **affordability**, **health**, **safety** and the **environment**.

- **EPRI members** represent 90% of the electricity generated and delivered in the United States with international participation extending to nearly **40 countries**.



Social Media: Facebook | LinkedIn | Twitter | YouTube

Electric Transportation is a global market



The future has more uncertainty than ever

Source: https://mapchart.net/world.html

But purchasing decisions are made locally

Adoption - What does it take for a customer to buy an EV?

1. Automotive OEMs
2. Car dealers
3. Customers
   - Does it meet my needs?
   - Do I like it?
   - Can I afford it today?
   - How do I fuel it?

Wild card: impact of COVID 19 and recession?

Of the top 25 best-selling cars, only one has a plug-in option today

Photo credit: Dan Bowermaster, EPRI

New EV Registrations in 2019

Regions of interest:

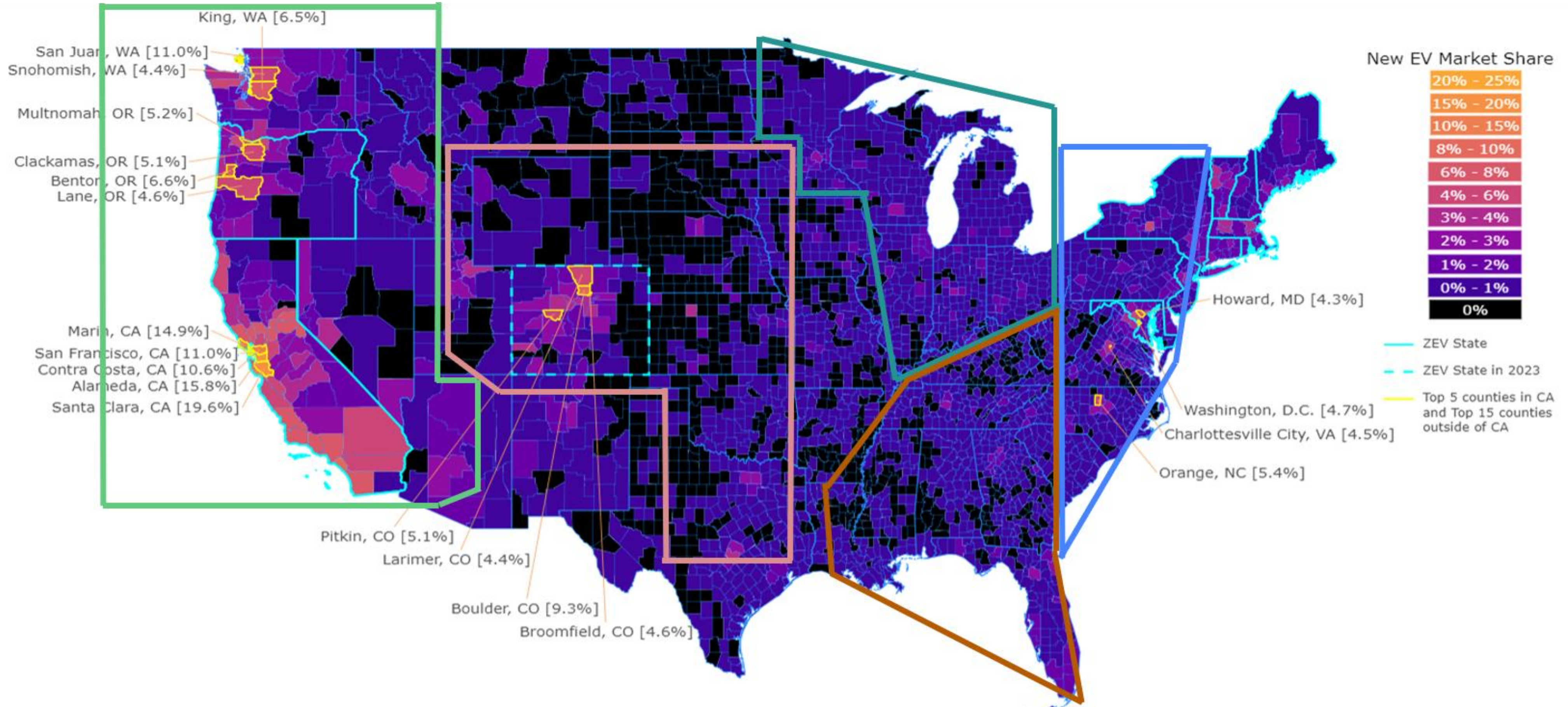
Western US*: California, Oregon, Washington

Eastern US*: DC, Maryland, Massachusetts, New York, North Carolina, Virginia

Mountain West, Midwest, & Texas*: Colorado, Idaho, Kansas, Nebraska, Texas

Great Lakes**: Illinois, Indiana, Michigan, Minnesota, Ohio, Pennsylvania, Wisconsin

South & Southeast US**: Alabama, Florida, Georgia, Kentucky, Louisiana, Mississippi, South Carolina, Tennessee



