MPSC EV Technical Conference

January 25, 2024

MPSC
MICHIGAN PUBLIC SERVICE COMMISSION

Keynote Speakers
Auto Industry Perspective in Scaling EV Deployment and Charging

Dan Bowerson, Auto Innovators

Mike Maten, GM

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ALLIANCE FOR AUTOMOTIVE INNOVATION

Michigan Public Service Commission EV Technical Conference

Auto Industry Perspective in Scaling EV Deployment & Charging

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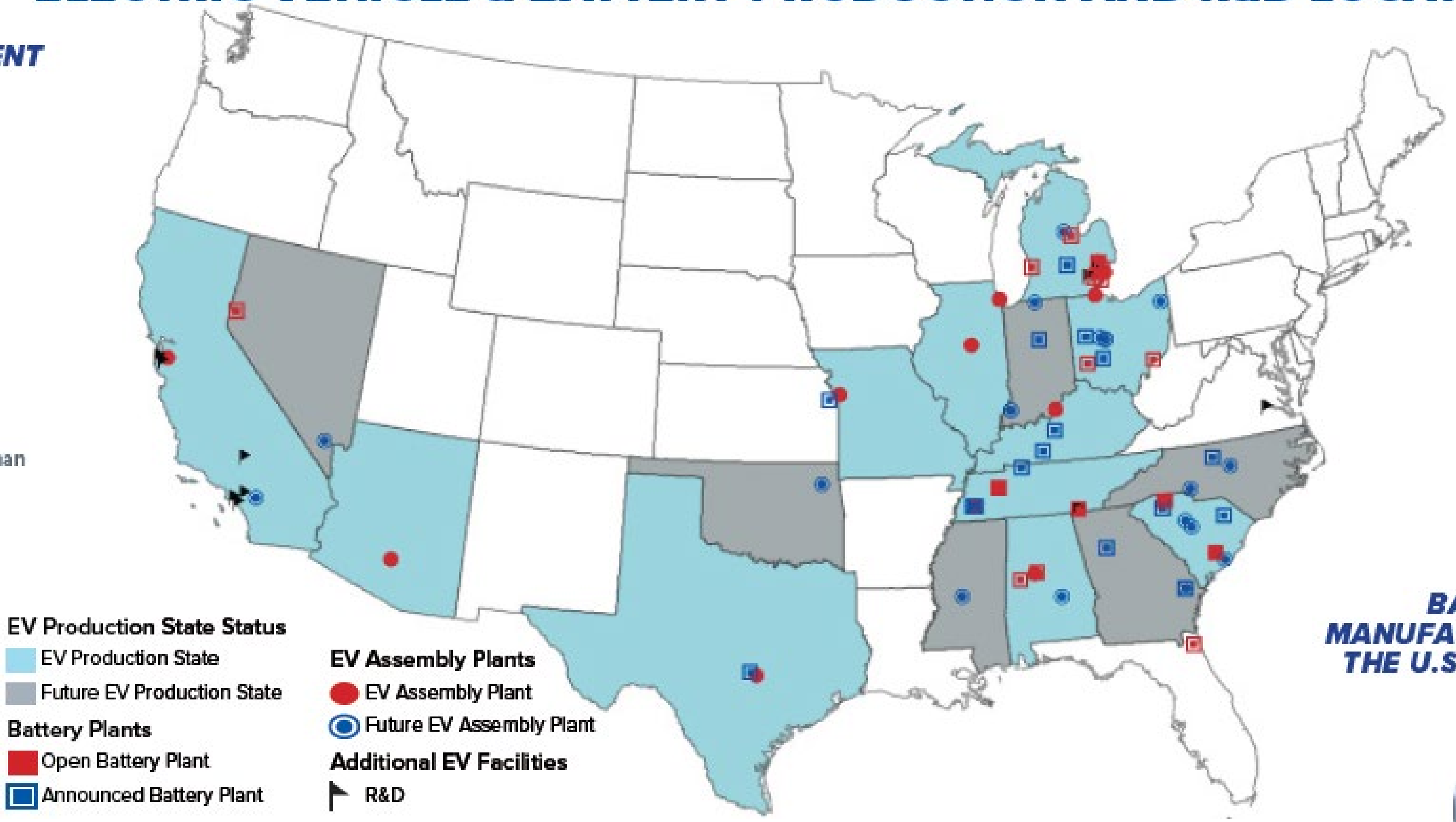
State of the EV Industry

The Future is Electric

ELECTRIC VEHICLE & BATTERY PRODUCTION AND R&D LOCATIONS

RESEARCH & DEVELOPMENT

In 2019, the National Science Foundation estimated the auto industry spent more than $23B in R&D in the U.S. alone.



BATTERY PLANT MANUFACTUING CAPACITY IN THE U.S. INCREASING 649%

In 2020, there was about 630 GWh of global battery production capacity, which is expected to grow about 2,300 GWh by 2025.

ELECTRIFYING INVESTMENTS

$125B

On a global scale, automakers are planning to spend an estimated $1.2 trillion through 2030 to develop and build new battery-powered vehicles.

From new assembly plants and battery factories to retooling and upgrading existing facilities, the automotive industry is investing in vehicle electrification.

Since 2017, automakers and thier battery partners have already committed to investing over $125 billion specifically in the U.S. to electrify products, and the U.S. continues to gain investment dollars as more of these planned investments are allocated.

EV Market Share (PHEVs, BEVs, and FCEVs)

EV Sales by Segment

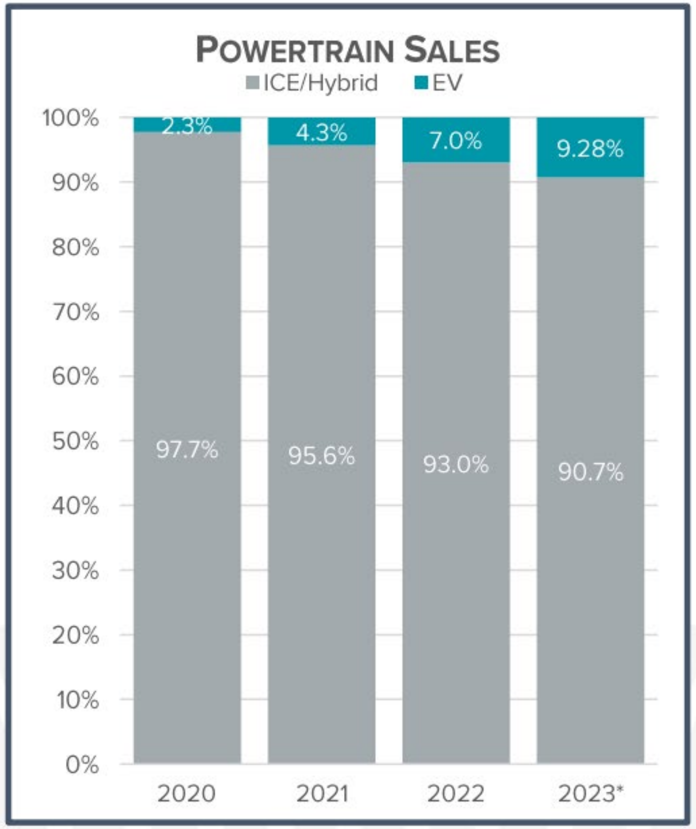
EV MODEL AVAILABILITY

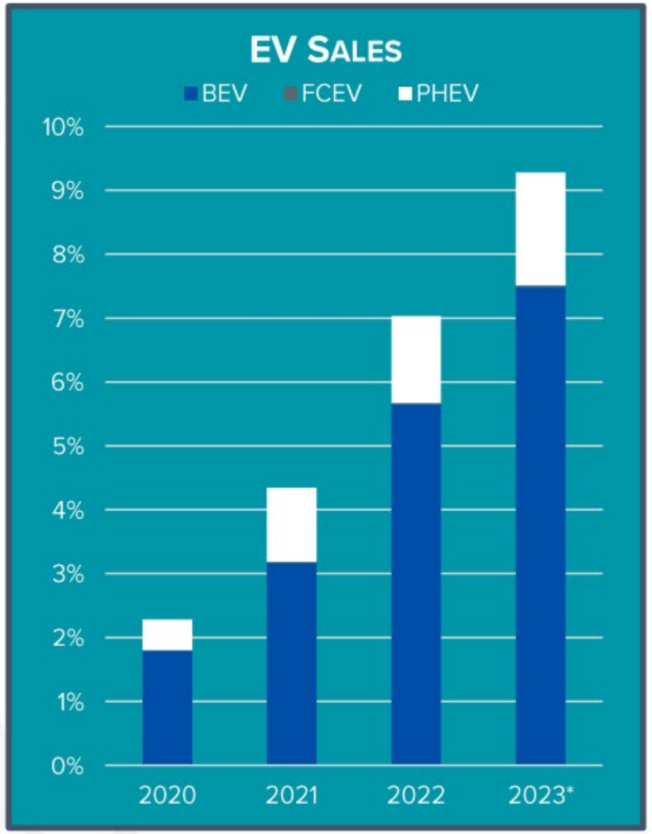
111 Vehicle Models Sold in Q3 2023:

61 Battery Electric Vehicles
- 21 Cars
- 33 Utility Vehicles
- 4 Pickups
- 3 Vans

48 Plug-in Hybrid Vehicles
- 17 Cars
- 30 Utility Vehicles
- 1 Van

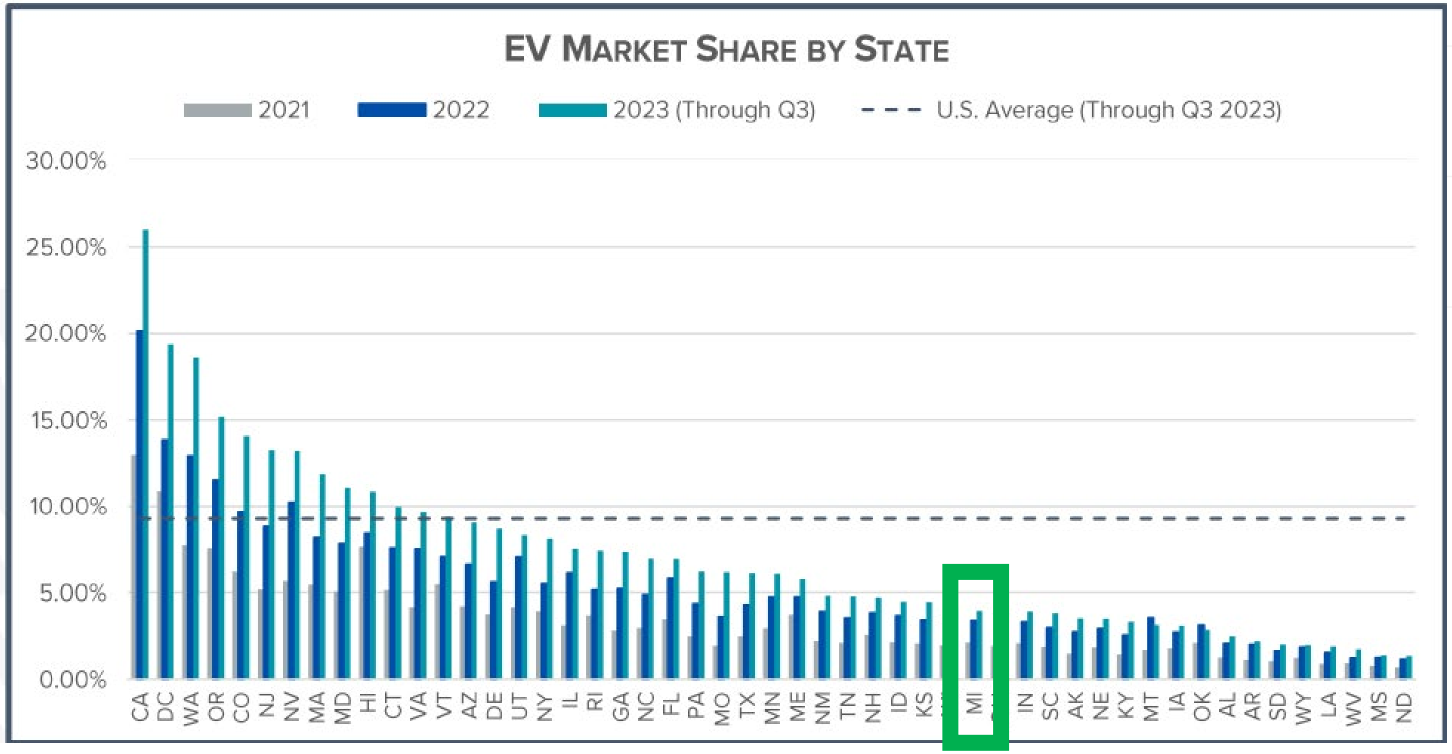
2 Fuel Cell Electric Vehicles
- 1 Car
- 1 Utility Vehicle





*2023 through Q3

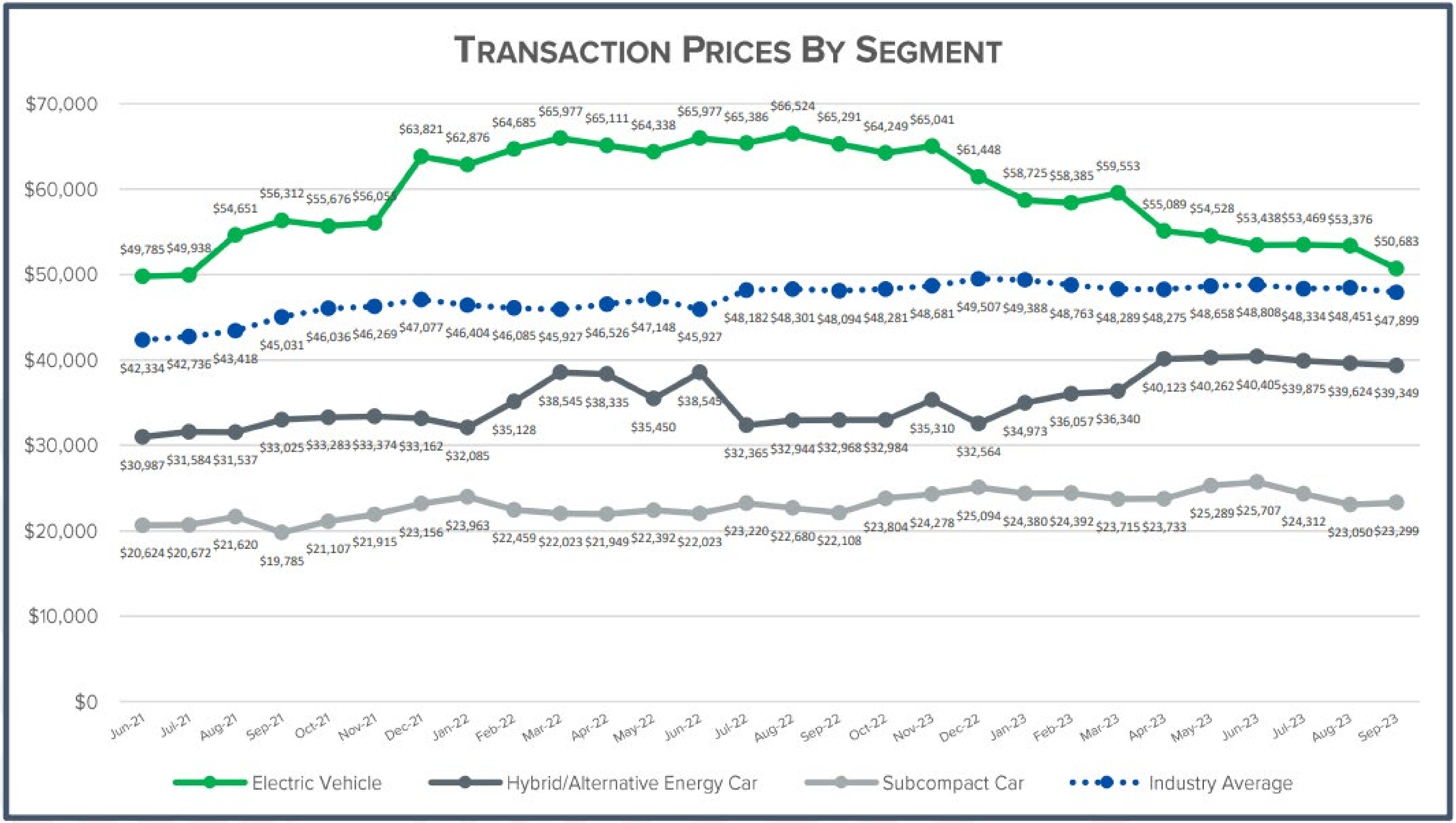
EV Market Share by State

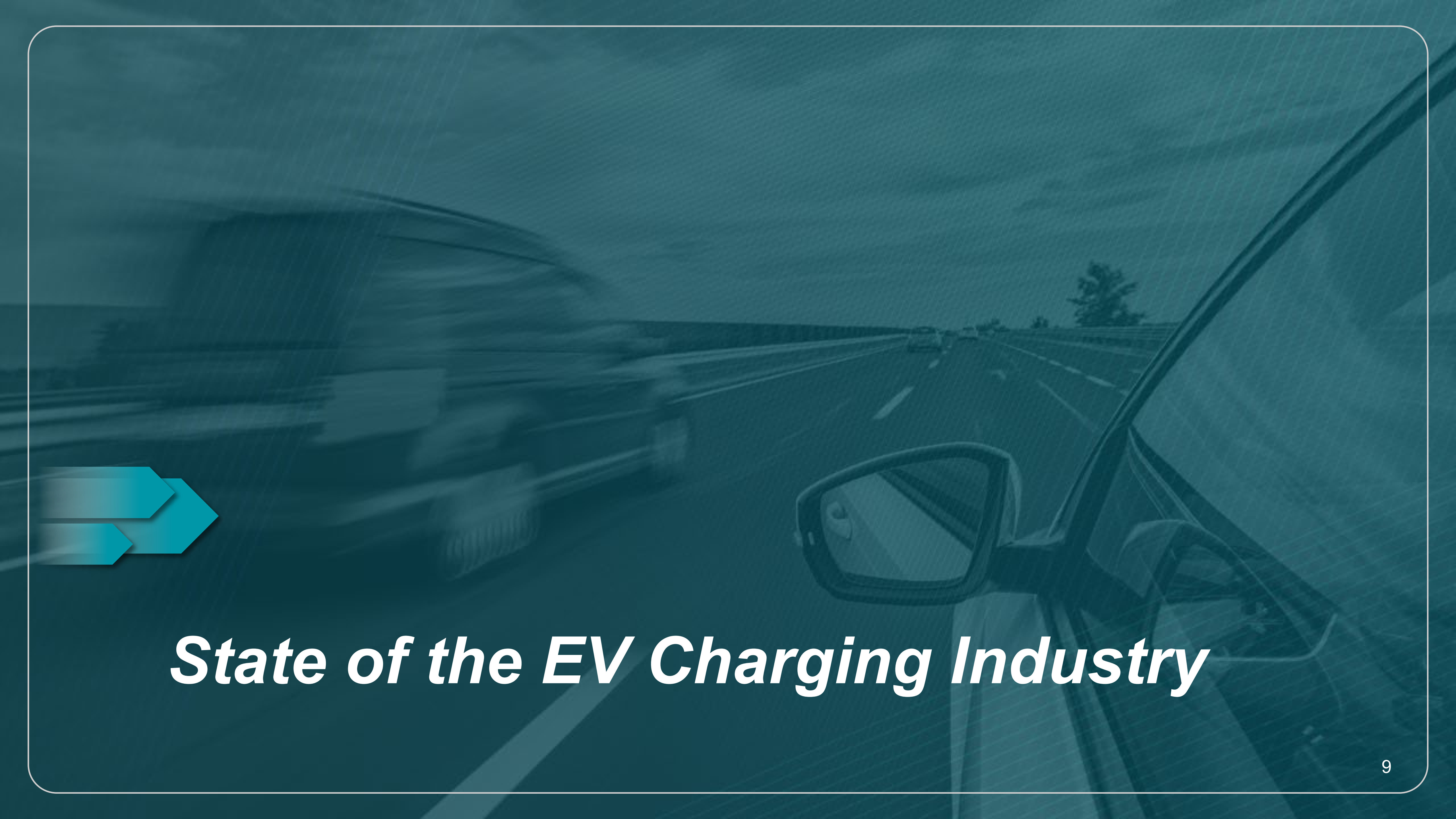


YEAR TO DATE (2023 THROUGH Q3) EV MARKET SHARE BY STATE[6]