*** Regions based on states that contained a 'Top 15' county over any of the 4 quarters of 2019**

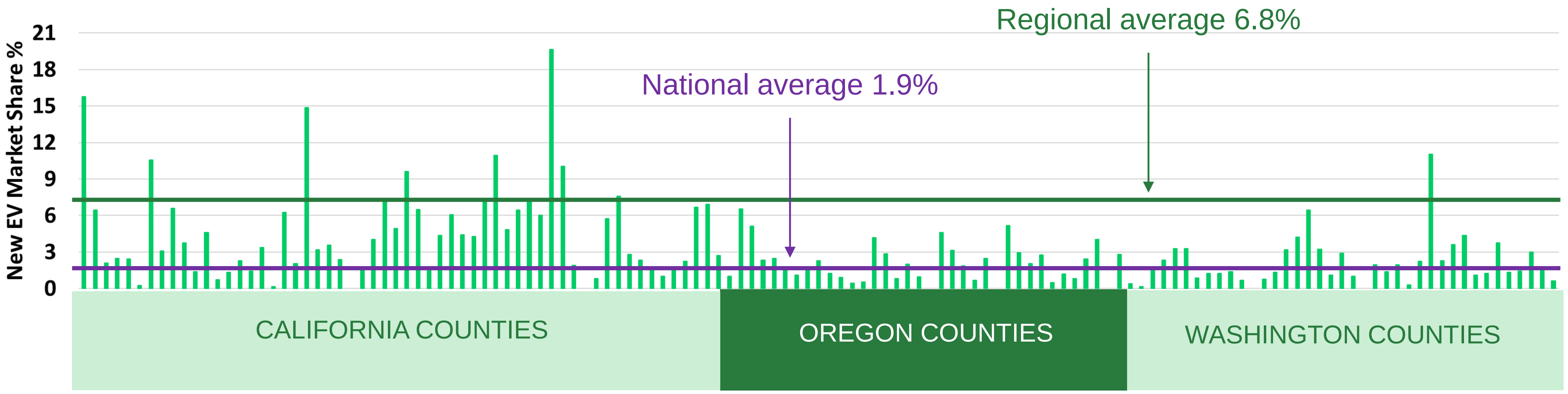
**** Regions selected to cover additional areas of the US**

Source: InsideEVs.com; IHS/Polk, 2020.

New EV Registrations 2019

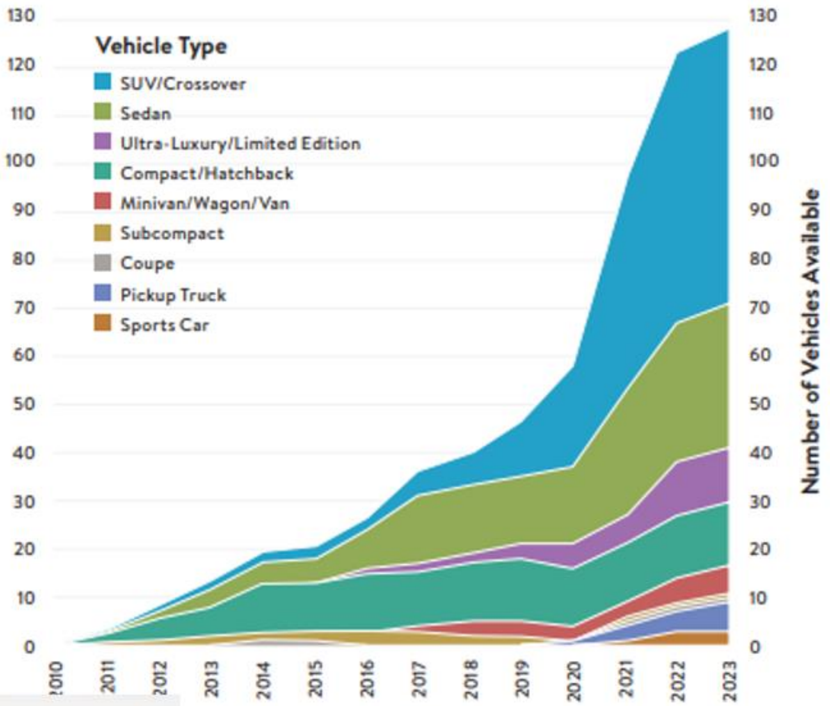
Western US: California, Oregon, Washington

Region covers 133 counties
79 counties have market shares exceeding US national average
13 counties have market shares exceeding regional average



Source: InsideEVs.com; IHS/Polk, 2020.

EPRI Consumer Guide to EVs – out now



BATTERY-ELECTRIC VEHICLE

MODEL NAME	RANGE (MILES)[1]	WHERE
SUV/CROSSOVER		
Audi e-tron	222	Nationwide
Jaguar I-Pace	234	Nationwide
Tesla Model X	258–328	Nationwide
Tesla Model Y	315	Nationwide
COMPACT/HATCHBACK		
BMW i3	153	Nationwide
Chevrolet Bolt EV	259	Nationwide
Mini Cooper SE	110	Nationwide
Nissan Leaf and Leaf Plus	150 and 226	Nationwide
Hyundai Ioniq Electric	170	Select Markets
Hyundai Kona Electric	258	Select Markets
Kia Niro EV	239	Select Markets
Volkswagen e-Golf	123	Select Markets
SEDAN		
Tesla Model 3	220–330	Nationwide
Tesla Model S	287–373	Nationwide
SUBCOMPACT		
Fiat 500e	84	Select Markets
SPORTS CAR		
Porsche Taycan 4S and Taycan Turbo	201	Nationwide

2020 Chevrolet Bolt EV
Battery-electric Compact/Hatchback

EPA electric range: 259 miles
Range/hour of charging: 26 miles
Fast charging: 100 miles in 30 minutes
Starting MSRP: $36,620

2020 Chrysler Pacifica Hybrid
Plug-in hybrid Minivan/Wagon/Van

EPA electric range: 32 miles
EPA total range (gas+electric): 520 miles
Range/hour of charging: 16 miles
Starting MSRP: $39,995

Changes:
- Updated format
- MSRP included
- New icons for BEV, PHEV and vehicle type