1	CA*	25.98%	11	CT*	9.95%	21	NC	6.96%	31	ID	4.47%	41	MT	3.12%
2	DC	19.36%	12	VA*	9.68%	22	FL	6.95%	32	KS	4.46%	42	IA	3.08%
3	WA*	18.60%	13	VT*	9.37%	23	PA	6.23%	33	WI	4.08%	43	OK	2.84%
4	OR*	15.15%	14	AZ	9.06%	24	MO	6.20%	34	MI	3.96%	44	AL	2.46%
5	CO*	14.07%	15	DE	8.71%	25	TX	6.14%	35	OH	3.95%	45	AR	2.19%
6	NJ*	13.24%	16	UT	8.33%	26	MN*	6.09%	36	IN	3.91%	46	SD	2.02%
7	NV*	13.18%	17	NY*	8.13%	27	ME*	5.80%	37	SC	3.83%	47	WY	1.98%
8	MA*	11.86%	18	IL	7.54%	28	NM	4.82%	38	AK	3.53%	48	LA	1.89%
9	MD*	11.06%	19	RI*	7.42%	29	TN	4.79%	39	NE	3.51%	49	WV	1.73%
10	HI	10.84%	20	GA	7.35%	30	NH	4.71%	40	KY	3.31%	50	MS	1.36%
												51	ND	1.32%

EV Transaction Prices





State of the EV Charging Industry

Infrastructure by State

Public Charging Outlets And Registerd EVs (as of 9/30/2023)

	EV Level 2	EV DC Fast	H2** Fueling	Total	Percent EVs of Total VIO***	Share of Registered EVs****	EVs Per Charger	EVs Per 10K Residents
AK	75	28	-	103	0.53%	0.08%	30	41.24
AL	523	299	-	822	0.29%	0.37%	18	30.45
AR	665	108	-	773	0.28%	0.19%	10	25.47
AZ	2,252	909	-	3,161	1.46%	2.52%	32	140.89
CA*	31,568	9,710	58	41,336	4.56%	35.52%	34	359.68
CO*	3,908	857	-	4,765	1.81%	2.48%	21	174.58
CT*	1,516	391	-	1,907	1.34%	1.02%	21	114.18
DC	907	48	-	955	2.96%	0.25%	11	144.74
DE	266	171	-	437	1.10%	0.25%	23	103.80
FL	6,296	2,041	-	8,337	1.32%	6.23%	30	117.13
GA	3,359	950	-	4,309	0.96%	2.27%	21	86.29
HI	703	47	1	751	2.49%	0.71%	38	199.40
IA	486	280	-	766	0.40%	0.32%	17	40.35
ID	256	110	-	366	0.57%	0.28%	31	64.49
IL	2,251	920	-	3,171	1.08%	2.74%	35	86.24
IN	877	439	-	1,316	0.51%	0.79%	24	47.50
KS	854	203	-	1,057	0.48%	0.35%	13	48.31
KY	544	177	-	721	0.33%	0.34%	19	30.70
LA	406	215	-	621	0.27%	0.25%	16	21.89
MA*	5,559	633	-	6,192	1.76%	2.41%	16	139.71
MD*	3,511	840	-	4,351	1.62%	2.07%	19	137.55
ME*	769	216	-	985	0.95%	0.32%	13	94.75
MI	2,239	640	-	2,879	0.70%	1.50%	21	60.08
MN*	1,420	384	-	1,804	0.82%	1.07%	24	76.44
MO	2,099	361	-	2,460	0.56%	0.81%	13	52.68
MS	281	112	-	393	0.15%	0.11%	12	15.37
MT	169	152	-	321	0.37%	0.14%	18	54.56
NC	2,462	900	-	3,362	0.83%	1.99%	24	76.95

Q3 2023*

Level 2: 116,692 EVSE Ports

DC Fast: 34,611 EVSE Ports

***U.S. Total:** 151,303 EVSE Ports*

2030 Projected Need

Level 2: 1,250,000 EVSE Ports

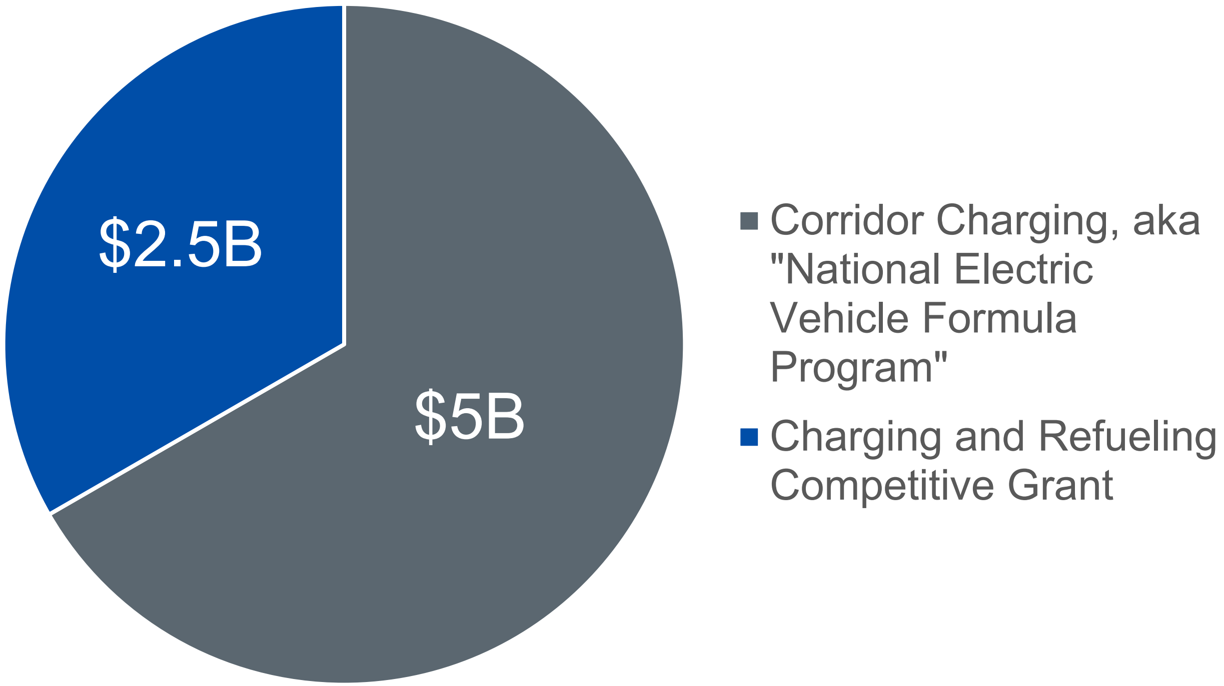
DC Fast: 182,000 EVSE Ports

***U.S. Total:** 1.4 million EVSE Ports*

Sources:
- U.S. Dept. of Energy AFDC as of 9/30/23
- NREL, *The 2030 National Charging Network Estimating U.S. Light-Duty Demand for EV Charging Infrastructure (2023)*

Bipartisan Infrastructure Law – EV Charging Funding

$7.5B EV Charging Infrastructure Funding



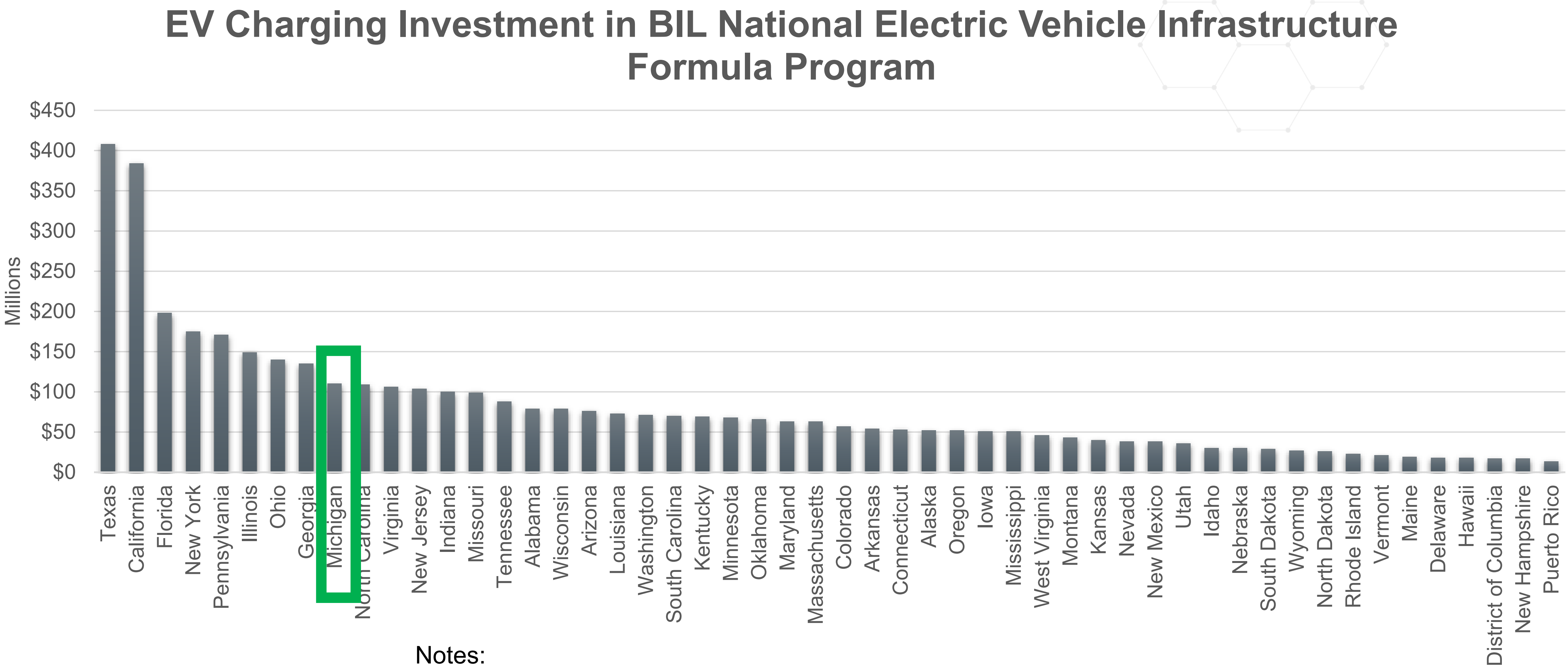
National EV Formula Program

- FY22 – FY26; Federal share = 80%
- Funds allocated to states using formula (23 U.S. Code § 104 subsection (c))
- To be used for EV charging on alternative fuel corridors
  - If alt. fuel corridors fully built out, funding may be used for publicly available chargers
- States submitted plans to DOT on intended funding usage
- DOT and DOE must provide guidance to states to prioritize investments, i.e.:
  - "current and anticipated market demands for [EV] charging infrastructure, including with regard to power levels and charging speed, and minimizing the time to charge current and anticipated vehicles"

Charging and Refueling Infrastructure Grants

- FY22 – FY26; Federal share up to 80%
- Charging *and* hydrogen, propane, and natural gas fueling
- 50% along FHWA-designated Alt. Fuel Corridors & 50% "Community Grants"
- Publicly accessible projects outside of Alt. Fuel Corridors given priority for rural, low income and underserved communities, and multi-unit dwellings

Bipartisan Infrastructure Law – NEVI



Notes:

- Values rounded to the nearest $million.
- Does not take into account $2.5B for competitive grants.
- Source - White House Fact Sheets


EV Opportunities for Utilities

Utility Engagement in EV Charging

Deploying charging infrastructure

- Authorize targeted utility investment in charging infrastructure (including make-ready).
- Draw on lessons learned across the industry to avoid pilot program repetition.
- Direct utilities to develop plans that provide a transportation electrification roadmap.

Planning and Financing Grid Upgrades

- Assess the ability of the current distribution system planning and financing to accommodate the scale of grid upgrades that will be driven by widespread EV adoption
- “Future proof” sites based on input from EVSPs, hosts, and fleet owners.
- Systematic planning for grid upgrades based on expected acceleration of EV adoption.

Vehicle Grid Integration

Rates and managed charging are the key to capturing the benefits of EVs

- Commercial and industrial EV rates
- Time of Use rates (whole house and EV-only)
- Include EVs in Demand Response (DR) programs
- Scale up pilots to full scale
- Build on the experience of other states.

Technology & Standards

- Include options for EV drivers to participate in EV rates and DR programs by leveraging telematics.
- Coordination between utilities and regulators developing submetering standards.
- Programs and policies that compensate EV drivers for exporting power to the grid.
- Streamlined interconnection rules for bidirectional EVs that are consistent and informed by learnings from other jurisdictions.
- Build off successful V2X pilots and demonstrations.

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FOR AUTOMOTIVE
INNOVATION

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EV Infrastructure & Charging

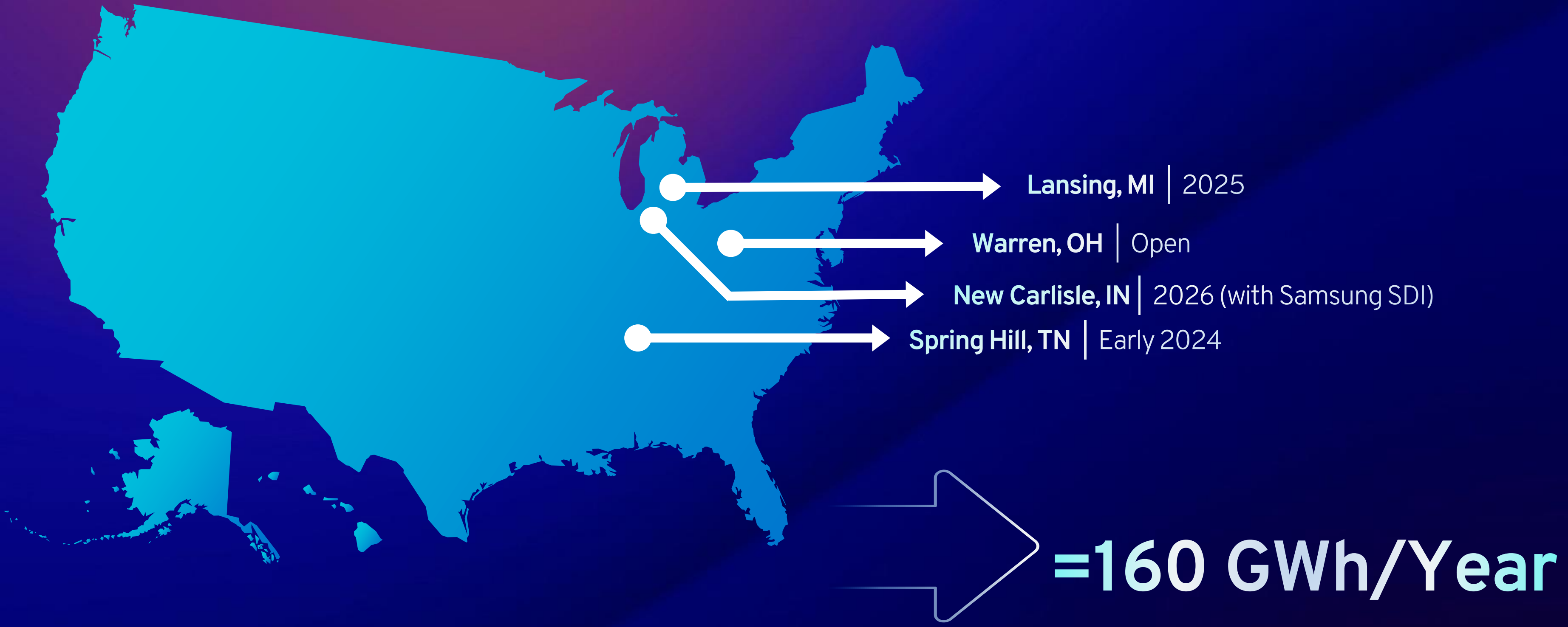
Michael Maten
Director, EV Policy and Regulatory Affairs – General Motors
January 2024

US EV Launches - Ultium

Underpinning our EV launches
in the US is the
Ultium architecture

ultium

EV Battery Cell Plant Investment



expanding access & improving experience

2020	2021	2023	2024+
metro	**home**	**highway**	**NACS**
Support EVgo to build 3,250 DCFC in top 50 metros	Free or subsidized turnkey home installation	Co-invest with PFJ to build 2,000 highway DCFC every 50 miles	Support J3400 (NACS) Expansion, Access to Tesla's Superchargers

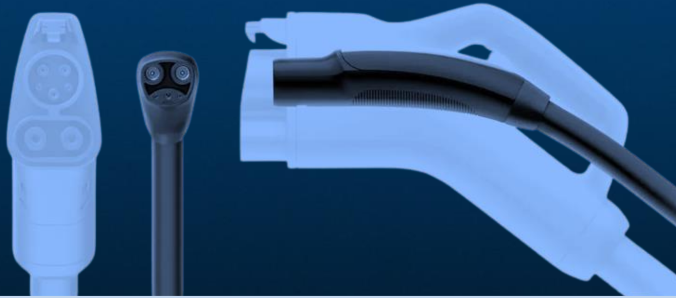
recently announced

Charging Joint Venture, deploying 30,000 DC chargers across North America

gm HONDA BMW STELLANTIS KIA HYUNDAI

NACS Adoption

- **Industry is moving to the North American Charging Standard – SAE J3400**
  – First GM EV with NACS in CY2025
  – SAE released J3400 TIR in December
  – Most of industry has now announced NACS adoption



- **GM customers will be able to access Tesla Superchargers**
  – 2x the fast chargers available today
  – Combined Charging System (CCS)-to-NACS adapter available early 2024

W H Y ?

- **Accelerate convergence to a single standard**
- **Accelerate customer confidence & EV adoption**
- **Improve customer experience with better availability, ergonomics, reliability**

GM Energy Expanding DC Fast Charger Network

EV INFRASTRUCTURE AND GRID INTEGRATION

Policy Opportunities

- Proactive Utility & Grid Planning
- Additional Funding
- Streamlined Permitting & Approval Processes

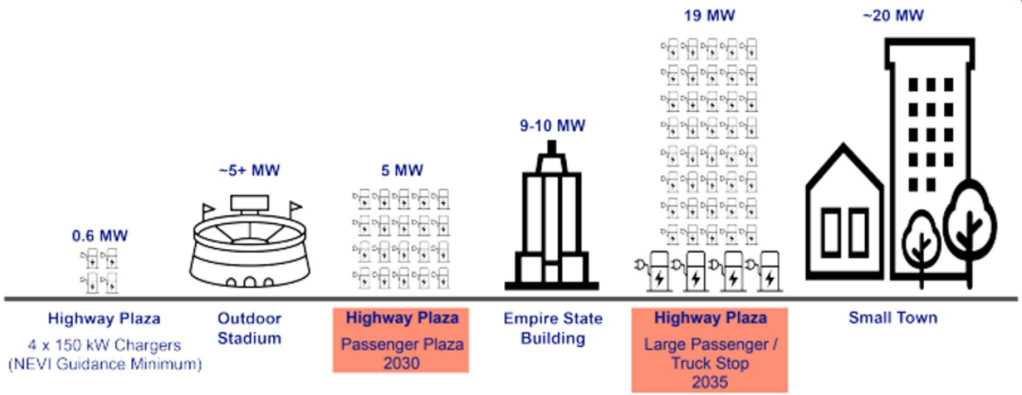
Ongoing Work

- Equipment Standardization
- Charging Reliability & Customer Experience
- Research & Roadmaps

EV INFRASTRUCTURE BUILDOUT: NEEDS AND POLICY CONSIDERATIONS

- **Needs:** DOE calls for **181.5k DCFC by 2030** for light duty
  - Sites can take years to permit, construct, energize
  - Supply chain constraints are adding to delays
- **Today:** Only 37,000 DCFC nationwide
  - Many “charging deserts” remain
  - Reliability, charging speed, queuing are all issues
- **Customer Experience:** deploying chargers is not enough
  - Overall customer experience needs improvement
  - Public charging can be more expensive than gas
- **Utility Role:** utilities and regulators are key partners
  - Demand charges can kill charging business case
  - Utility upgrades can be costly and slow
  - Regulatory construct needs to evolve
- **Policy:** funding is necessary but not sufficient
  - $5B NEVI is a “down payment,” not a panacea
  - State and local policy are key enablers/barriers

Timely Deployment Requires Utility/Regulatory Innovation



Source: National Grid Study, November 2022

- Charging sites often require substantial upgrades on fast timelines
- Proactive upgrades and regulatory approvals may be needed
- Utility practices will need to evolve to enable faster energization

Thank you.