Under evaluation:
- Online and mobile versions
- Translation into Spanish

Source: 2020 EPRI Consumer's Guide to EVs,

Source: 2020 EPRI Consumer's Guide to EVs,

More electric crossovers, SUVs, and trucks are coming in 2020-2021

2020 Ford Escape PHEV

2021 Jeep Wrangler PHEV

2021 Rivian R1S BEV

2021 Ford Mustang Mach-E BEV

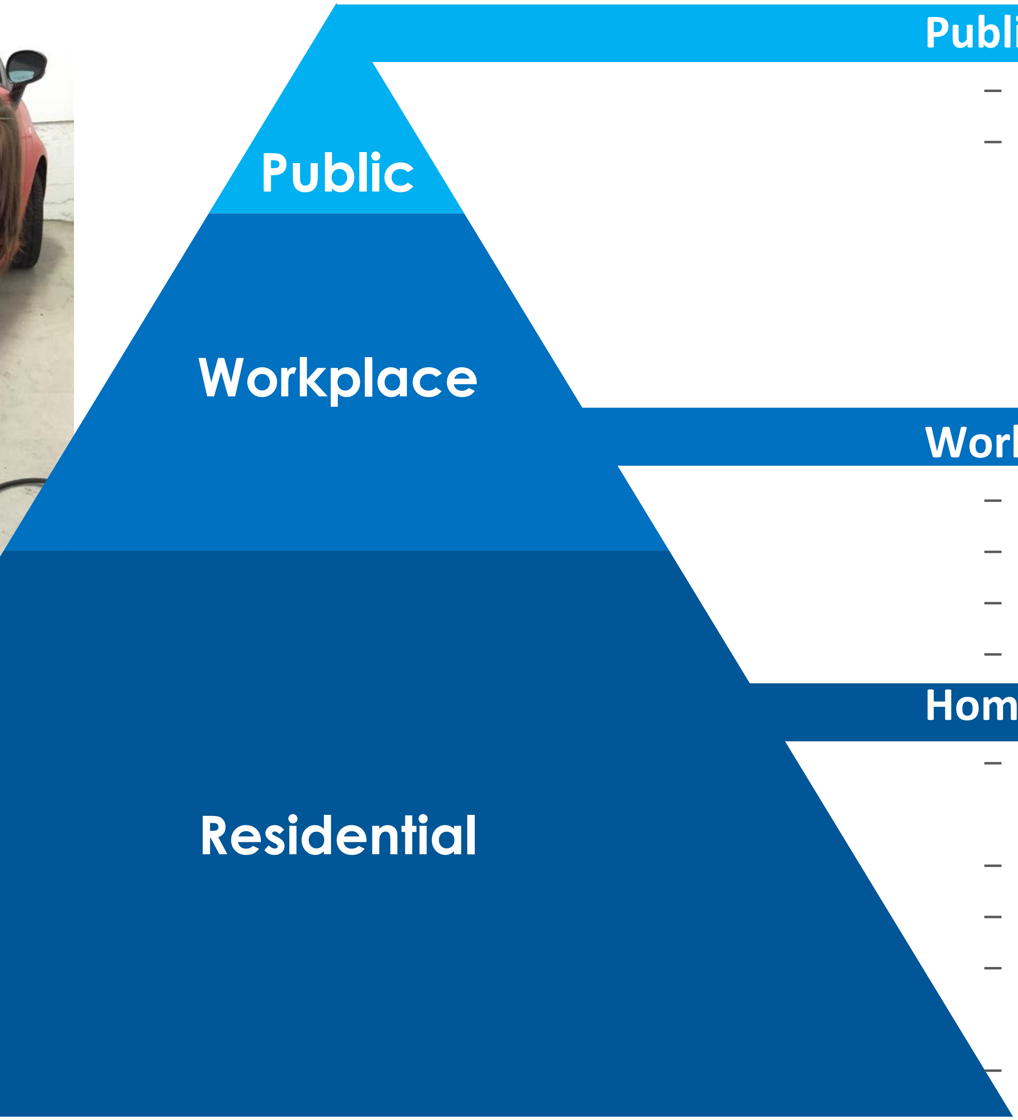
2021 Rivian R1T BEV

2020 Toyota RAV4 Prime PHEV

Photos: Cedric Daniels, Alabama Power, a division of Southern Company (January 2020); Dan Bowermaster EPRI (November 2019)

The bulk of EV charging in US will be done at home and work (AC)

Public charging is largely DC fast charging



Public (DC) charging (~5-10%) – *SRP, 2018 3%*

- Necessary for adoption of BEVs (not PHEVs)
- Four challenges:
  1. Separate networks
  2. Different plugs
  3. Infrastructure costs, rates, utilization
  4. Increasing power levels

Workplace charging (~15%) – *SRP, 2018 16%*

- Extends electric range of PHEVs, short- range BEVs
- Minimal distribution grid impacts
- One plug
- Challenges with parking and accessibility