How to Drive Equity in EV Deployment

Shatina Jones
Diversity, Equity and Inclusion Officer, MPSC

Brittany Blair
Research and Industry Strategy Analyst, SEPA

Natalie King
Founder and CEO, Dunamis Clean Energy Partners LCC

Quinn Parker
CEO, Encolor

Komal Doshi
Director of Mobility, Walker-Miller Energy Services

Cici Vu
Associate Director of Climate, DNV

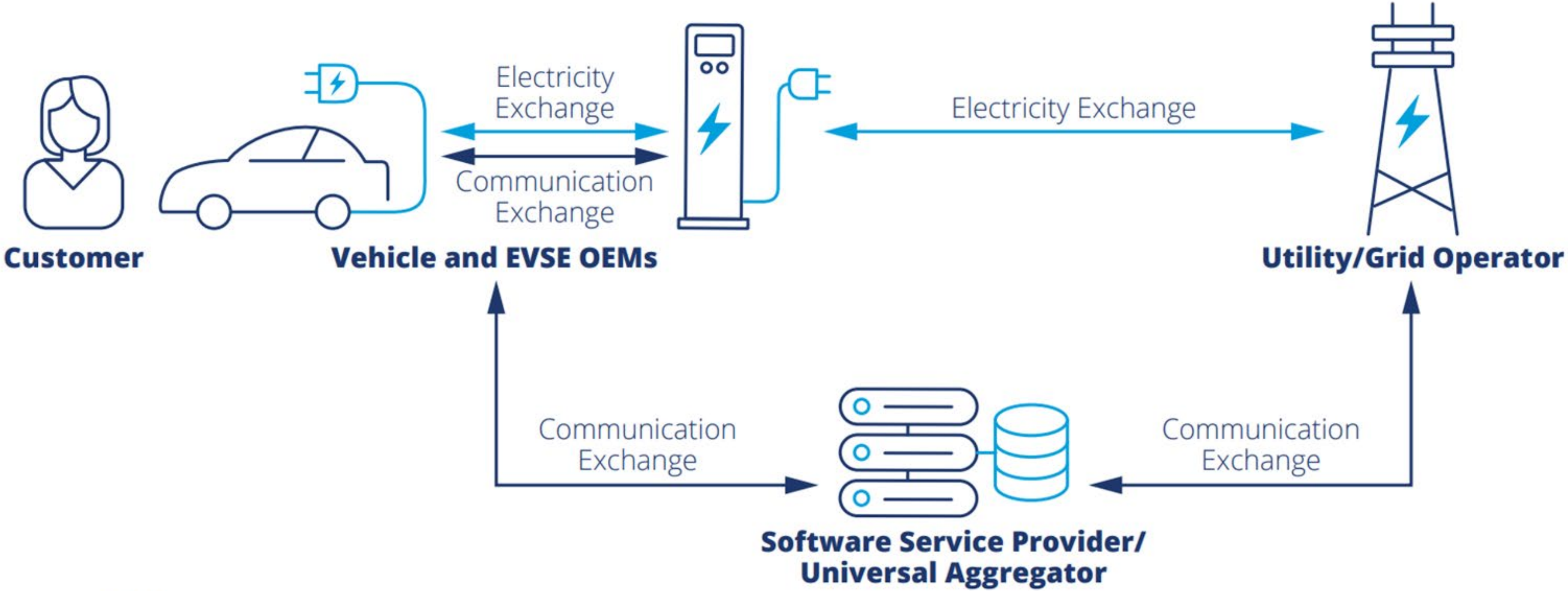
Who is SEPA?

Smart Electric Power Alliance

- A membership organization
- Staff of ~50
- No Lobbying – 501c3
- Founded in 1992
- Unbiased
- Research, Education, Collaboration and Standards
- Technology Agnostic
- Local, State and National Focus

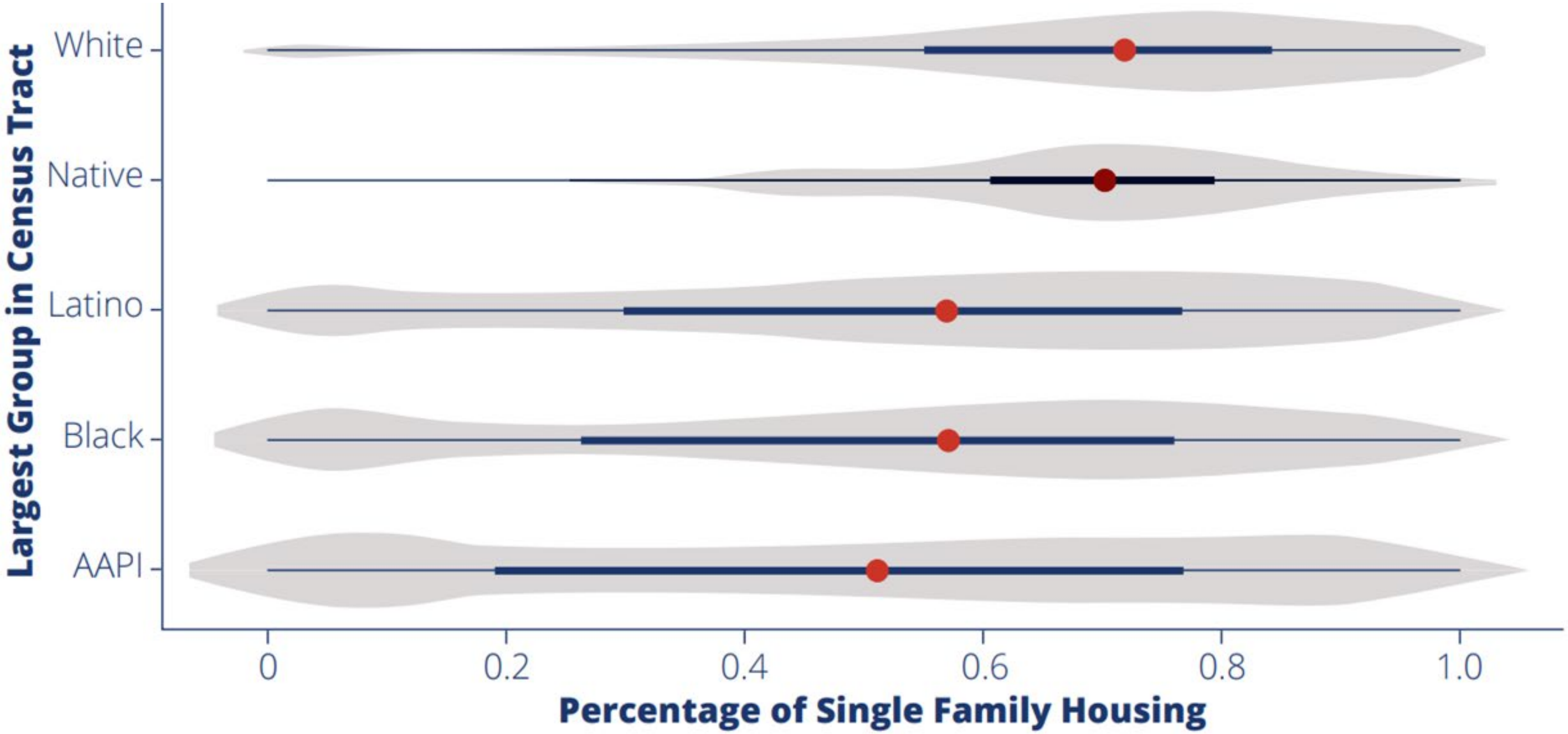
EV Ecosystem

Smart Electric Power Alliance



Source: SEPA. (2023).

Charging Challenges



Source: Brooking Metro, n.d., *Brooking Analysis of 2015-2019 American Community Survey Fiver-year Estimates*. Reformatted by SEPA.

Key Barriers to Equitable EV Adoption

Smart Electric Power Alliance

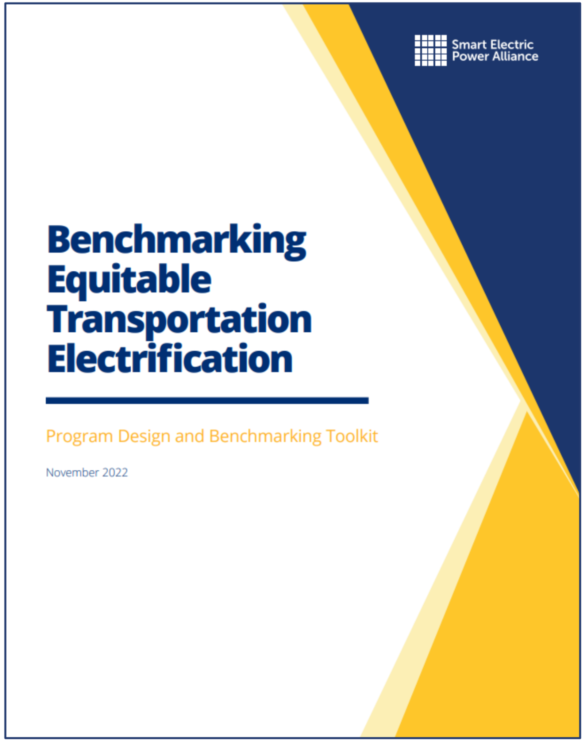
Vehicle, Charger, and Installation Costs

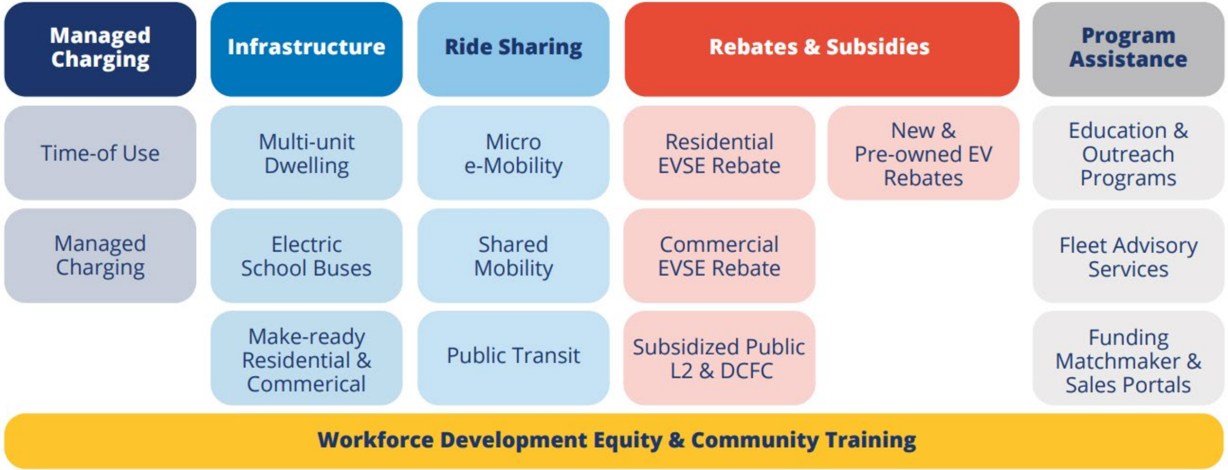
Education

Fair Distribution of Benefits

EV Equity Resource

Smart Electric Power Alliance





Source: SEPA, 2022

Website Link: https://sepapower.org/resource/benchmarking-equitable-transportation-electrification/

DUNAMIS™
CHARGE

- **First African-American, Female-Owned EV Charging manufacturer in the world**
- **Spin-off of Division of Successful 12-year-old Cleantech Company**
- **High-quality EV Charging Solutions 'Made in America'**
- **Focused on Innovation and Sustainability**
- **Committed to Promoting Diversity and Inclusivity in the EV Industry**

Interconnection Opportunities and Obstacles for V2H and V2G

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Interconnection & Distributed Energy Resources Manager, MPSC

Haukur “Hawk” Asgeirsson
Standards Development, IEEE and SAE

Valerie J.M Brader
Shareholder, Rivenoak Law, On behalf of Ford

Steve Letendre, PhD
Senior Director of Regulatory Affairs, Fermata Energy

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Standards for Bi-Directional Electric Vehicles

January 25, 2024

MPSC Electric Vehicle Technical Conference

Hawk Asgeirsson

U.S. DEPARTMENT OF ENERGY BATTELLE

PNNL is operated by Battelle for the U.S. Department of Energy

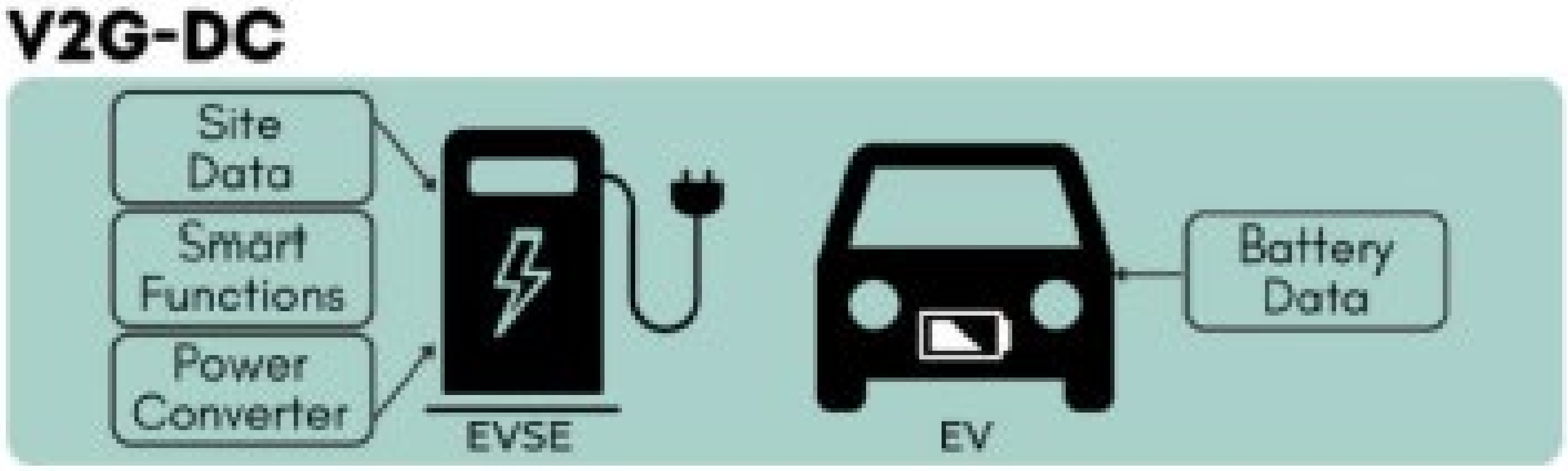
Agenda

- Types of Inverter System for EVs
- Standards for bi-directional EVs (V2G & V2H)
  - Grid standards - IEEE
  - EV standards - SAE
  - Consumer safety standards – UL listed and labeled
- EV Charging Station - EVSE (electric vehicle supply equipment)
  - DC Operation or fast charging
  - AC Operation

EV Capable of bi-directional exchange of power between an EV and an electric power system

Types of Inverter Systems (V2G/V2H)

- V2G-DC the **EVSE contains the grid interactive inverter** that interacts with the EV and the local EPS



- V2G-AC the EVSE interacts with the **on-board EV inverter** and the local EPS

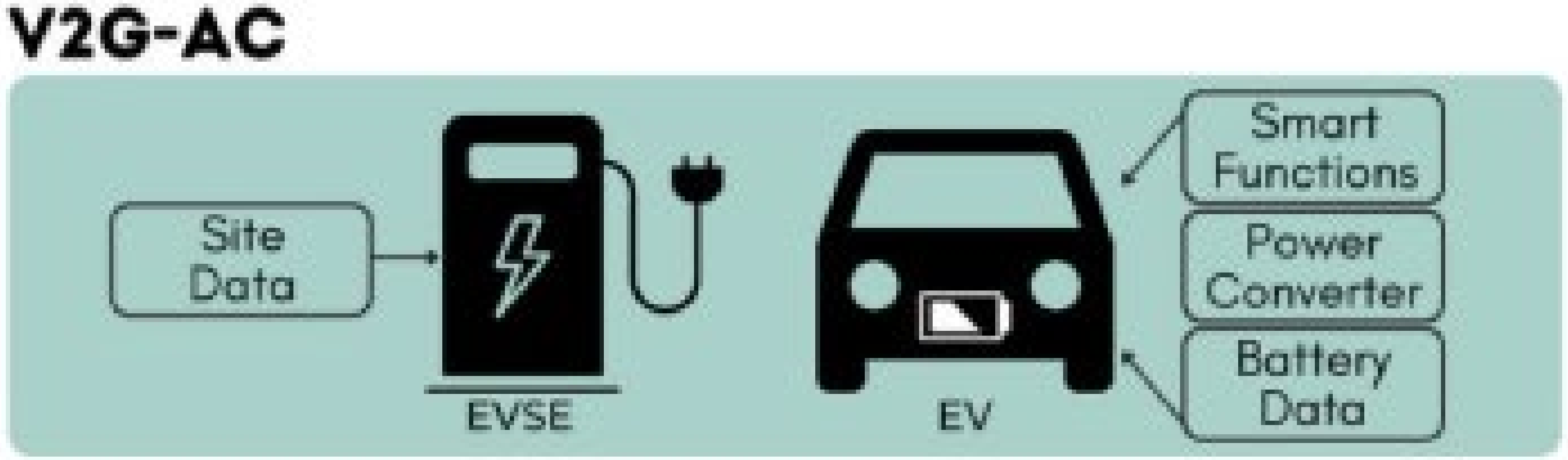


Diagram Source, Interstate Renewable Energy Council (IREC)
https://irecusa.org/wp-content/uploads/2022/01/Paving_the_Way_V2G-Standards_Jan.2022_FINAL.pdf

Key Standards

Table 1: V2G-Applicable Standards by Certification Topic

Scope	Standards & Protocols
Interconnection	IEEE 1547-2018
	IEEE 1547.1-2020
EVSE Safety & Functionality	UL 1741
	UL 9741
Vehicle Functions	SAE J2836/3
	SAE J3072
Communication	IEEE 2030.5-2018 (SAE J2847/3)
	OCPP
	OpenADR
	ISO 15118

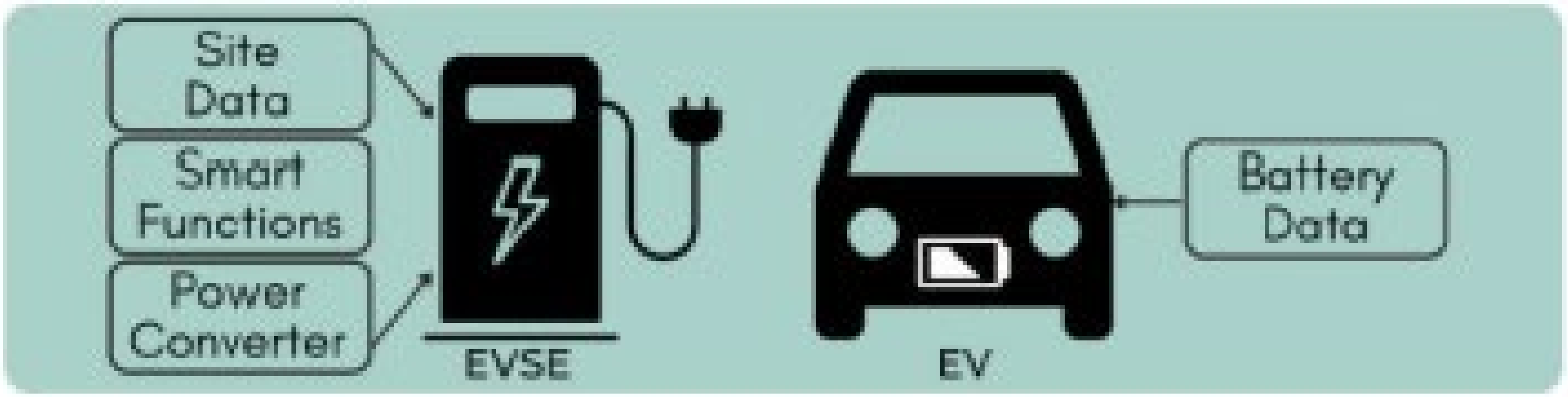
Source, Interstate Renewable Energy Council (IREC)
https://irecusa.org/wp-content/uploads/2022/01/Paving_the_Way_V2G-Standards_Jan.2022_FINAL.pdf

Key Standards

- IEEE 1547, IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces
- IEEE 1547.1, IEEE Standard Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces
- UL 1741, Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources
- UL 9741, Safety of Bidirectional Electric Vehicle Charging Systems and Equipment
- SAE J3072, Interconnection Requirements for Onboard, Grid Support Inverter Systems – Requires IEEE 1547 Standard for EV inverter

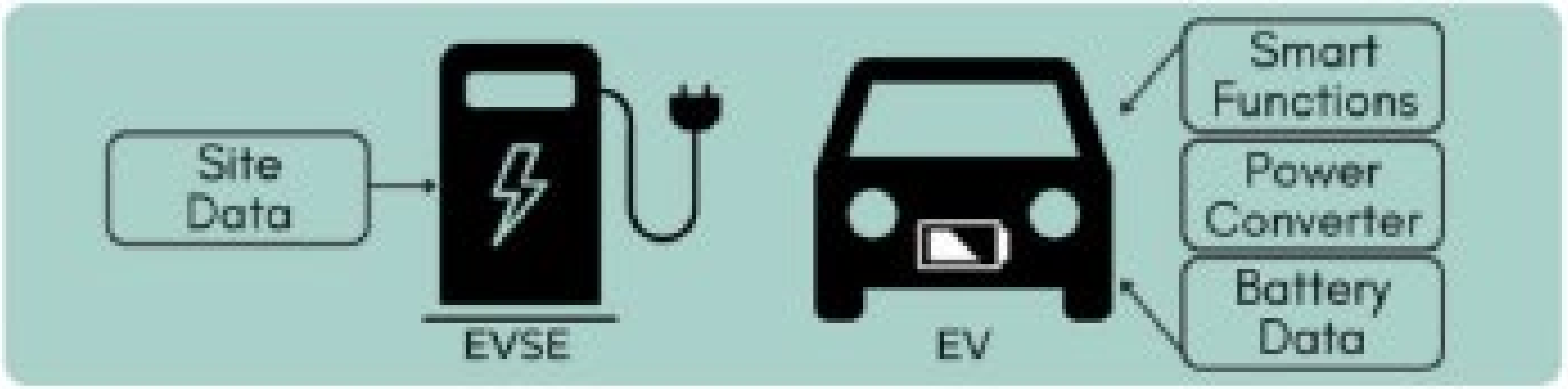
What Standards Apply – Mobile Energy Storage

V2G-DC



- IEEE 1547 & 1547.1 – inverter in EVSE
- UL 9741 references UL 1741 grid interactive inverter
- SAE EV Standards

V2G-AC



- IEEE 1547 & 1547.1 – Inverter on EV
- UL 1741 SC (Draft) grid interactive inverter
- SAE J3072

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Thank you

Interconnection & EVs: The Need for Clarity

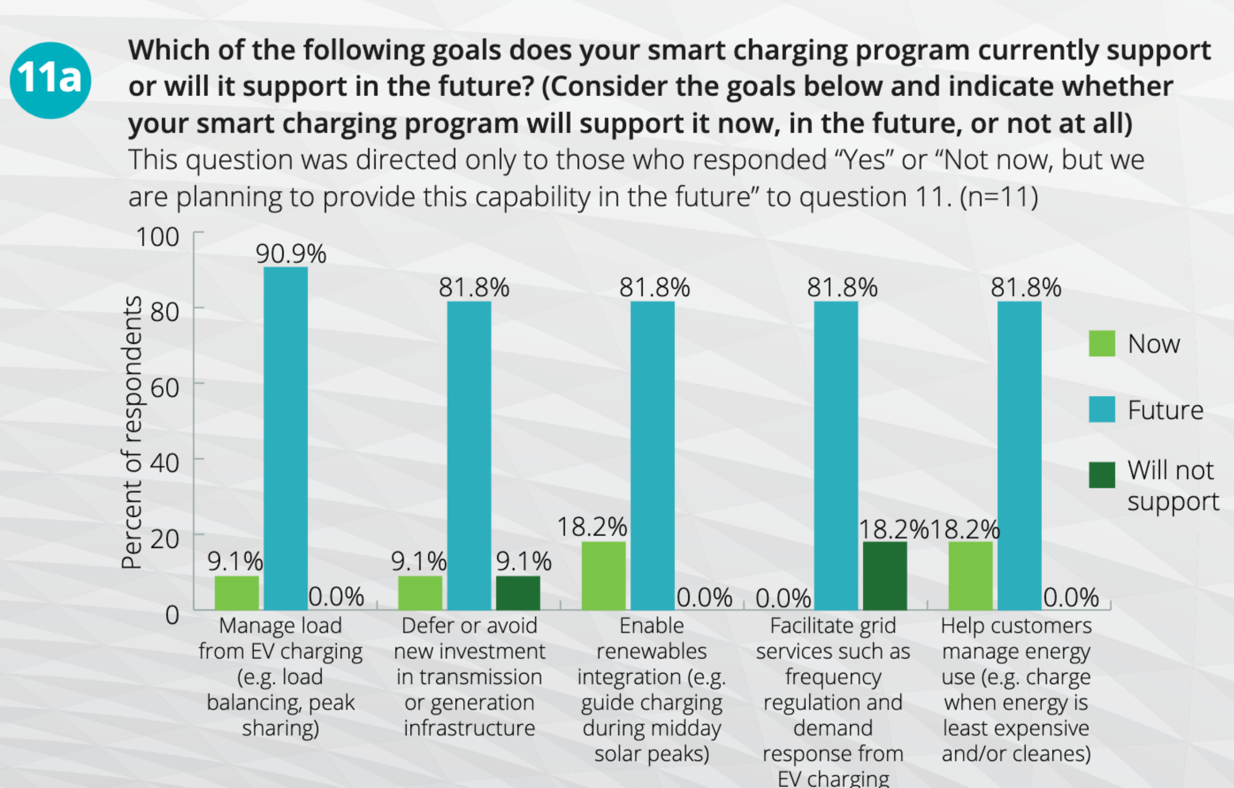
If. When. How. How Long.

Valerie Brader, Rivenoak Law Group • Jan 2024
Michigan Public Service Commission EV Tech Conference

Nothing in this presentation constitutes or substitutes for legal advice.

Fun EV Tech Conversations

Source: Deloitte 2017 [Utility Electric Vehicle Survey]



Some of what was in the future 6 years ago was discussed yesterday as moving from pilots to permanent.

Many of the next wave of innovation people talk about today has a key first step: **interconnection!**

Interconnection: If you need it, you need it.

Interconnection and EVs

The Past: Charging Only, But Often in Home with Solar

Almost all of today's EVs. No interconnection is needed for the vehicle. It is for the solar.

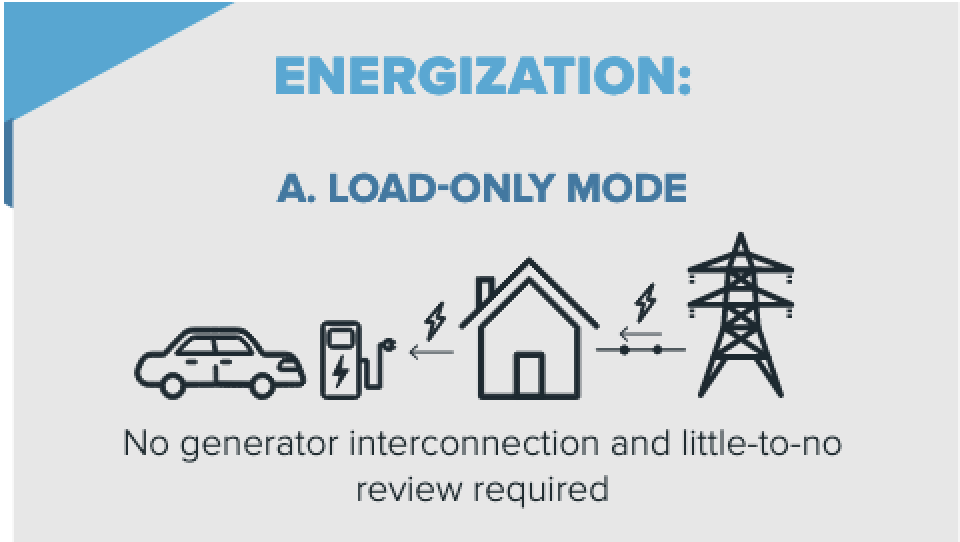
The Past & Present: Non-Parallel Operation

EV that can run your home when power is out (but not otherwise). But sometimes will recharge from solar panels that are interconnected.

The Future:

We don't know, but everyone is anticipating parallel operation and full bi-directionality. That means interconnections.

When You Don’t Need One: No Parallel Operation



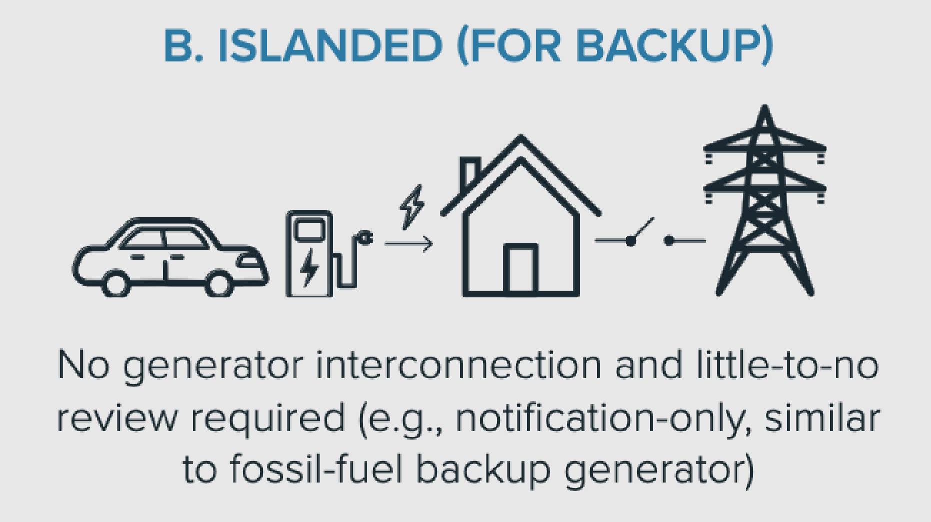
Graphic source: *[Vehicle-Grid Integration Council resource]*

Clarity Opportunity: Solar + EV

- Load-only EV is added to house with properly interconnected solar, is a new study needed? (No, no parallel operation.)

Ford F-150 Backup Power Saves a Michigan Wedding

When You Don’t Need One: No Parallel Operation



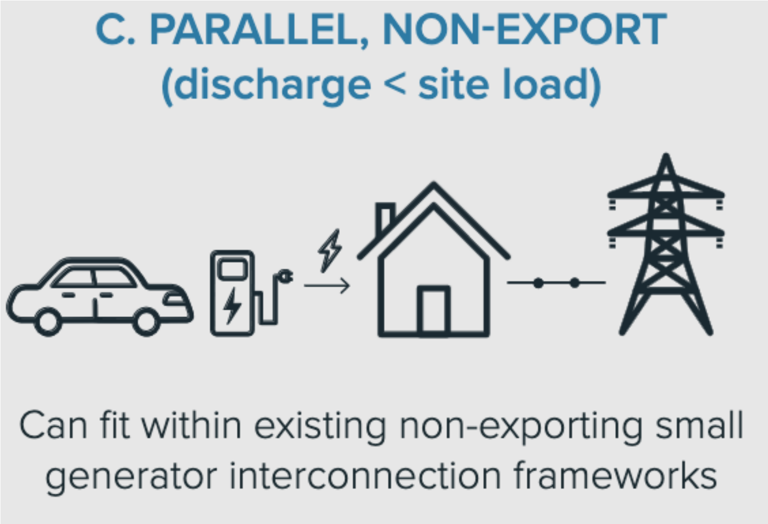
Graphic source: [Vehicle-Grid Integration Council resource]

Clarity Opportunity: Ford’s Home Backup Power

- Backs up home when grid is down. Need interconnect?

  No.

When You Do Need One: Parallel Operation

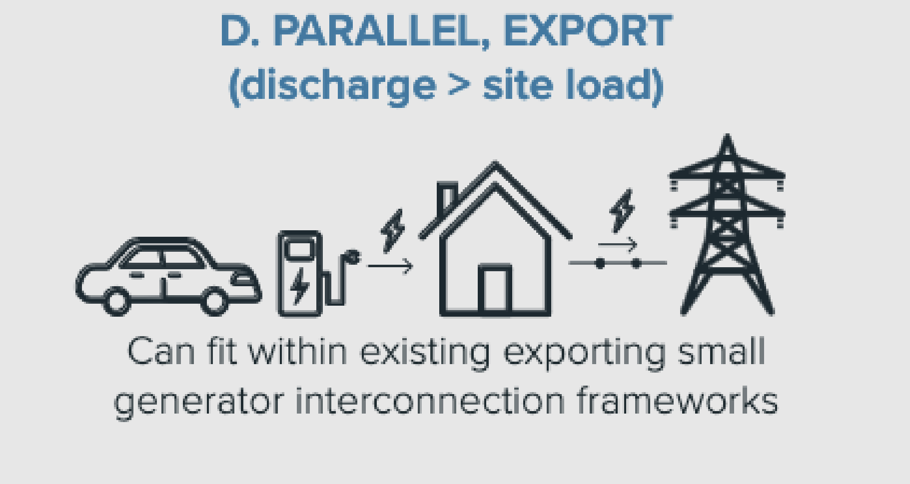


Clarity Opportunity: Charging Before Parallel Op.

- A customer needs to be able to charge at home from day one.
- What interconnection procedures would be used? (Should be easier for non-export.)

Graphic source: Vehicle-Grid Integration Council resource

When You Do Need One: Parallel Operation



Clarity Opportunity: Non-Export Discharge vs. Export

- Can vehicle "turn on" additional features as various interconnection milestones met? (i.e. backup only to parallel discharge to exporting)

Graphic source: Vehicle-Grid Integration Council resource

Utility/Automaker Coordination Opportunities

Fear of the Future

Some utilities struggle to know when to require interconnection because of a fear EVs will change capabilities without notice. Terrible customer experience. Need communication norms and protocols to avoid this.

What about Neighborhood EV #4?

How do we think about distribution circuits that can absorb some EVs in parallel operation but not a lot of them (cost allocation, okaying hookups)? How quickly can neighbor #4 get an interconnection compared to #1-#3 if additional studies/equipment now needed? Can we use geo-fencing and other software fixes to avoid radically different customer timelines?

Rate Design/Interconnection/Software Intersection

If we tell everyone the best rate starts at 10 pm, how do we make sure all EVs don't turn on at the same time, and how does that intersect with interconnection? Does limited export/import to prevent this within a geofence while we get the interconnection done?

EV technical conference

Interconnection Opportunities and Obstacles for V2H and V2G

1/25/2024

DTE is committed to reducing barriers to electric vehicles and preparing for widespread EV adoption to support the future of mobility

- Improving interconnection procedures to support EVs, V2H and V2G
- Partnering with EV-related businesses with similar goals through the Emerging Tech Fund, a program looking to financially support novel EV solutions
- Evaluating additional funding opportunities through state and federal such as DOE's Vehicle Technology Office
- DTE is currently involved in many EV charging technology projects throughout the service territory
- DTE's Westland DER lab and training center plays a crucial role in testing emerging technologies, such as V2G, ensuring the company stays at the forefront and well prepared for the future

V2H: Backup power that is not able to parallel with the grid

V2G: An interconnection that can be parallel to grid.

There are multiple opportunities to provide streamlined interconnection for V2H and V2G

V2G with certified equipment goes through the process the same as any other storage interconnection

Investigating ways to provide notification for V2H and "V2G capable" to make program sign up and eventual interconnection easier

Communicate process:

- Guides and knowledge sharing
- Capacity maps (for larger projects)

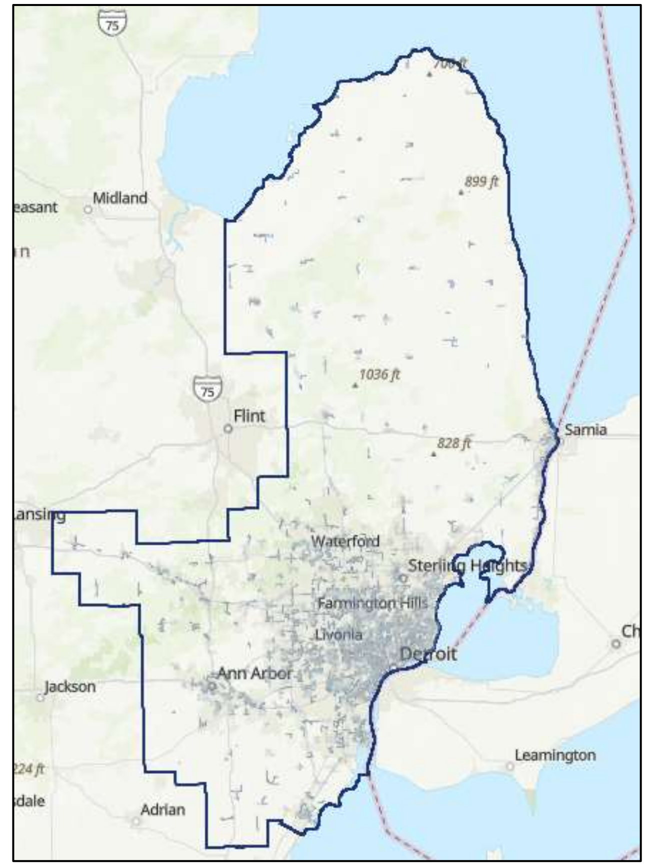
Streamline process:

- Automating screening
- clearly defining requirements

Standards compliant and tested equipment:

- Listed equipment greatly simplifies review
- device communications will improve grid code compliance

– Hosting Capacity (arcgis.com)



There remain some obstacles to streamlining interconnection for V2G

Standards and harmonization is still developing:

- Utilities: UL certified systems – increasing rigor and complexity of IEEE1547 with active functions
- Vehicles: SAE self certified systems – new systems

Implementation time:

- Certified products take time to get tested and out to consumers
- Innovation coming to market faster than standards compliance
- Intermediate products now, more interoperability and capability in the future

Familiarity with system installation requirements by installers, AHJ's and inspectors regarding NEC and utility requirements

More rigorous DER configuration and data management from FERC and markets

The Emerging Technology fund supports a number of V2H projects at DTE to test load management, trial new approaches for underserved communities and test second life applications for EV batteries

Automotive OEM Residential V2H pilot

manage charging and discharging of vehicle through DTE issued demand response events

it's electric

Curbside EV charging

FORTH

carshare vehicles and charging ports at income qualifying multi-family housing in DTE territory

BOSCH

Home V2H platform and controller

WeaveGrid

Managed EV Charging pilot

rainforest automation

Load demand management to accommodate EV chargers

The Emerging Technology Fund and DOE support a number of active Projects that are testing the ability to secure the vehicle to grid interaction and provide opportunities for resiliency

U.S. DEPARTMENT OF ENERGY

EVs@RISC – Department of energy project for EV smart charging interfaces and cyber secure vehicle charge management

Liberas

Software to streamline and improve Interconnection processes and digitize contracts and validation

Automotive OEM V2G Pilots

V2G pilots at customer homes

System integration lab testing

Battery storage units with integrated fast charger & Battery buffer EV fast charger

Enables fast charging at constrained locations and opportunities for grid support

Efleet battery support

Reuse and repackaging of transit bus batteries for grid support

V2G combined with managed charging provides opportunities to decrease peak load but also provide support to the grid where vehicles are available at peak times

Fleets and Charging Depots

Electric School Busses

DTE

Fermata Energy

Park It. Plug It. Profit.