Home charging (75-80%) – *SRP, 2018 81%*

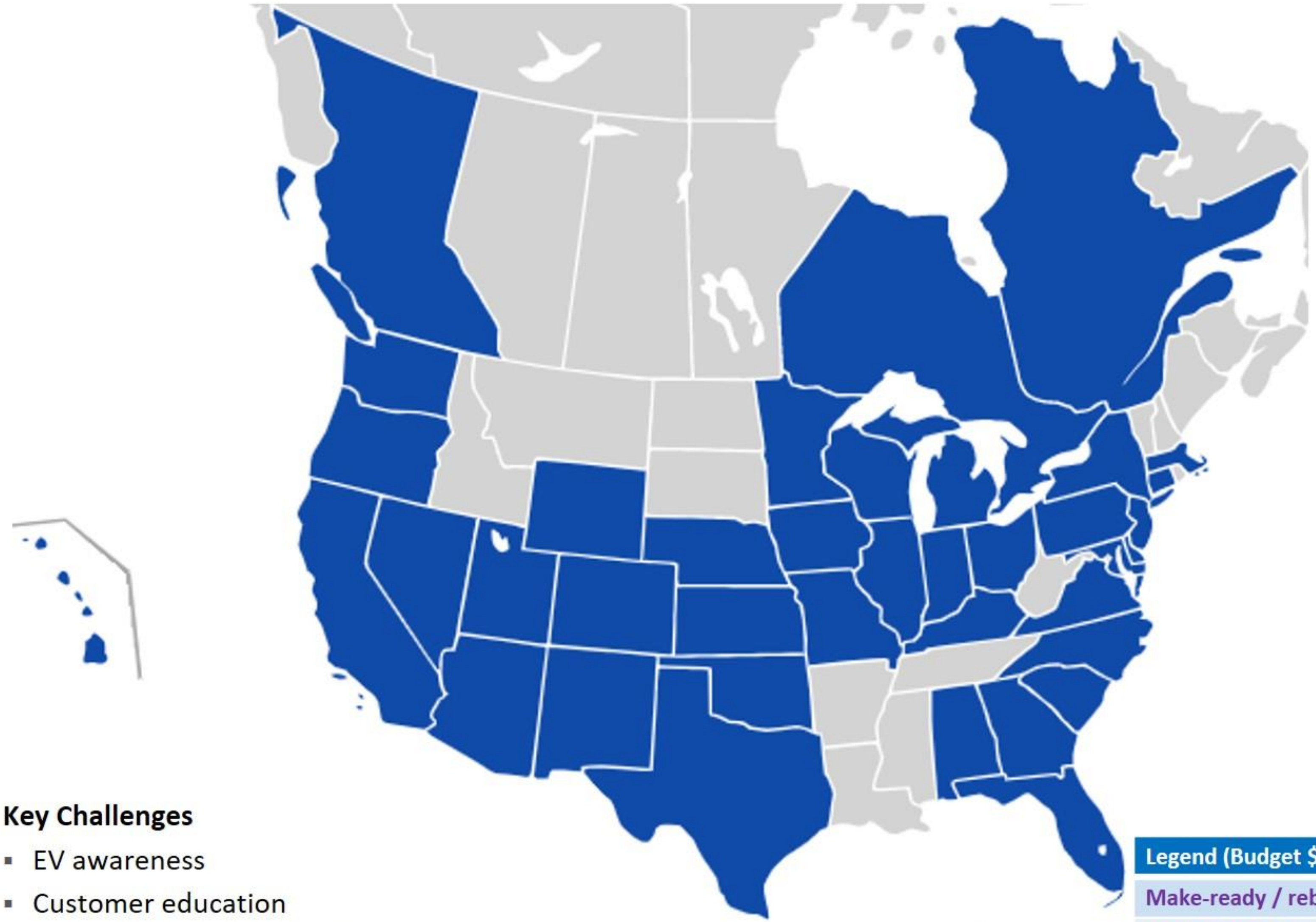
- Many customers charge at 120V AC or use an existing 240V dryer outlet
- Minimal distribution grid impacts
- Existing infrastructure companies serve this market
- Opportunities for TOU rates, smart charging, and further customer study
- ~2,800 kWh/residential EV/year

The EPRI Charging pyramid, M. Duvall, EPRI, circa 2007

Electric Vehicle Driving, Charging, and Load Shape Analysis: A Deep Dive Into Where, When, and How Much Salt River Project (SRP) Electric Vehicle Customers Charge

North American utilities are proposing ~$3B in EV charging infrastructure

Hawaiian Electric $2.0M
Seattle City Light $2.2M
Avista $3.1M
Puget Sound Energy $15.5M
PGE $19.1M
Pacific Power $4.6M
PG&E $130M $284M
Southern California Edison (An Edison International® Company) $22M $375.7M $760M
LA DWP Los Angeles Department of Water & Power $400M
SDG&E (A Sempra Energy utility) $45M $244M
NV Energy $15M
TEP $2.2M
Rocky Mountain Power $10M
Xcel Energy $23.7M
DTE Energy $13M
Consumers Energy Count on Us $10M
Austin Energy $3.2M
Tri-State Generation and Transmission Association, Inc. $2M



$10.0M Hydro Québec
$20M Ontario
$43.5M conEdison
$45M Eversource Energy
$30M nationalgrid
$250M New York Power Authority
$9M Narragansett
$1.7M delmarva power
$14.9M atlantic city electric
$15M pepco
$364M PSEG We make things work for you.
$3.7M ipl an AES company
$10.0M American Electric Power
$0.1M Boundless Energy
$11M Ameren
$5.6M KCP&L
$0.5M LG&E KU PPL companies
$10.45M Georgia Power
$1.5M Alabama Power
$0.4M Gulf Power
$8M $72M Duke Energy