Interconnection Opportunities and Obstacles for V2H and V2G

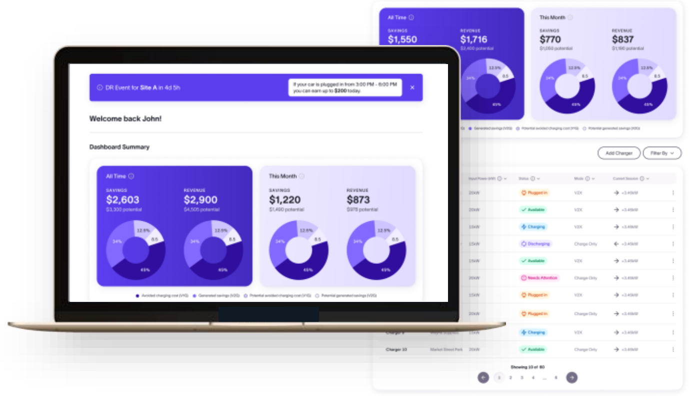
Steve Letendre, PhD
Senior Director of Regulatory Affairs

January 25, 2024

Fermata Energy V2X Ecosystem

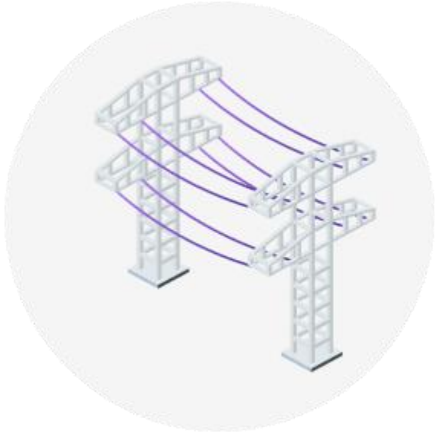
Fermata Energy Cloud Software

- V2G + V1G operation + reporting
- V2G event notification
- Charge scheduling
- Site + building load monitoring
- Charger + EV data analytics



FE- Link

- Site Controller
- IoT Gateway
- Building Meter



EV

- Manage + Preserve Battery Warranty
- Lower Total Cost of Ownership

Charger Integration

- FE-20 20kW bidirectional charger developed with Heliox
- Integrating with others

Site Load Integration

- Load Management
- Site Resilience Support

Utility

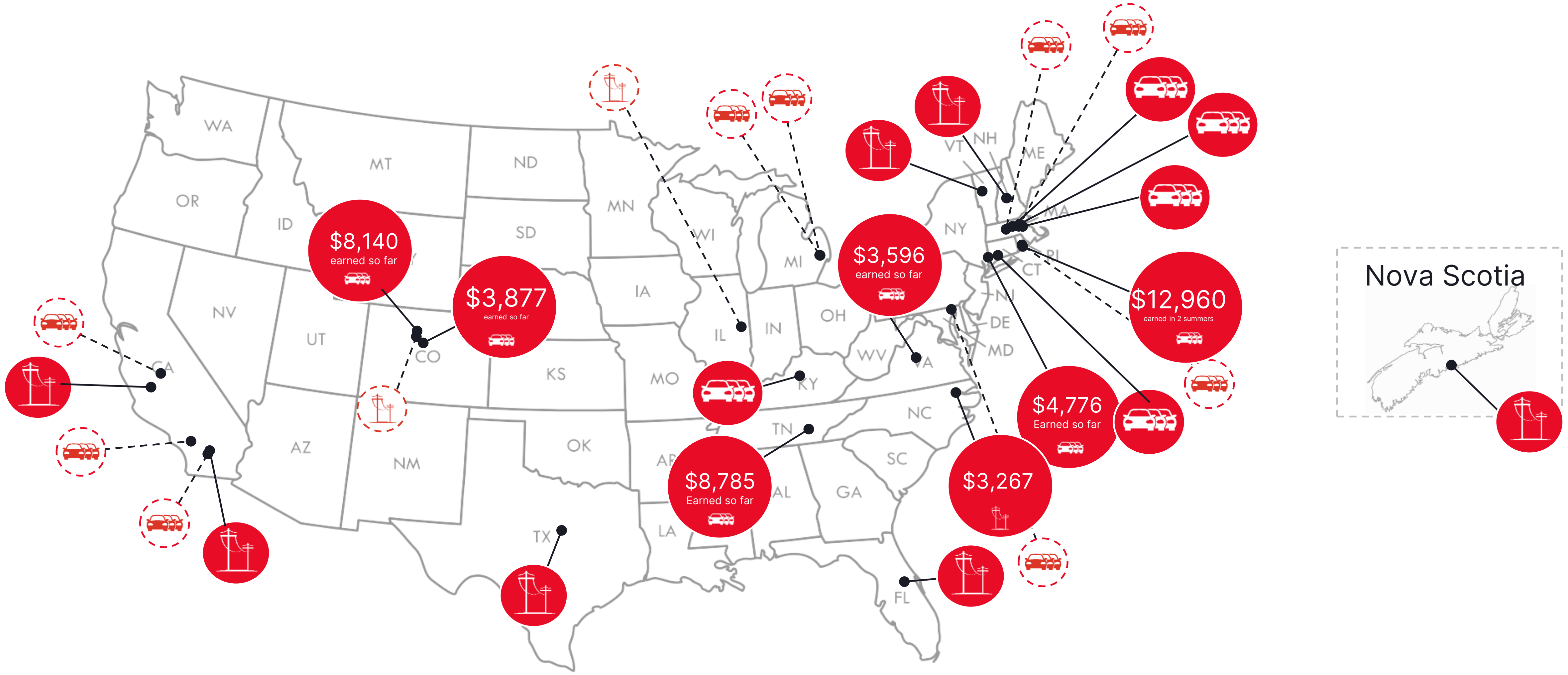
- DERMS integration
- Demand Response
- Interconnection
- Aggregation
- Grid Resiliency Support
- Use Case Development

V2G is Happening Now

Jan 2024

Verified V2G operations with

- Utilities
- Federal government
- Municipalities
- Private deployments
- Automotive manufacturers



Fleet site operating

V2G earning for customers

Fleet site in development

Utility site operating

Utility site in development

Rhode Island municipal deployment earns $12,500+

When: **Summers 2021, 2022, & 2023**

What: Vehicle-to-grid (V2G) demand response using Fermata Energy's V2X bidirectional charging platform

EV Earned: **$12,553 with 1 EV and 1 Fermata Energy V2G bidirectional charging platform**

Where: Municipal wastewater treatment facility

Program: **Rhode Island Energy - "Connected Solutions."** Discharging energy in an EV battery back to the grid at times of peak grid demand, during 2-3 hour long events in late afternoon.

"These results help to give us confidence that **electric vehicles can be a reliable partner in providing a clean and resilient electricity grid** for the future," said John Isberg, Vice President of Customer Sales and Solutions at National Grid (now a Rhode Island Energy project).

V2B nonprofit carshare generates $3,870+ in savings with century-old building

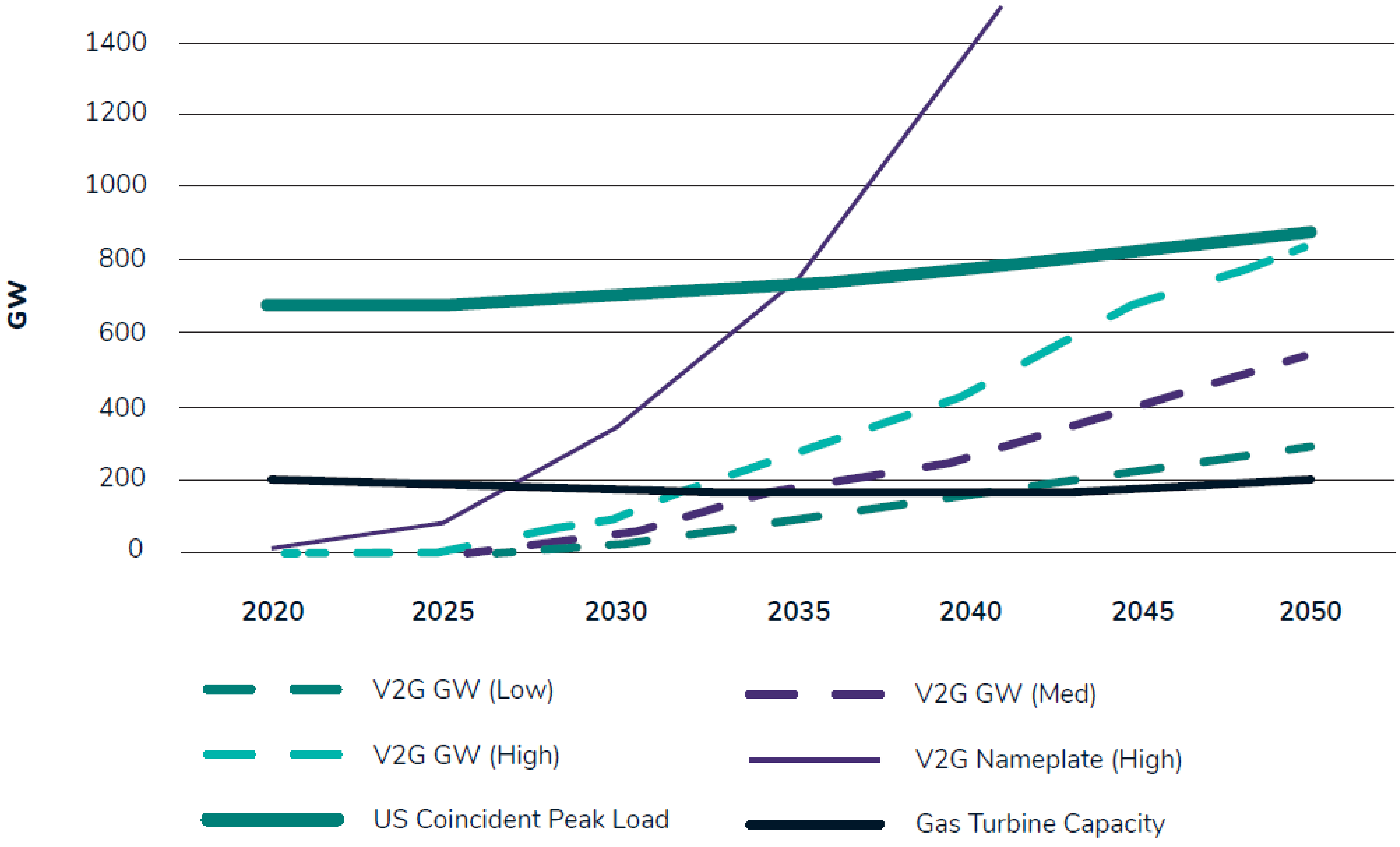
When: **Ongoing - activated June 2021**

What: Vehicle-to-building (V2B) demand charge management + carshare

EV Delivers Savings: **$3,870+ with 1 EV and 1 Fermata Energy bidirectional charging platform**

Where: The Alliance Center in Denver, CO - the first all electric building in Denver

Program: Reduced demand charge on electricity bills by discharging energy in an EV battery to offset high building electricity consumption. The project has provided CO Car Share members access to an emissions-free transportation option.



EPRI Projected V2G capacity based on EIA projections of EV populations
Source: Presented at an October, 2022 EPRI Webex

Three Types of Bidirectional Charging Configurations

(discharge < site load)

Figure 2. Parallel V2B Operation without Export

(discharge > site load)

Figure 3. Parallel V2G Operations with Export

Emergency Power (Islanded Mode)

Figure 4. Islanded V2B Operation During Grid Outage

Opportunities to Scale Bidirectional Charging

- Parity with Stationary Storage
  - incentive programs comparable to those for stationary storage
  - integrate V2X in utility planning processes

- Make-Ready and EV Charging Infrastructure Funding Access
  - access for bidirectional chargers to utility make-ready funding opportunities
  - technology-neutral rebates for V2G chargers and associated equipment

V2X Environmental Benefits

Using the batteries in EVs to do double duty by providing both mobility and grid storage capabilities offers significant environmental benefits:

- reduced resource extraction and processing provides emissions benefits
- land use impacts from resource extraction and siting stationary storage projects are reduced
- reduce renewable energy curtailments to near zero

A mining pit in Yuqia, Qinghai, China.
(source)

Conclusions

- A renewable grid requires massive amounts of energy storage
- Bidirectional EVSE have been successfully interconnected in numerous jourisdictions (recognize V2X as an eligible technology)
- The pace and scale of stationary storage deployments may not meet grid-scale storage needs
- V2X is a big, cheap, fast, and clean complement to stationary storage
- EVs with V2X technology represent a new class of grid resource that is not well understood:
  - ubiquitous throughout the distribution system
  - extremely fast responding
  - controlled very precisely in response to grid conditions
- Policymakers and regulators should incentivized bidirectional charging as a complement to stationary battery storage

Thank you.

For more information, please visit

www.fermataenergy.com

or contact

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U.S. DEPARTMENT OF ENERGY
EVGrid Assist
ACCELERATING THE TRANSITION

VGI Emphasis

1/25/2024

Lee Slezak

Vehicle Technologies Office

U.S. DEPARTMENT OF ENERGY

Vision

Millions of highly electrified vehicles – both large concentrated fleets and small dispersed vehicles - actively connected to the grid, that help support a decarbonized, secure and reliable grid by 2030

Note: Focus on VGI, but with an eye towards broader cross-technology activities

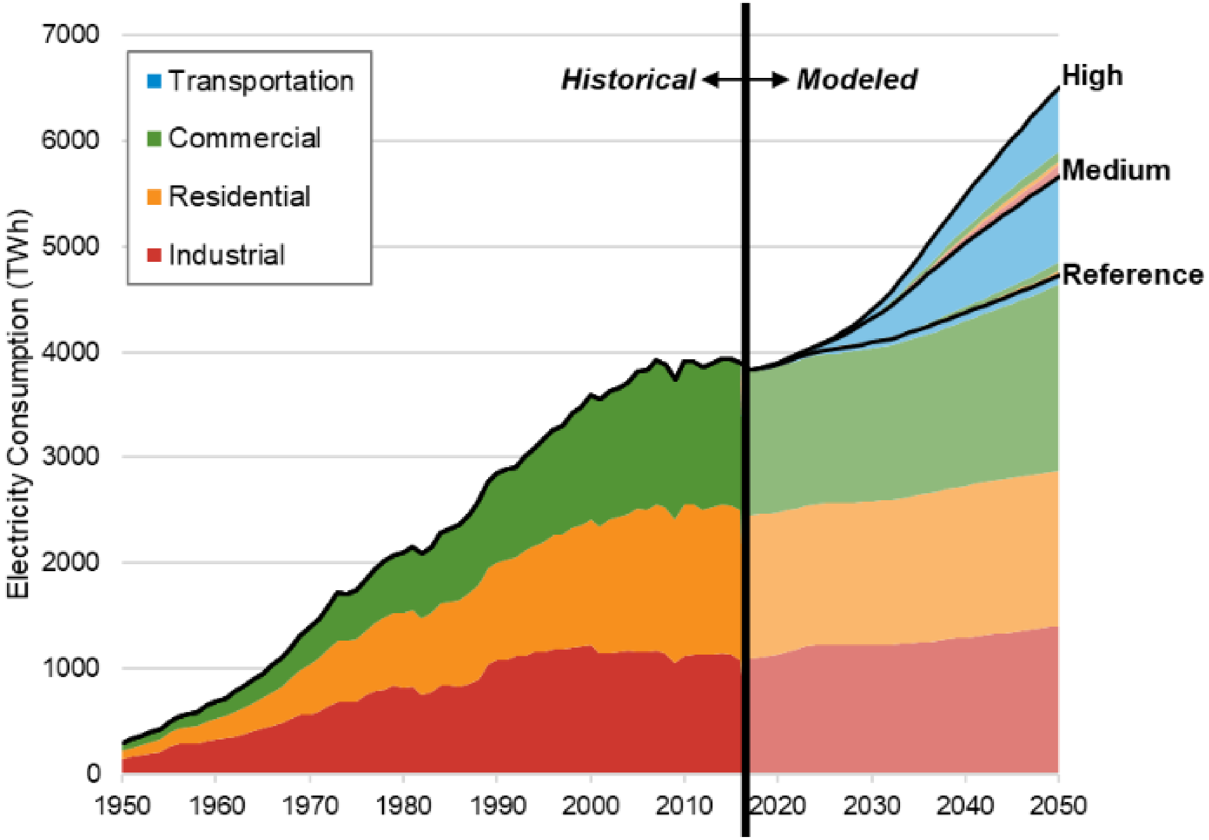
Goals

- Speed up deployment
- Ensure affordability for customer and system, downward pressure on rates
- Leverage all approaches – rates, regulation, technology etc.
- Increase confidence and investment by institutions/actors

Transportation Electrification is Happening Now

- **What's happening**
  - Rapid deployment of cost-effective electric vehicles
  - Increasing consumer demand

- **Resulting Impact**
  - Largest projected new load growth with different operational characteristics
  - Brings together electricity and transportation sector in unprecedented ways
  - Heightened need for coordination among stakeholders and proactive decision making



Electrification Futures Study: A Technical Evaluation of the Impacts of an Electrified U.S. Energy System | Energy Analysis | NREL

U.S. DEPARTMENT OF ENERGY EVGrid Assist ACCELERATING THE TRANSITION | U.S. DEPARTMENT OF ENERGY

Concurrent Transformations

Requires unprecedented coordination

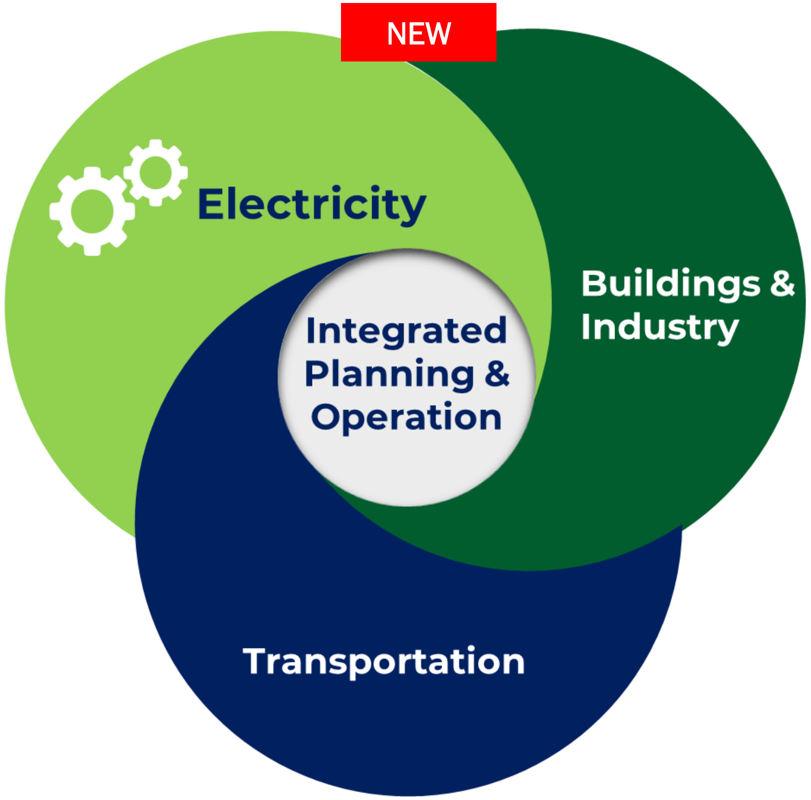
Decarbonizing the full energy system requires **major changes** in system planning and operation, regulation, and market design – and **unprecedented coordination** between previously disparate sectors

NEW

Variable and asynchronous generation at zero marginal cost

NEW

Large and unpredictable sources of demand



NEW

Reliance on distributed resources and individual choices

NEW

Constantly evolving cyber and natural threats

U.S. DEPARTMENT OF ENERGY EVGrid Assist ACCELERATING THE TRANSITION

U.S. DEPARTMENT OF ENERGY

Why Emphasize VGI?

1. **Business as usual will not meet the pace and scale of the transition**
   - Load management is critical to ensure reliability and affordability; traditional supply-driven strategies are not sufficient
   - New grid capabilities are essential to fully integrate EVs

2. **VGI maximizes use of existing grid capacities**
   - Grid enhancements can be deferred
   - Allows for better alignment of charging infrastructure and grid upgrade planning
   - New communications and control technologies/approaches can improve grid operational efficiencies

How is VGI Emphasized?

1. **DOE's Evs@Scale National Lab Consortium**
   - R&D on Smart Charge Management, High Power and Advanced Charging Equipment and Facilities, and Cyber-physical Security Technologies
   - Supporting Codes and Standards development and validated test procedures

2. **Funding Opportunity Announcement (FOA) Projects**
   - Accelerate final development, validation, and market introduction of near-market technologies
   - Offset costs and risks with Federal funding
   - All funded projects must include a market introduction strategy/plan to be executed upon successful demonstration

Thank you for your time and attention.

Lee Slezak

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EV Cost-of-Service, Tariffs, and Rate. Oh My!

Kayla Gibbs
Commissioner
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Regulatory Policy, Xcel Energy

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MPSC
MICHIGAN PUBLIC SERVICE COMMISSION

Alliance for Transportation Electrification

RATE DESIGN FOR ELECTRIC VEHICLES

Presentation to Michigan PSC
EV Technical Workshop (Case No. U21492)

Presented by
Philip B. Jones

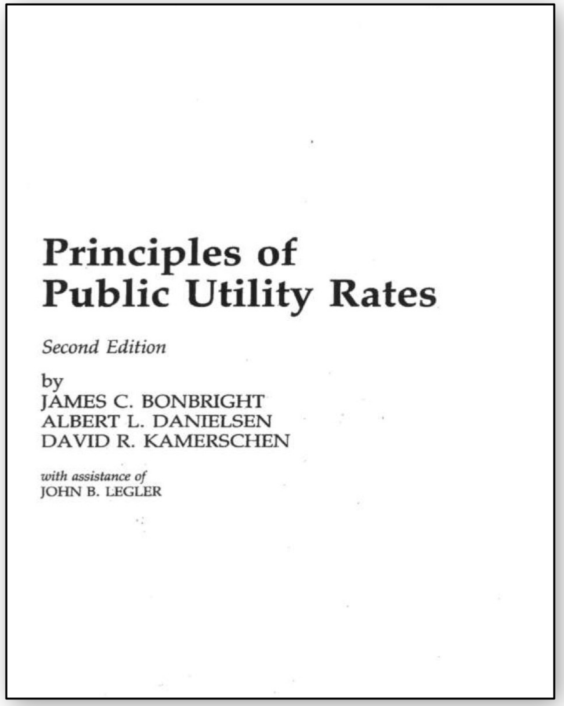
ATE Executive Director
Former Washington UTC Commissioner
Past President of NARUC

January 25, 2024

Rate Design Principles

Alliance for Transportation Electrification

- ✓ ATE’s Rate Design Whitepaper: A useful document for commissioners, staff, and parties in state proceedings.
- ✓ Recognizes that each state and utility are different, with unique precedents and rules for cost of service.
- ✓ Rates must meet the J&R standard and be sustainable over time.



Bonbright’s Four Functions

Capital Attraction Function	Efficiency Incentive Function
Establishes revenue requirements to attract adequate investment.	Regulation intended to compel market-like performance.
Demand Control Function	**Income-Distributive Function**
Scarcity / supply and demand Get the price signals right	Can address with equity / low-income programs and incentives.

Goals

- Benefit customers – electricity vs gasoline (or diesel)
- Benefit the system – increased utilization
- Achieve policy goals (e.g., health, carbon / GHG)
- Retain cost-reflective rates

Issues to be considered

- Beneficial electrification
- Benefit-Cost Analysis
- Public policy
- Flexibility
- Equity
- Technology treatment
- Managed charging (passive / active)
- Long-term vs transitional

Commercial Rates: Demand Charges

Alliance for Transportation Electrification

Key components of rates:

- **Fixed / customer charge**
- **Delivery charge (sometimes)**
- **Energy charge (kWh)**
- **Demand charge (kW)**

1. The EV market requires pervasive DC fast charging infrastructure and reliable home charging.
2. Public DC fast charging (as well as certain other types) incurs high fixed demand charges, but utilization can be low.
3. When utilization is low there are few kWh to spread demand charges across, which drives up the effective price per kWh.

✓ Commercial rates are complex, highly varied, and little-understood.

✓ Demand charges are typically the most contentious issue.

EV Charging Use Cases

Alliance for Transportation Electrification

Use-case	Tariff	Typical Peak Load (kW)	Utilization	Demand Charges*	Flexible use**	Comments
Single-family	Residential	< 10	Low	No	Yes	About 80% of charging occurs at home when driver has access to dedicated and owned parking.
Multi-family / townhouses	Commercial	7 to 100 +	Low	Yes	Yes	Difficult use case as these are commercial customers; some utilities may offer a rate similar to single-family residential.
Workplace and Commercial (light-duty; trucks/buses)	Commercial	7 to 100 +	High	Yes	Varies	Loads are generally easier to predict with load profiles; can benefit from V1G solutions, such as TOU.
Public DC Fast	Commercial	500 to 2,000	Varies by location	Yes	No	Utilization often too low to be economic in early years; opportunistic charging; load profiles more unpredictable.

* Varies by utility and peak load
** Flexible loads can utilize managed charging to benefit from TOU pricing; requires smart meter or reliance on EVSE or EV for metering

Demand Charge Models

Model	Description	Sample Utility
Transitional Treatment	When low utilization results in high per-kWh costs, Commission directs a demand charge mitigation for temporal period, such as 10 years	SCE (CA)
Demand Limiter	Predefined maximum charge per kWh (could be measured over 12 months). Rate may also have a predefined sunset period.	FPL (FL) and APS (AZ)
Subscription Rate (Flat)	This rate structure offers a flat demand charge which covers up to a certain peak load; cost-based; usually includes TOU	PG&E and SDG&E (CA)
CoS Without Demand Charge	Appropriate for low-load factor applications, with lower voltage levels, both Level 2 and DCFC stations (along with other C&I customers)	Dominion (VA)
Varying Demand Charge Discounts based on Utilization	Low or reduced demand charge below certain utilization, demand charge increases as utilization increases until 100% demand charge is reached.	Con Edison (NY)
Embedded in Other Volumetric Component	Similar to the CoS without demand charge (Dominion cited above), but explicitly increases energy charge (volumetric), e.g., for multi-family units	Pepco (DC)
Sliding scale discounts	Demand charge is mitigated at low power factors, then increased, as utilization increases. For a defined period, such as 5 or 10 years	National Grid (MA and NY) (Phase In rate)
Energy storage	Battery energy storage solutions (static, or BESS) may be deployed by customers, or customers/host sites can purchase equipment with such attributes	

National Grid (MA) Sliding Scale Demand Charge

Alliance for Transportation Electrification

Demand charge discounts will vary based on load factor

$$\text{Load factor} = \frac{\text{Billed Energy in kWh}}{\text{Billed Demand in kW x Hours in Billing Period}}$$

Load Factor (“LF”) Threshold	Enrollment Years	Demand Charge Discount
None	1	100%
LF <= 5%	2 to 9	100%
5% < LF <= 10%	2 to 9	75%
10% < LF <= 15%	2 to 9	50%
LF > 15%	2 to 9	0%

- ✓ Annual evaluations are made to determine applicability
- ✓ Applies only to commercial class with general service rates
- ✓ Four load brackets (see table)
- ✓ Discount phases out at 15% load-factor
- ✓ Approved for 10 years
- ✓ Similar framework coming soon in New York

Equity and Residential Rate Design

Alliance for Transportation Electrification

Utility rates and programs are increasingly statutorily required to be socially equitable, particularly for residential customers in disadvantaged communities

One of Bonbright's core and time-tested principles is the income-distributive function, which today may be referred to as equity

Customary offerings for low and moderate income ratepayers include:

- ✓ Bill discounts
- ✓ Assistance with arrearages
- ✓ Home weatherization and other energy efficiency measures

Two approaches to implementing equity-oriented programs

1. Compensation Standard: Reflects flow of funds between consumer and utility relative to other costs of consumers in society
2. Income-qualified, or "quasi-tax" standard. This is the so-called ability-to-pay principle.

To achieve social equity, one can argue that the taxpayer – through legislative actions – should bear the burden of such equity costs in energy delivery and ratemaking, and not just the "ratepayer."

In the EV space, many utilities are offering residential rebates for EVSE or installation with enhanced levels for income-qualified customers (usually 2x), targeted or preferential assistance, enhanced vehicle (both pre-owned and new) rebates, etc.

A variety of programs and rates could be tested here, and they would stretch the boundaries of the distributive function of ratemaking, such as:

- ✓ Free or heavily discounted transit fares for battery electric buses
- ✓ Rebates to drivers for TNCs that live in and serve disadvantaged communities with a ride-hailing company
- ✓ Rebates for car- sharing organizations (CBOs) that serve underserved communities

Conclusions

- Retain Basic Principles
- Utilization, or low load factors for utility and grid, are the key challenges in the market transformation from early to mature phase;
- We continue to oppose purely volumetric rates, rates based solely on SRMC (short-run marginal cost). Separate rate class for EV are possible, but cost allocation in commercial class may offer better solution;

- Rates should be based on CoS in the long-term in all cases, avoiding long-term cost shifts between customers and rate classes (“subsidies”)
- We support demand charges as a basis for EVSE rates in the medium and long-term, while recognizing there may be a need for short-term mitigation. There are also viable alternatives to demand charges in some cases
- Equity issues in ratemaking, although contentious, can be accommodated but should be dealt with carefully and with a certain time horizon.

Alliance for Transportation Electrification

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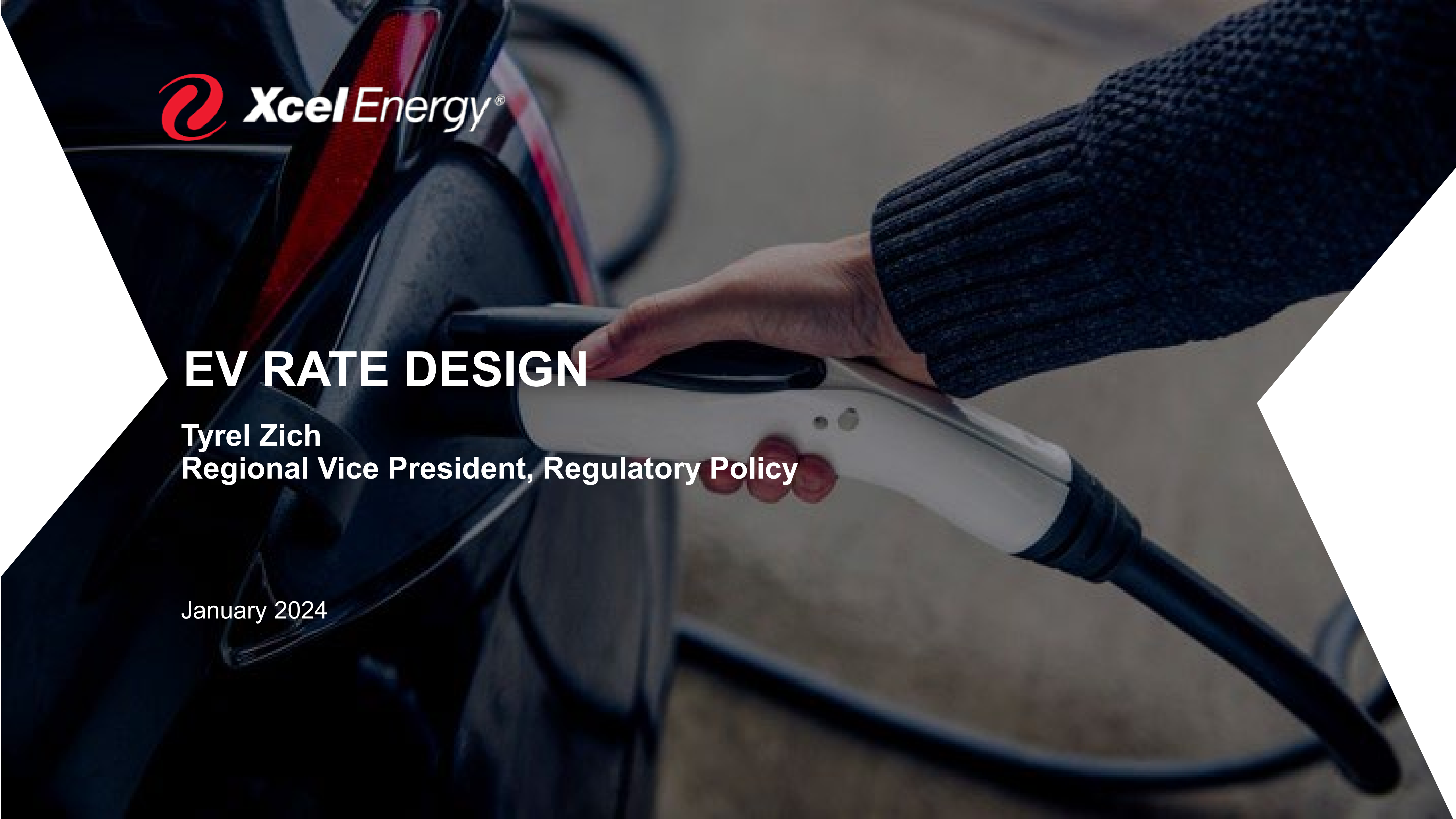


Xcel Energy®

EV RATE DESIGN

Tyrel Zich
Regional Vice President, Regulatory Policy

January 2024

Xcel Energy Net-Zero Energy Provider by 2050

Goals that cover all the ways our customers use energy

	Electricity (from 2005 levels)	Heating* (from 2020 levels)	Transportation** (from 2020 levels)
2030	80% lower carbon emissions	25% lower greenhouse gases	1 in 5 vehicles are EVs in our states
2050	ZERO carbon emissions	NET-ZERO gas service	ZERO-CARBON FUEL accessible within 1 mile

*Spans natural gas supply, delivery and customer use

**Includes the Xcel Energy fleet; zero-carbon fuel is electricity or other clean energy

Innovative EV Solutions

Our innovative programs raise awareness, reduce up-front costs, and make it easier for customers to charge electric vehicles on low cost, low carbon energy in a way that's good for the grid

Xcel Energy service territories in light blue on map

Xcel Energy Residential EV Programs - Overview

EV Accelerate At Home (EVAAH)

- Xcel Energy installs and maintains a Level 2 (L2) charger
- Monthly fee of $12-$17 (varies by state) on bill with no upfront cost
- ChargePoint, Enel X L2
- Subtractive Metering (MN, WI)

Colorado Minnesota New Mexico Wisconsin

Optimize Your Charge (OYC)

- Rewards customers for charging at times that benefit the grid
- $50 annual credit for charging off peak

Colorado Minnesota New Mexico

Charger & Wiring Rebate

- Applies to home wiring or L2 charger
- $500 (market) or $1,300 - $2,500 for income-qualified (IQ) customers
- Up front if in EVAAH

Colorado New Mexico

EV Purchase/Lease Rebate

- Reduces the cost of an EV for IQ only
- New EVs $5,500, pre-owned EVs $3,000
- Network dealers can provide at point of sale

Colorado

Xcel Energy Commercial EV Programs - Overview

Fleet Electrification Advisory Program (FEAP)

- Fleet suitability assessment, data analysis and advisory services
- Free of charge

Colorado
Minnesota*
New Mexico
Wisconsin

Electric Vehicle Supply Infrastructure (EVSI)

- No-cost advisory and turnkey services for fleet, workplace, community charging hubs, and multifamily buildings
- Includes design and construction of EVSI (but not chargers)

Colorado
Minnesota*
New Mexico**
Wisconsin

Charger Service (EVSE)

- Option to pay a monthly fee for an Xcel Energy owned L2 charger for multifamily, fleet, and workplace customers

Colorado
Minnesota *

New Construction & Small Business Rebate

- New construction allowance of $2,000 per port to support new multifamily construction for EV ready parking spots
- Rebate of $2,500 for wiring costs for Small Businesses

Colorado

Charger Rebates for Income Qualified (IQ) & High Emissions Communities (HEC)

- Fleet/Workplace Rebate: up to $2,200 per L2 port and $45,000 per DCFC port
- Community Charging Hub Rebate: up to $8,800 per L2 port (minimum of 4 ports) and $31,200 per DCFC port
- MFH Rebate: $8,500 per L2 port
- Small Business Rebate: up to $2,000 per L2 port (3 port max)

Colorado

**Pilot Program fully subscribed*
***Program currently available for some but not all charging use cases*

ACTIVE EV PROCEEDINGS IN CO, MN, & WI

2024-2026 Colorado Transportation Electrification Plan

- Filed on May 15, 2023. Building upon current TEP programs to leverage customer and stakeholder feedback, enhance operational excellence and incorporate lessons learned.
- Approximately $440 million three-year budget. Hearings scheduled for early 2024 with a decision expected in mid-2024.

Advisory Services
- Residential
- Commercial
- Community
- IQ/DI Community Outreach and Engagement*

$16.4M

Clean Vehicles
- Residential EV Rebate
- TNC and DNC High-Mileage Rebate*
- Governmental EV Rebate*

$17.7M

Public Charging Acceleration Network
- DCFC rebates for high-speed charging equipment in equity-eligible and rural communities*

$20.2M

Residential
- EV Accelerate At Home (EVAAH)
- EV Charger and Wiring Rebate
- Managed Charging Program with Passive Control Option and Active Control Option*
- EVAAH Back Up Power Option*

$27.7M

Commercial
- Commercial EVSI
- EVSI Rebate*
- New Construction Wiring Rebate
- Level 2 (L2) Charger Service
- Commercial Equity L2 Charger Rebate
- No Regrets Investments – Distribution Grid Reinforcement*

$260.6M

Innovation
- V2X Demonstrations
- School Bus Electrification
- Open Innovation*

$48.1M

Equity-Supportive Programs:
Advisory Services, Residential EV Rebate, Public Charging Acceleration Network Portfolio, Residential EV Charger and Wiring Rebate, Commercial Equity L2 Charger Rebate, Commercial EVSI, School Bus Electrification, and Open Innovation

* New Program

2024-2026 Minnesota Transportation Electrification Plan

- Filed on November 1, 2023 with a total budget of approximately $45 million
- We expect a decision from the Minnesota Public Utilities Commission in April 2024

Residential Programs & Managed Charging

- Proposal to expand EV Subscription Service Pilot into permanent program
- Proposed Home Wiring Rebate to remove large upfront cost barrier to residential charging

Commercial EV Pilot Bridge

- Bridge funding for fleet and public charging pilots to provide services for interested customers in our pipeline

Electric School Bus Demonstration

- Electric School Bus Demo to support electrification of school buses in our communities and test vehicle-to-grid (V2G) technology

Public DCFC Market Analysis

- Worked with stakeholders and industry participants to assess deployment plans and customer needs in MN

2024 Test Year Wisconsin Rate Case

- Filed on April 1, 2023
- We received a decision from the Wisconsin Public Service Commission in December 2023

Residential Programs

- Modified residential program to create a Bring Your Own Charger (BYOC) model.