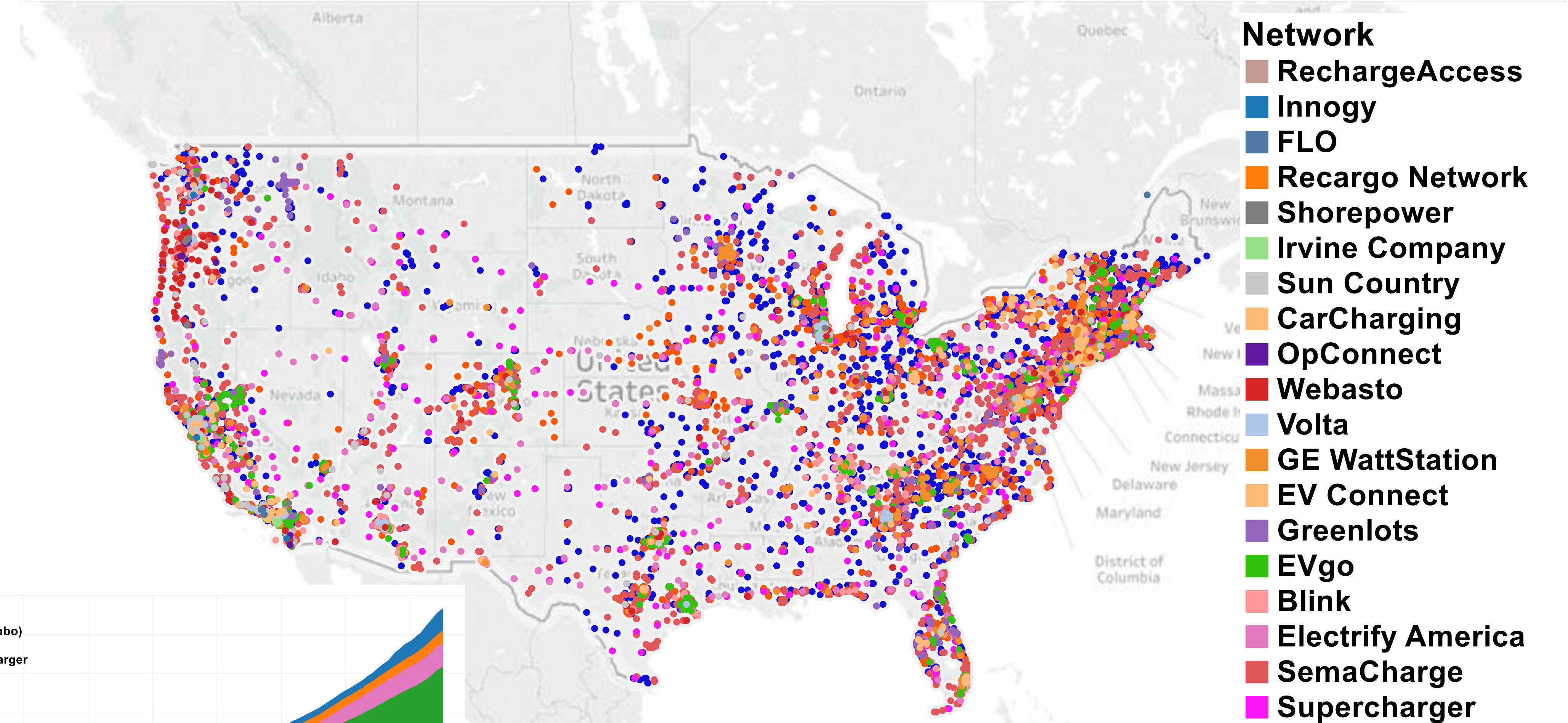
Key Challenges

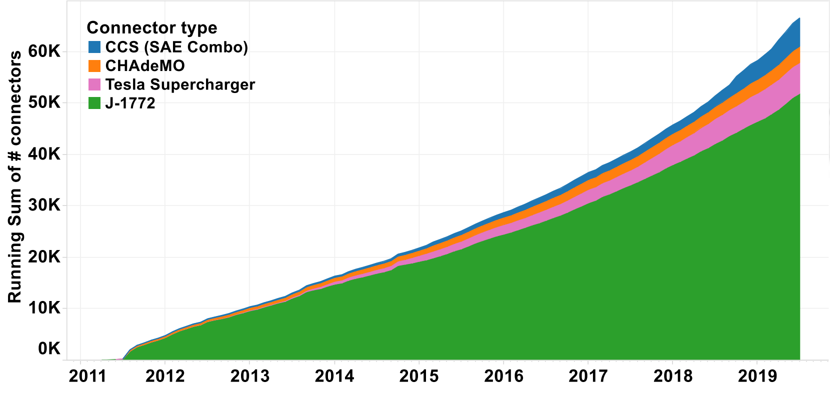
- EV awareness
- Customer education
- Easy and reliable public charging infrastructure (to find, access, use, and pay)

Legend (Budget $)
Make-ready / rebate
Utility-owned
Hybrid

Updated: 4/13/2020, Source: North American Utility Electric Transportation Charging Infrastructure Program Overview – 2019 status

Public Charging Infrastructure Density is Increasing

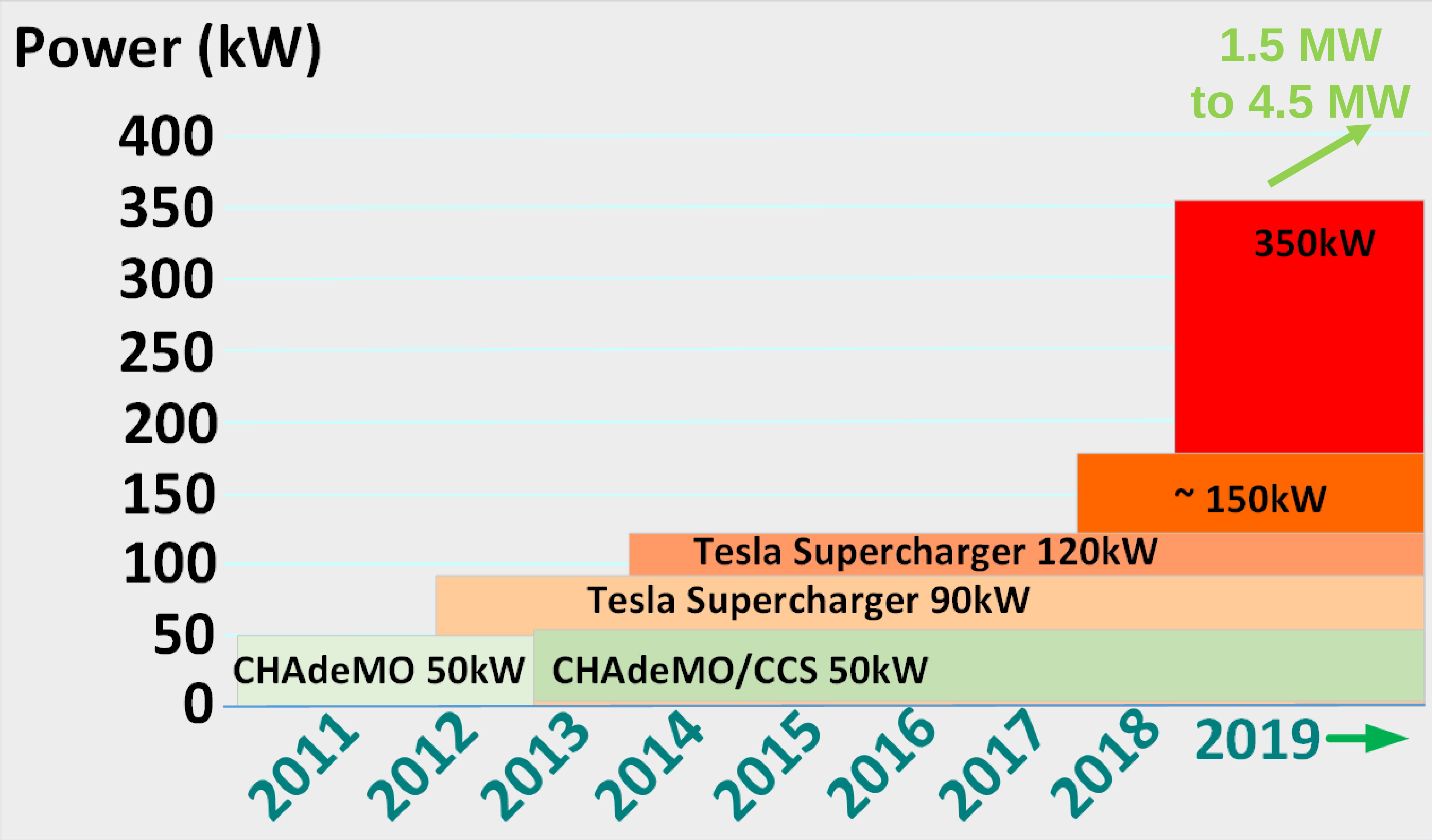




Source: PlugShare, February 2020

DC charging power is increasing

Market trends are leading to higher power DC fast charging



And here come the really big EVs

Photo credits: Mark Kosowski, Dan Bowermaster

V2G Overview

State of the technology April 2020

- What V2G can do to manage grid impacts of charging?
- How soon is V2G likely to be possible?
- What are the unknowns of V2G?
- What are the challenges of V2G related to technology/payment/battery health?

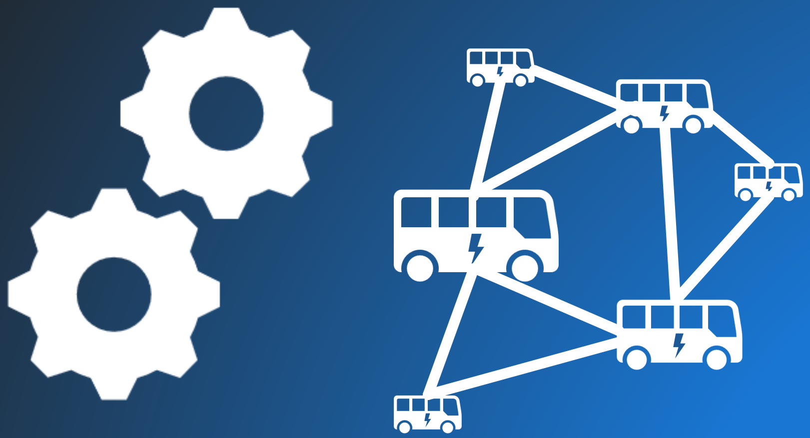
- Bottom line: how does V2G make sense for the customer as well as the grid, and how does it scale?

Research Question Categories

- Bus Operations
- Customer Satisfaction
- Environmental Impact
- Charging Operations
- Distribution Impacts
- Transmission Services
- Cost vs. Benefit

Research Question Evaluation Methods

- Strategy
- Design
- Cost-Benefit Analysis
- Simulation
- Survey
- Data Collection
- Active Testing



Bus Operations

1. How should bus routing be optimized considering timing, efficiency, and battery capacity (esp. during cold weather)?
2. How many buses are required to serve the territory effectively?
3. How to accommodate after/hours programs and sporting events?
4. How to optimize bus (passenger) capacity, battery size, route length, and travel time?
5. What is the degradation of the bus batteries due to providing grid services along with normal operations?