Commercial Programs

- Simplified EVSI Incentive
- Established Multi-Family Housing EVSI Program

Public Charging

- Approval of ~$2M for Utility-Owned Public Charging in 2024
- Operated by the Utility or a Partner

EV COST ALLOCATION

Cost Allocation of EV Programs (Wisconsin)

Wisconsin Docket 5-EI-158: Investigation of EV Policy and Regulation

- Commission encourages utilities to propose EV programs to address a) rates related to EV charging, b) load management efforts to control charging, c) initiatives to address upfront purchase costs of EVs and charging equipment
- Program proposals must include **“a description of proposed accounting procedures that explains how program costs will be recovered through rates in accordance with cost causation principles”**

Cost Allocation of EV Programs (Wisconsin)

Xcel Energy Program Cost Allocation in Wisconsin

- Residential: Revenue, capital and O&M of EVSE direct assigned to residential class.
- Commercial: Revenue, capital and O&M of EVSE and EVSI allocated among commercial rate classes based on proportion of program rate base in each class
- Company-Owned Public Charging: Revenue, capital and O&M of EVSE and EVSI allocated among all rate classes based on proportion of EVs in each class

Specific EV Customer Class

Pros and Cons

- EV use cases vary greatly with correspondingly varied load profiles (residential, workplace, fleet, public, mixed-use, etc.).
- Low penetration of EVs means load profiles may vary greatly creating uncertainty about the appropriate allocation of costs to the EV class.
- Customer classes are typically established based on load characteristics (residential vs non-residential, peak demand, and service voltage) rather than end-use. There are some exceptions (lighting, water pumping, etc.).
- Colorado and New Mexico use rate recovery riders to track and recover EV program costs. Other states recover EV program costs in base rates and/or from participants as applicable.

EV RATE DESIGN

EV Tariffs and Rate Design

Specific EV Tariffs

- Many EV use cases can benefit greatly from EV-specific rate options:
  - Time Varying Rates (modern three-part Time-of-Day rates)
  - Critical Peak Pricing
  - Appropriately Designed Demand Charges
- EV specific rates, just like standard rate options should follow cost causation principles and establish appropriate price signals.
- Alternative rate options can benefit other energy end-uses, not just EVs.

EVR-1 Rate Design (Wisconsin)

Residential Electric Vehicle Service Program

Peak Periods

	Time	Days
On-Peak	12:00 pm – 8:00 pm	Mon-Fri (Excluding holidays)
Intermediate-Peak	8:00 am – 12:00 pm	All Days
Intermediate-Peak	8:00 pm – 12:00 am	All Days
Intermediate-Peak	12:00 pm – 8:00 pm	Sat-Sun and Holidays
Off-Peak	12:00 am – 8:00 am	All Days

	EVR-1 Rate
Customer Charges	
Bundled Service	$18.00/month
Bring Your Own Charger	$8.00/month
Delivery Charges	
On-Peak	June – September 6.960¢/kWh October – May 4.360¢/kWh
Intermediate-Peak	4.360¢/kWh
Off-Peak	2.300¢/kWh
Energy Charges	
On-Peak	June – September 14.400¢/kWh October – May 9.500¢/kWh
Intermediate-Peak	9.500¢/kWh
Off-Peak	4.850¢/kWh

Commercial EV Rates

Demand Charges and Alternatives

- Use existing commercial tariffs for commercial EV use cases (Wisconsin)
  - Demand limiters or other rate design approaches can mitigate the need for EV-specific tariffs
- Use alternative tariffs for commercial EV use cases:
  - Energy-Only Pricing (Colorado)
  - Critical Peak Pricing (Colorado)
  - Demand Charge Holidays

How We Determine Demand Charges (Wisconsin)

- **Demand Charges recover all distribution costs and a portion of fixed production and transmission costs.**
- **Customer Demand Charges** – 12-month maximum demand
  - Recover fixed distribution costs, goal is to recover 100% of distribution costs.
- **On-Peak Demand Charges** – current month maximum on-peak (9am to 9pm weekday) demand
  - Recover a portion of fixed production and transmission costs.
- Only a portion of fixed P&T costs should be recovered in demand charges to reflect the fact that customers of differing load factors have a varying probability of their load being coincident with the system peak and consequently driving peak demand costs (The Bary Curve).
- In addition to recovering a portion of P&T costs in energy charges, we also use **Demand Limiters and High Load Factor Credits** to further differentiate peak demand cost causality among customers with varying load factors.
- Low load factor EV use cases share characteristics with other low load factor use cases (grain driers, car crushers, agriculture, etc.).
- For more information see Direct Testimony of Ryan Moldenhauer and Rebuttal Testimony of Tyrel Zich in Xcel Energy's latest Wisconsin Electric rate case (PSCW Docket No. 4220-UR-126).

How Demand Limiters Support Low Load Factor Customers

- Demand limiters adjust all demand billing units to mitigate the impact of demand charges for all low load factor customers.
  - "In no month will the billing demand be greater than the value in kW determined by dividing the kWh sales for the billing month by 150 hours."
- Demand limiters create a predictable fixed per kWh price for low load factor customers equivalent to an energy-only tariff.
- Demand limiters do not necessitate the selection of a specific load factor as the basis for the energy-only tariff.
- Demand limiters automatically transition customers to lower average prices as load factors increase.
- Demand limiters are difficult to explain to EVSE owners and for all C&I customers. This is a solvable problem with advisory services.

Table 1: Demand Limiter

	Cg-9 Current Rates	Cg-9 Energy-Only
Cg-9 Demand Charge	$13.00 per kW	
Cg-9 kWh Equivalent Demand Charge*		$0.13 per kWh
Charger Capacity kW	350	
Hours of Use	100	
kWh Use	350 x 100 = 35,000	
Limited Demand kW**	35,000 / 100 = 350	
Bill Impact	**$13 x 350 = $4,550**	**$0.13 x 35,000 = $4,550**
Effective per kWh Price	**$0.13 per kWh**	**$0.13 per kWh**

* At 100 Hours Use ($13.00 / 100 Hours Use = $0.13 per kWh)
** In no month will the kW demand be greater than dividing the kWh sales by 100/150 hours.

S-EV and S-EV-CPP Rate Design (Colorado)

Rate Options for Commercial Fleets and Public Charging Stations

- Reduced demand charges to accommodate lower utilization as industry is still growing
- CPP rate option preferable for commercial fleets with ability to respond to events when called (4-hour events, up to 15 events per year)
- Non-CPP rate option (S-EV) was introduced in response to feedback from public charging stations that found it difficult to respond to events

	S-EV Rate	S-EV-CPP Rate
S&F Charge	$59.21/month	$59.21/month
Dist. Demand Charge	$3.01/kW-month	$3.01/kW-month
Energy Charges		
Summer On-Peak	$0.13024/kWh	$0.06935/kWh
Summer Off-Peak	$0.02605/kWh	$0.01387/kWh
Winter On-Peak	$0.06512/kWh	$0.03467/kWh
Winter Off-Peak	$0.01302/kWh	$0.00693/kWh
CPP Charge	N/A	$1.44/kWh
On-Peak Hours	2pm – 10pm, non-holiday weekdays	2pm – 10pm, non-holiday weekdays

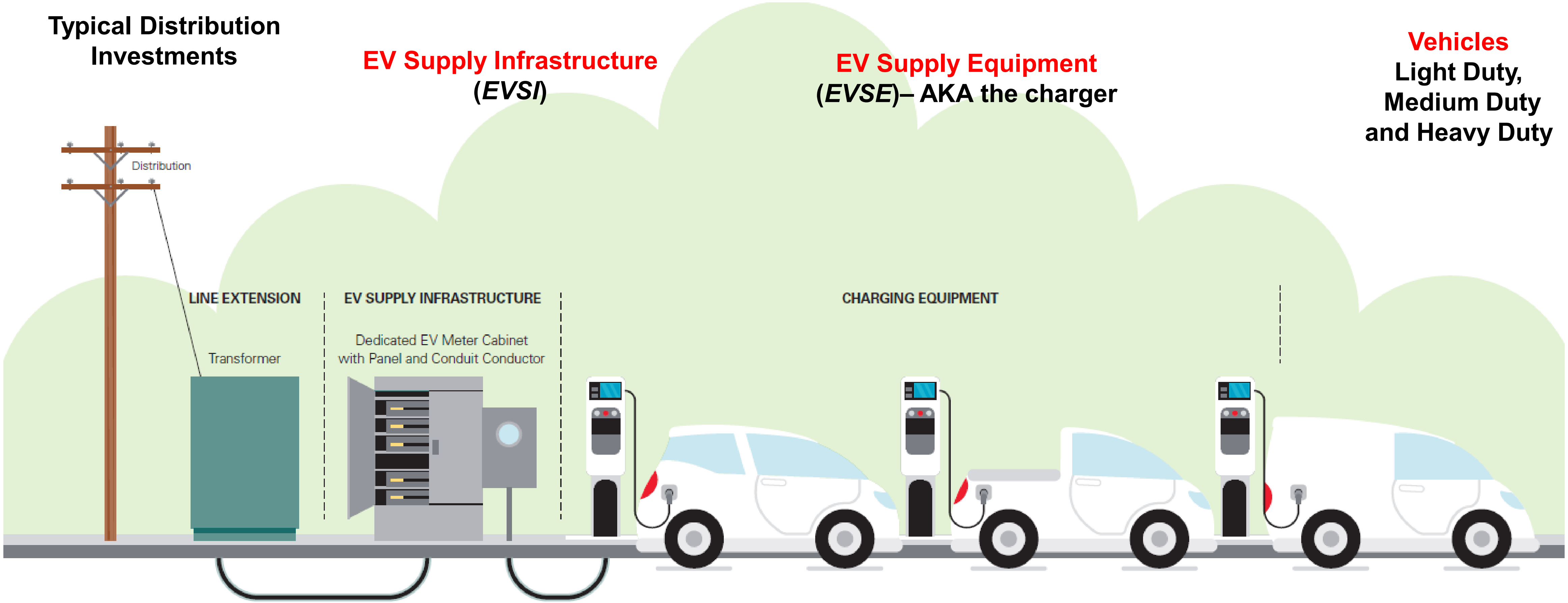
Overview – EV Ecosystem and Terminology

Typical Distribution Investments

EV Supply Infrastructure (*EVSI*)

EV Supply Equipment (*EVSE*)– AKA the charger

Vehicles
Light Duty, Medium Duty and Heavy Duty

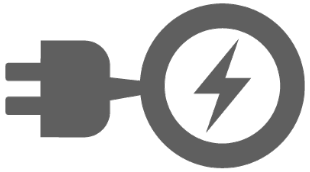


Clean Transportation Vision

Our Vision is to enable one out of five vehicles in the areas we serve to be electric by 2030 and all vehicles to run on carbon-free electricity or other clean energy by 2050

ZERO CARBON ENERGY

Provide the fueling infrastructure and energy system to run all vehicles on carbon-free electricity or other clean energy



EASY CHARGING

All customers can conveniently access affordable EV charging at home or within one mile of home

ACCESS

Underserved communities can participate in our programs and the related economic development benefits

XCEL ENERGY FLEET

Our entire fleet runs on carbon free electricity or other clean energy

Achieving the Vision – 2030 Benefits

Enabling one out of five vehicles in the areas we serve to be electric by 2030 delivers significant benefits

$1 BILLION

In customer fuel savings annually by 2030

$1 OR LESS PER GALLON
(EQUIVALENT)

To drive an EV with Xcel Energy's low, off-peak electricity prices at home

5 MILLION TONS OF CARBON EMISSIONS

Eliminated annually by 2030 with our clean energy

ACCESS

Holistic programs and infrastructure for all customers at home, work and on the go

Note that one out of five vehicles being electric by 2030 is the equivalent to at least 1.5 million EVs on our roads

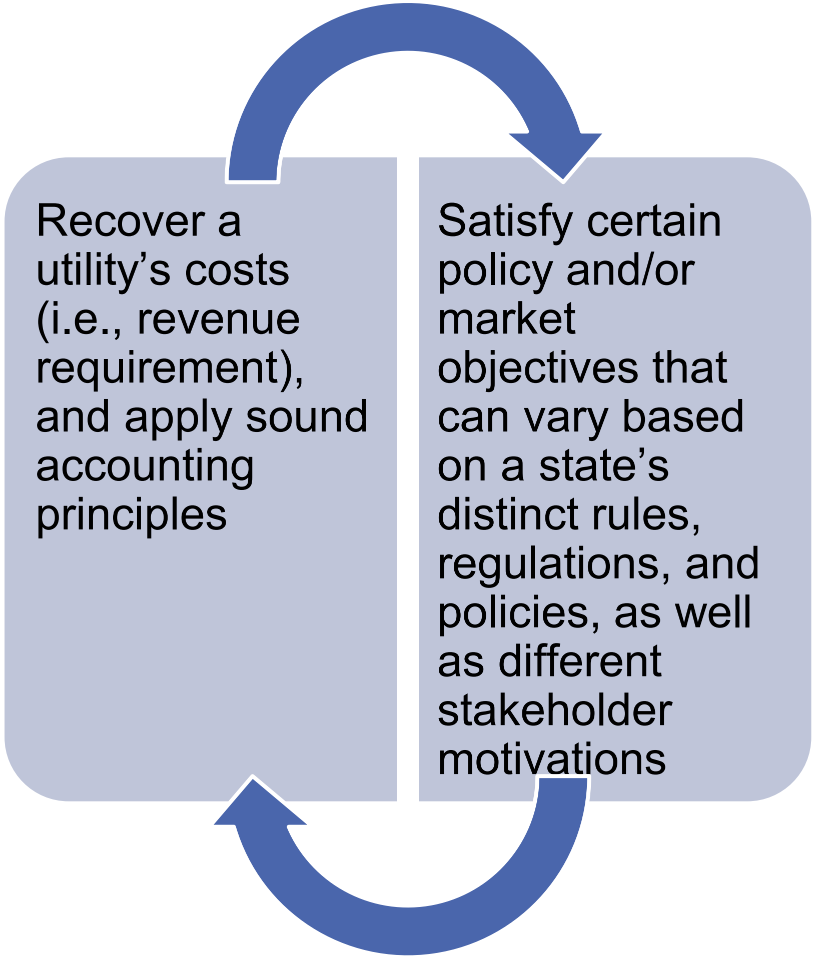
Electric Vehicle Rate Design Theory and Practice

Andy Satchwell, Berkeley Lab

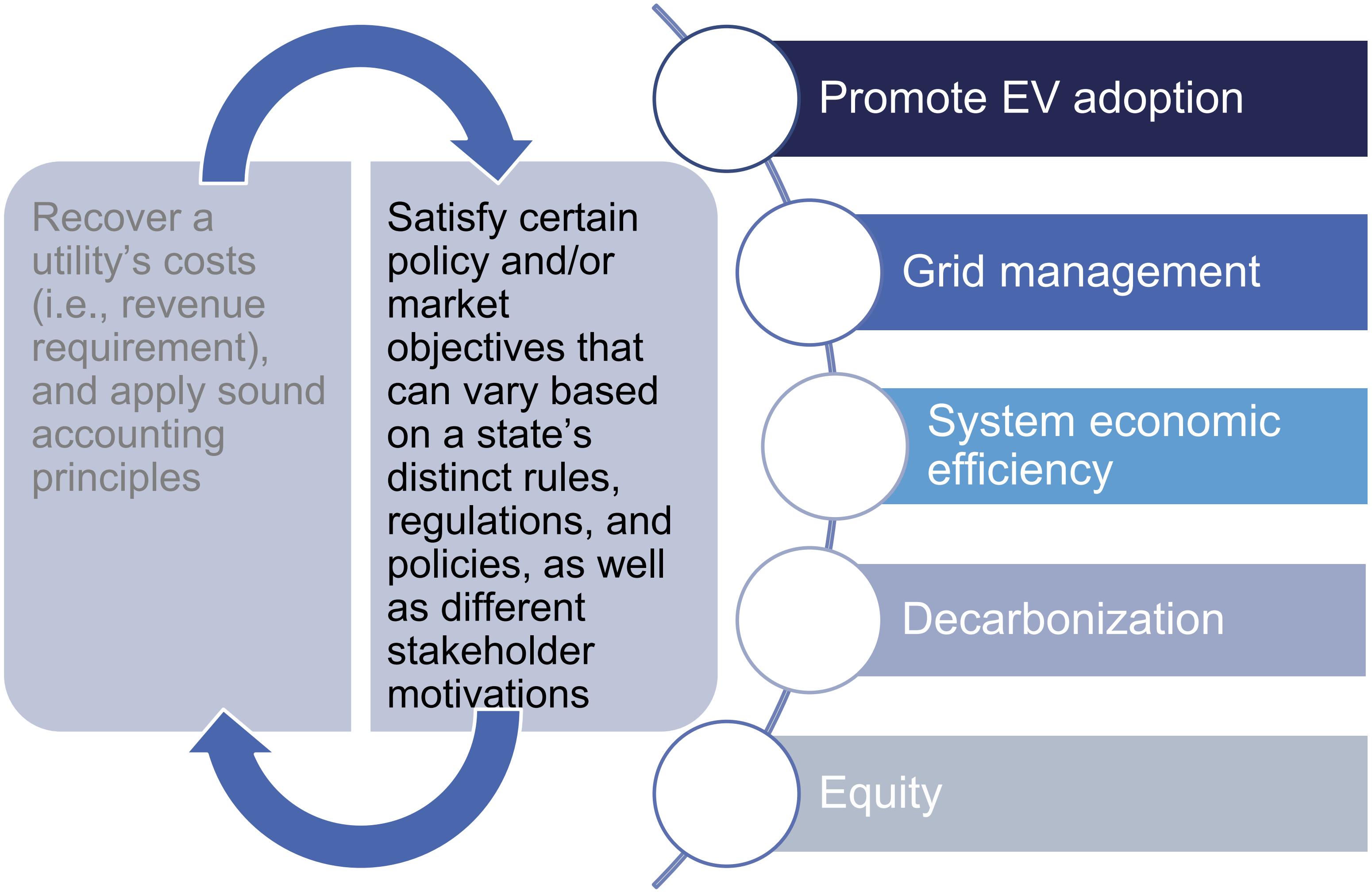
January 25, 2024
Michigan Public Service Commission Electric Vehicle Technical Conference

This work was funded by the U.S. Department of Energy's Office of Electricity under Contract No. DE-AC02-05CH11231.