Customer Satisfaction

6. How reliable and available are electric buses compared to diesel?

7. How do electric buses affect the local community (noise, local air quality, safety, etc.)?

8. What is the total cost of ownership of the electric buses compared to diesel?

9. How does the bus driving experience change in terms of daily operations, training, etc?

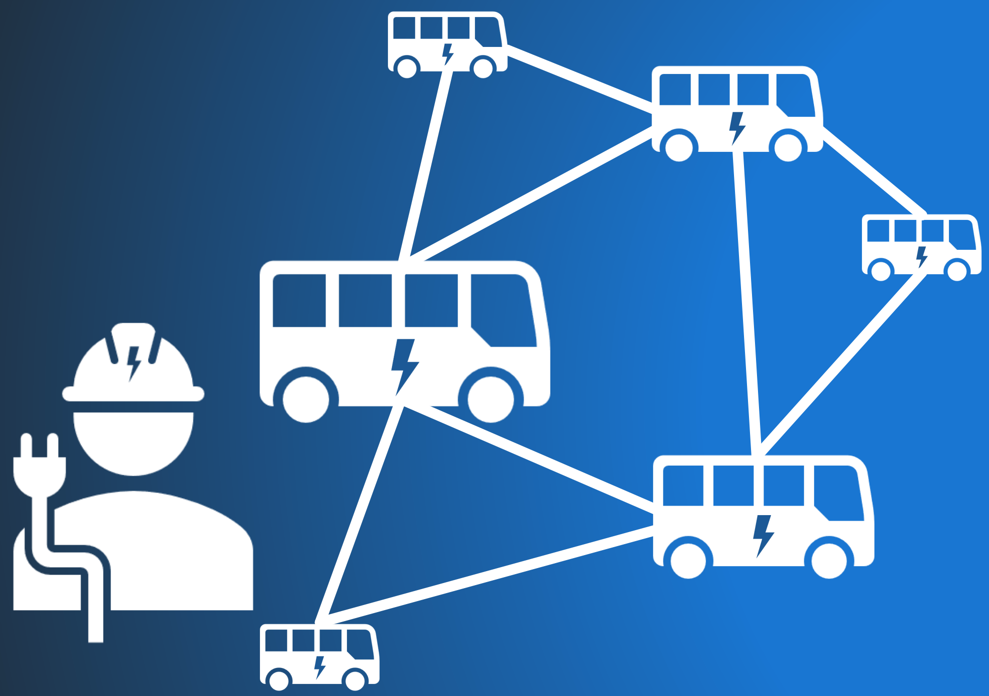
10. What challenges exist for installing new charging infrastructure (timing, land use, aesthetics)?

Environmental Impacts

11. How much do electric buses reduce the carbon intensity of school transportation?

12. How much do electric buses reduce local particulate emissions (NO_x, SO_x)?

13. What are the environmental lifecycle implications and disposal options of electric buses and chargers?



Bus Charging

14. How should bus depots schedule and operate charging for both turnaround and grid services?

15. How are different charging types and rates best combined?

16. What type of backup or local generation is needed to ensure reliable bus operation?

Distribution System Impact

17. How to best manage any voltage or thermal issues on existing infrastructure caused by additional bus load?

18. How to best utilize the V2G charger capacity (active and reactive) to support the distribution system?

19. How to best select the interconnection location (electrically) for minimal impact and maximum grid benefit?

20. What additional infrastructure (transformers, lines, and or substations) will be required to serve electric buses?

21. Can V2G be utilized to defer other distribution system investments?

22. How to best structure the interconnection process and system commissioning for V2G units?

Transmission Services

23. What is the normal (baseline) charging profile for defining grid services?

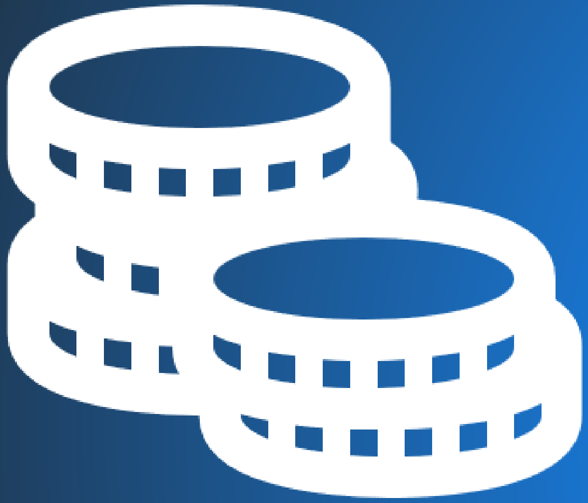
24. How should buses be aggregated to bid into the PJM market?

25. Are buses capable of high-speed services such as frequency regulation (AGC)?

26. How much bus capacity can be reasonably committed as reserves?

27. Would buses be more effective as demand response or energy storage in the market?

28. What is the benefit of using buses for energy arbitrage during normal operation?



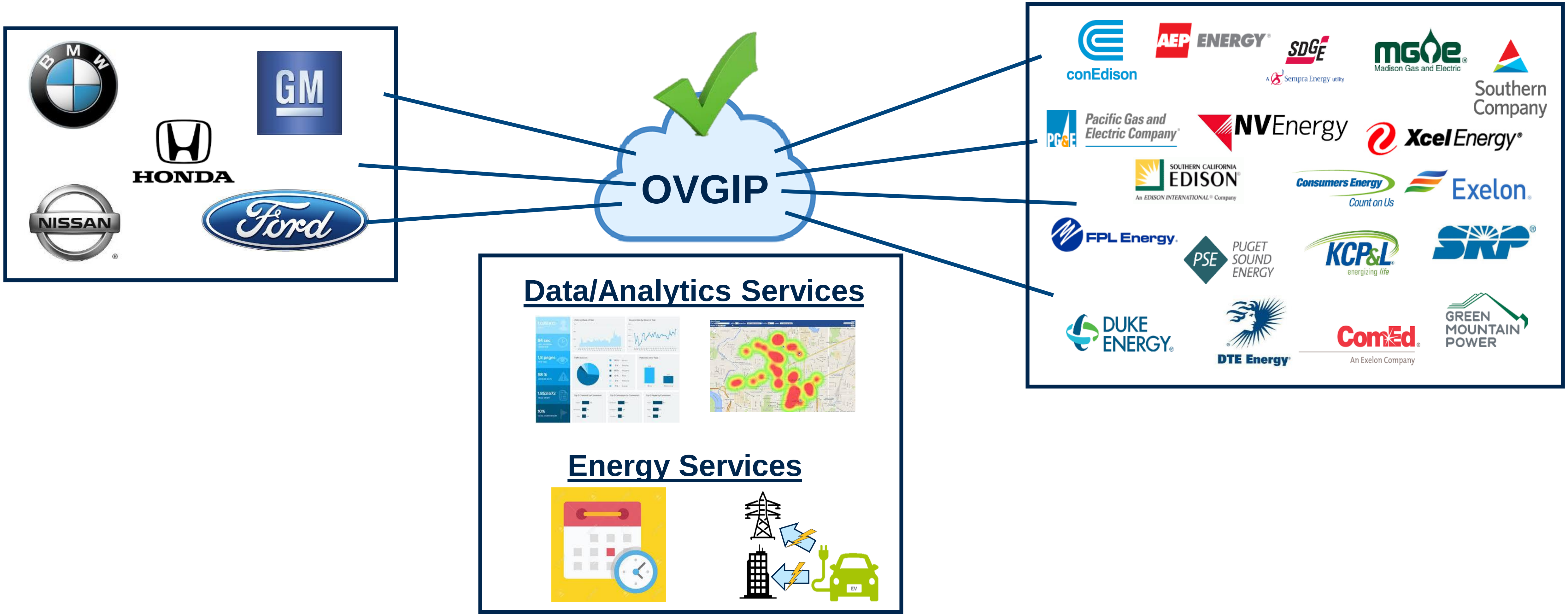
Study of Cost vs. Benefit

29. What is the overall cost-benefit of converting to electric buses?

30. How would these benefits change over time and with scale?

What about V1G? Open Vehicle-Grid Integration Platform

Solves the Many-to-Many problem



Business Efficiency for automotive OEMs and Utilities

Source: Dave McCreadie (Ford Motor Company); Adam Langton (BMW).

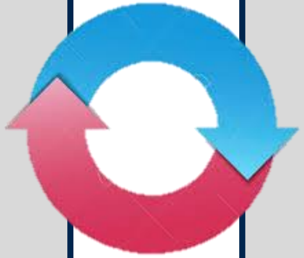
Open Vehicle-Grid Integration Platform Pillars

OVGIP

EV-Grid Services

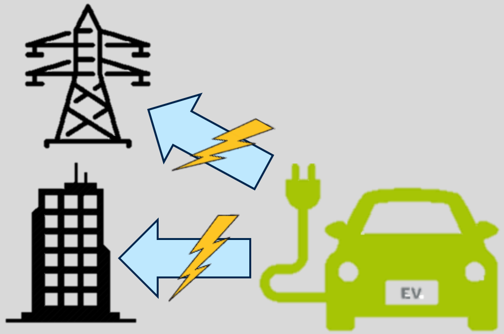
Data/Analytics Services

- ❑ EV Charging: When? / Where? / How much?
- ❑ Predictive analytics



Energy Services

- ❑ Managed Charging Schedules
- ❑ EV as power supply back to Building/Grid



Utilities, Regulatory Agencies, Cities

Utilities, Regulatory Agencies, Building/Facility

Source: Dave McCreadie (Ford Motor Company); Adam Langton (BMW).

Lessons Learned from the past two decades

EVs and charging

- EV technology improvements
- Decreased battery costs
- Impact of policy and incentives
- Importance of customer choice
- Compelling emotional reasons to drive an EV
- Charging can be as easy a 120V wall outlet
- Autonomous driving still very challenging

Looking ahead to 2040

Numerous key questions remain

- Structure
- Options
- Ownership model
- Customer experience
- Roles

Photo credit: Dan Bowermaster, February 2019, EPRI

EPRI EV Resources

Technical Reports:

- The Impact of Incentives on Electric Vehicle Adoption: National Average Results
- Electric Vehicle Driving, Charging, and Load Shape Analysis for Tesla Drivers: A Deep Dive Into Where, When, and How Much Salt River Project (SRP) Tesla Electric Vehicle Customers Charge

Presentations:

- Commercial and Industrial Electric Transportation: Presentation to Colorado EV Coalition

Case Studies/Quick Reads:

- Fast Charging in a Rural Interstate Corridor: Southern California Edison Case Study
- Fast Charging in a Mixed-Use Urban Redevelopment Community: Georgia Power – Atlantic Station Case Study
- DC Fast Charging at Busy Interstate Service Plaza: Eversource Case Study
- EPRI Electric Transportation Hotline: EV Battery Recycling and Rare Earth Metals
- Consumer Guide to Electric Vehicles

Photo credit: Dan Bowermaster, February 2019, EPRI

Together…Shaping the Future of Electricity

Audience Questions

Does the working group have any additional questions for the panel?

Peer Discussion – Commissioners and Commission Staff Only

Facilitators

- Working Group Chair Maria Bocanegra and Illinois Commerce Commission Staff
- Working Group Vice-chair Jason Stanek and Maryland Public Service Commission Staff

Discussion Questions

1. Do you expect managed charging to play a large role in managing EV load? Why or why not?

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3. What barriers to managed charging pilots or large-scale programs exist? What additional information would you like to see?
4. Do you expect V2G to play a large role in managing EV load? What is the largest roadblock for widespread V2G implementation (e.g. battery health, economics, technical challenges, etc.)?

Announcements

May Meeting:

- Topic: *Ensuring equity: infrastructure buildout and impact on rates*
- **May 26, 3:00 – 4:30pm ET**
- Speakers and agenda to come

EVSWG Listserv: NARUC-EVSWG@lists.naruc.org

Presentations and recordings of past EVSWG events:
www.naruc.org/cpi/cpi-past-events/