Retail rates are designed based on two broad concepts

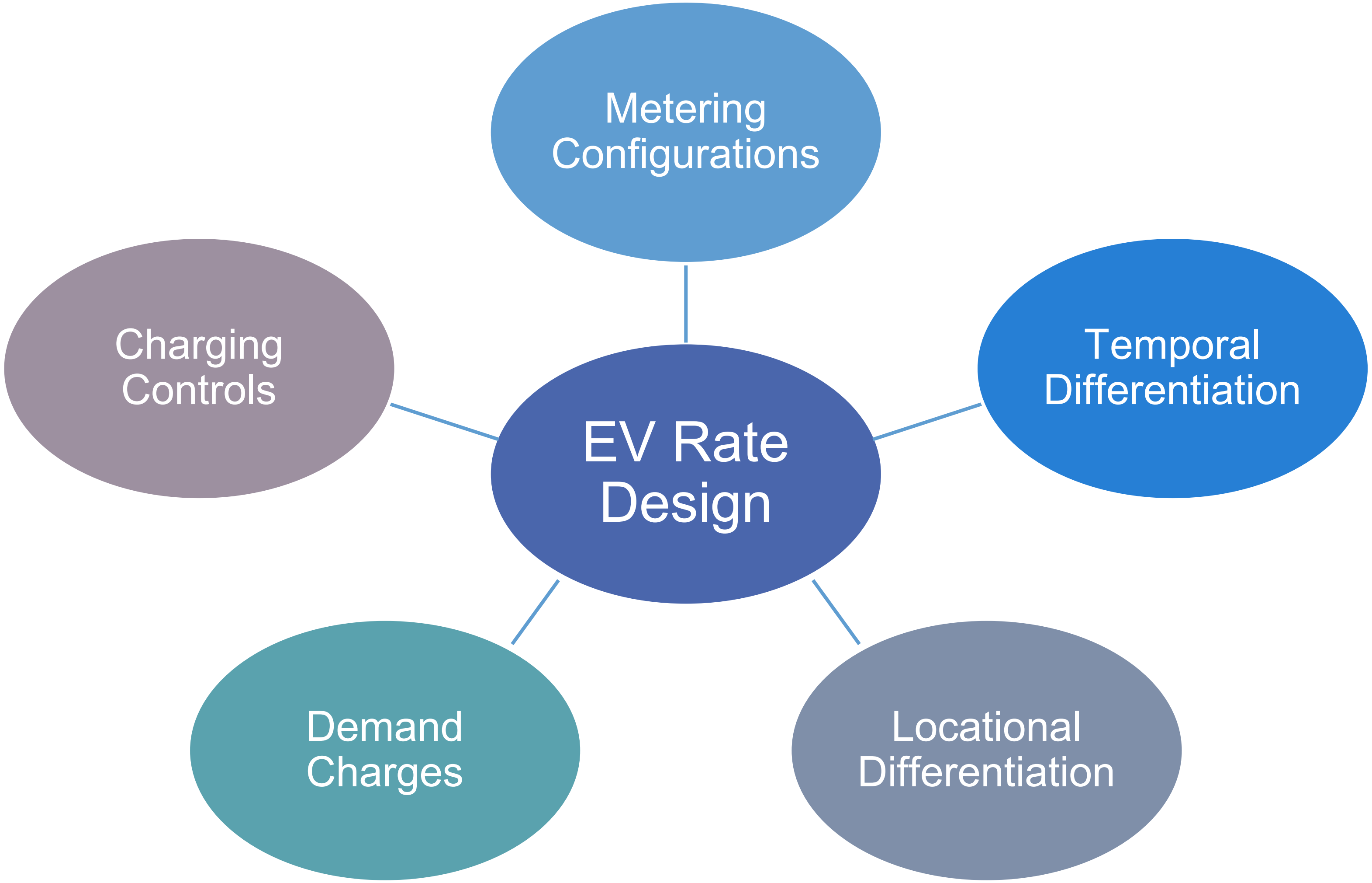


Policy-driven objectives that may be used as the basis for EV retail rate design

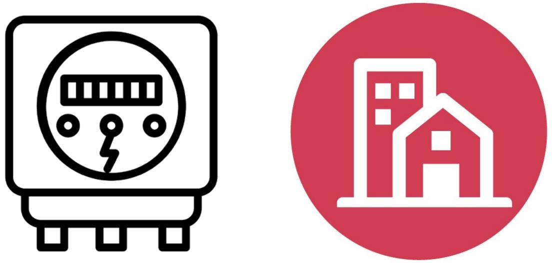


Source: Cappers and Satchwell (2023). EV Retail Rate Design. Available at: https://emp.lbl.gov/publications/ev-retail-rate-design-101

EV rate design typically comprised of five different components



Metering configurations

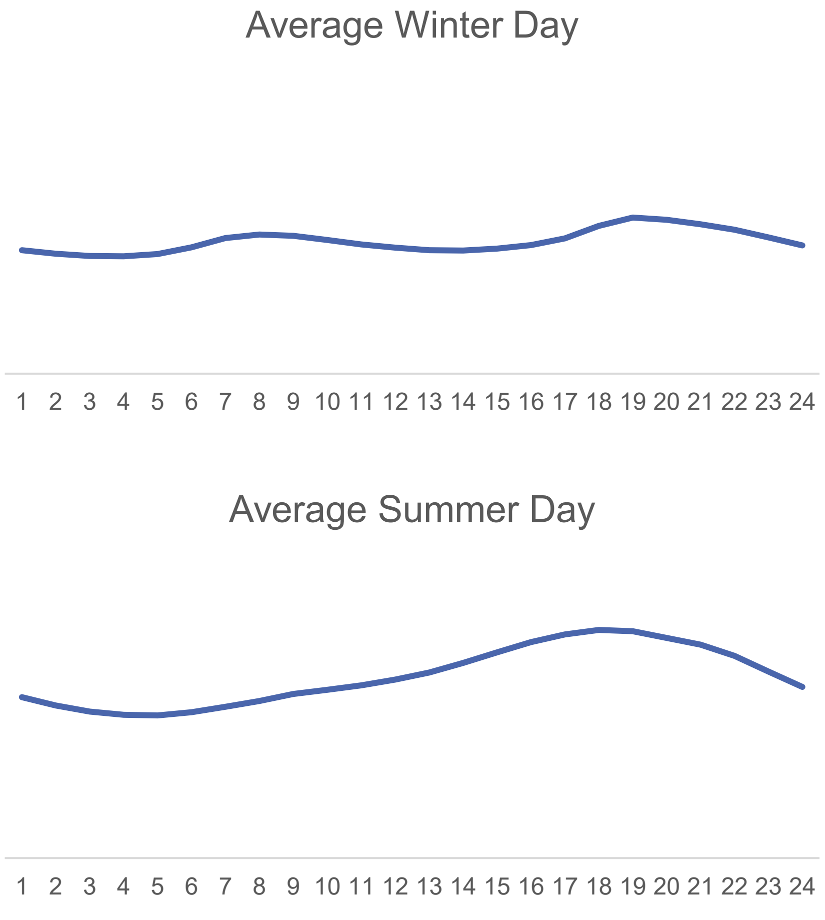


Whole home/facility consumption
via account meter

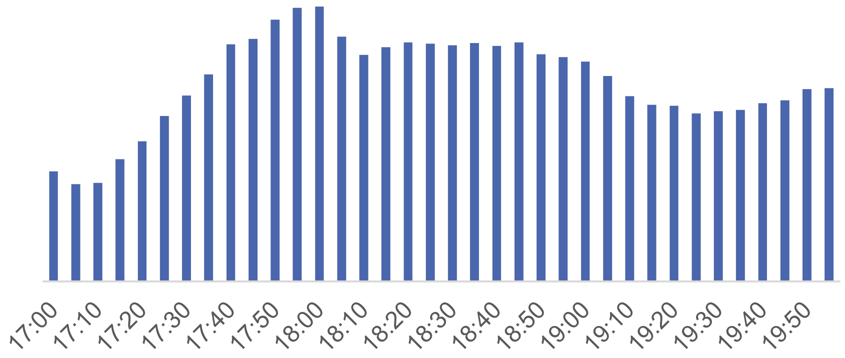
EV charging consumption
via account meter

Submetering via EVSE or vehicle

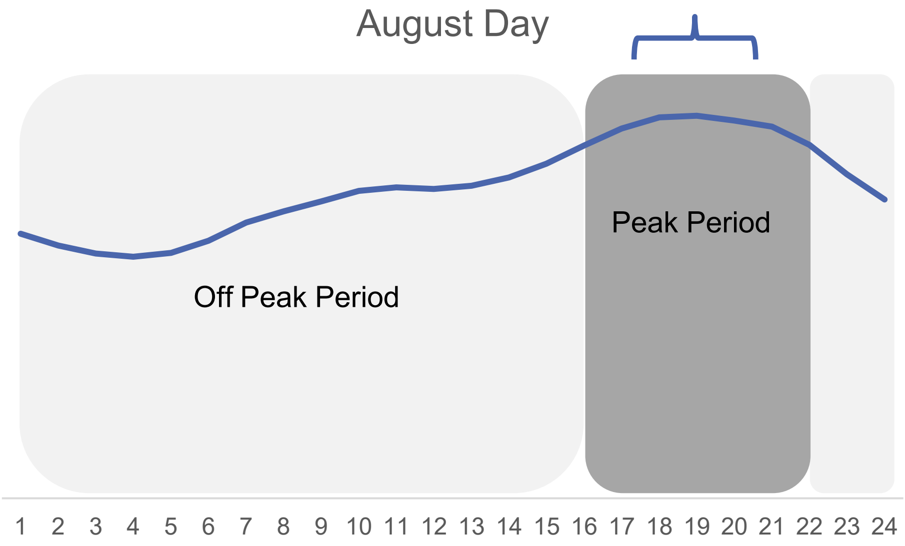
Temporal differentiation



Seasonal Differentiation



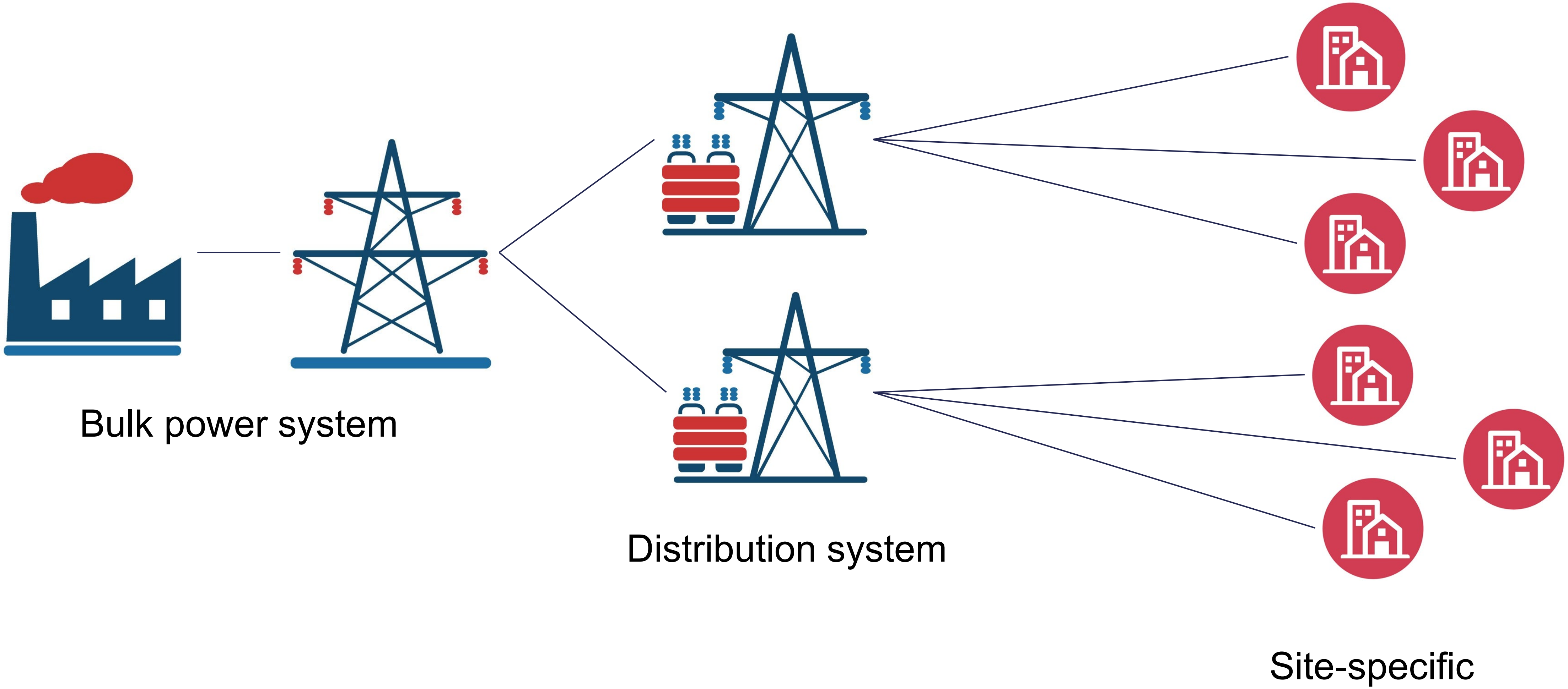
Sub-hourly Differentiation



Hourly and Period Differentiation

Note that figures show temporal differentiation in *load* but there is also temporal differentiation in system *costs* and *emissions* that could be used as the design basis

Locational differentiation



Demand charges

- ✓Max demand period
- ✓Demand ratchet
- ✓Seasonal
- ✓Coincident peak
- ✓Non-coincident peak

IOUs are mostly offering simple overnight TOU rates for EV charging

	Residential		Commercial		Utility-Owned	
	1st Most Offered	2nd Most Offered	1st Most Offered	2nd Most Offered	1st Most Offered	2nd Most Offered
Whole Premise Metering	○	●	○	○	○	○
Dedicated EV Metering	●	○	●	●	○	○
Flat or Block Energy Charge	○	○	○	○	●	○
TOU Energy Charge	●	●	●	●	○	●
Traditional Demand Charge	○	○	○	○	○	○
Alternative Demand Charge	○	○	●	○	○	○
Geographic Differentiation	○	○	○	○	○	○
Control Tech Requirement	○	○	○	○	○	○
Count / % of Class Total	25 / 46%	16 / 30%	13 / 27%	13 / 27%	16 / 60%	8 / 30%

Based on a review of 136 EV-specific retail rates currently approved and/or offered to customers

Source: Cappers et al. (2023). A Snapshot of EV-Specific Rate Designs Among U.S. Investor-Owned Electric Utilities. Report and rates database available at: https://emp.lbl.gov/publications/snapshot-ev-specific-rate-designs

Forward-looking considerations for EV rate design

Implications of EV rate designs for other DER objectives and policies

Alignment of system value with EV charging

Revisiting EV rate designs as EV deployments increase and/or system conditions change

Contact

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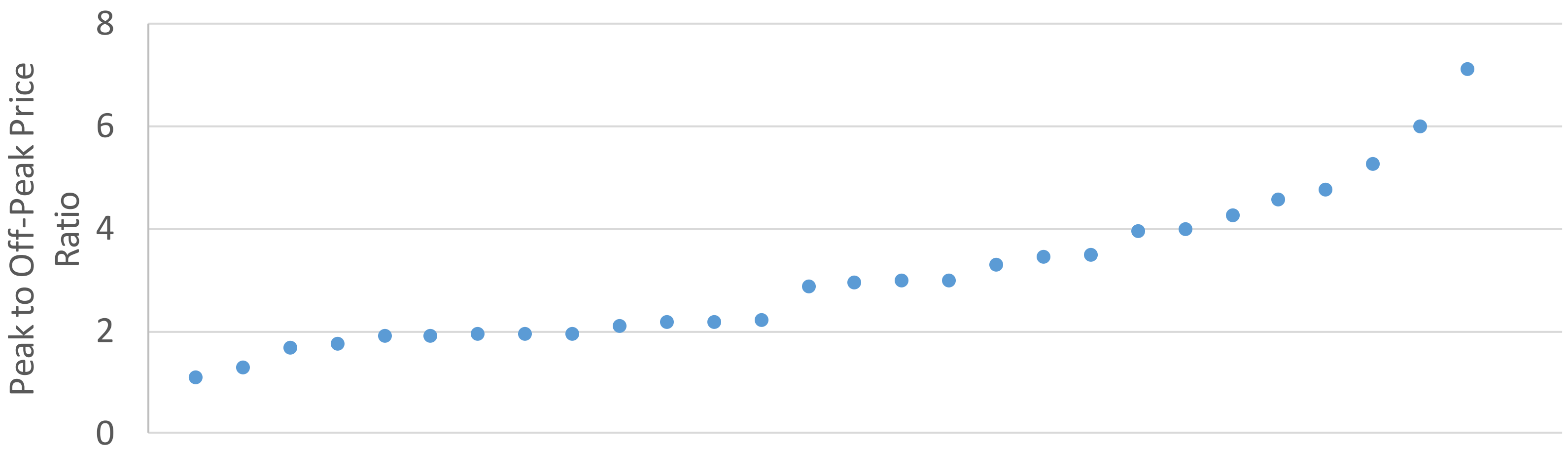
For more information

Download publications from the Electricity Markets & Policy: https://emp.lbl.gov/publications
Sign up for our email list: https://emp.lbl.gov/mailing-list
Follow the Electricity Markets & Policy on Twitter: @BerkeleyLabEMP

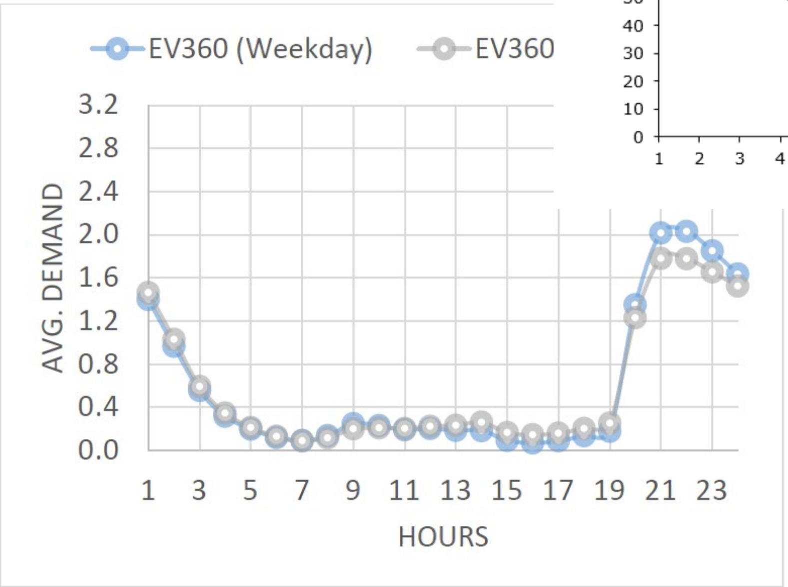
Appended slides on customer response to EV retail rates

Do customers respond to EV rates?

- Reviewed eleven (11) evaluation reports of EV rate offerings published between 2013-2020
- Most evaluation reports were outcomes of short-term (6 months – 2 years) pilots; very few system-wide roll outs were evaluated
- Pilots were evenly split between having whole house vs. EV-only metering
- Most pilots had at least a 2:1 peak-to-off peak price ratio and a small number had 4:1 or greater price ratio

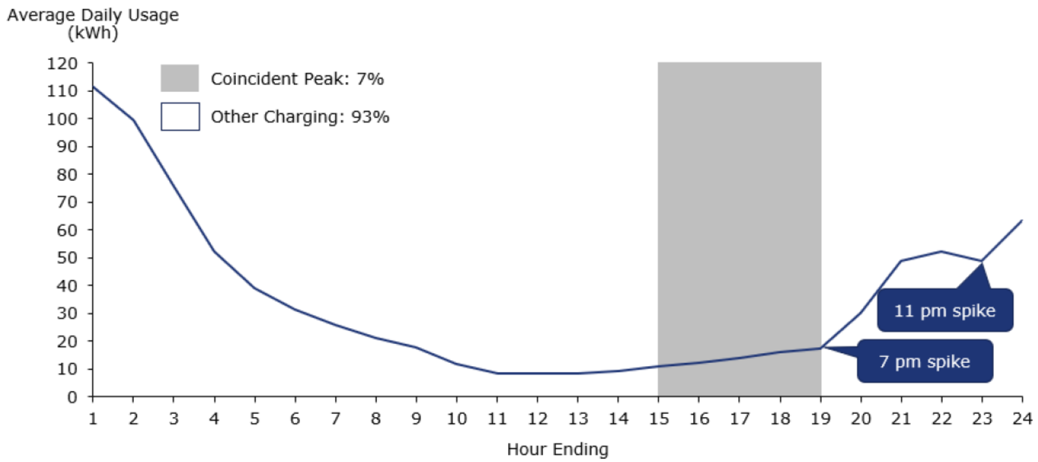


Properly designed rates can be an effective tool for managing EV charging behavior

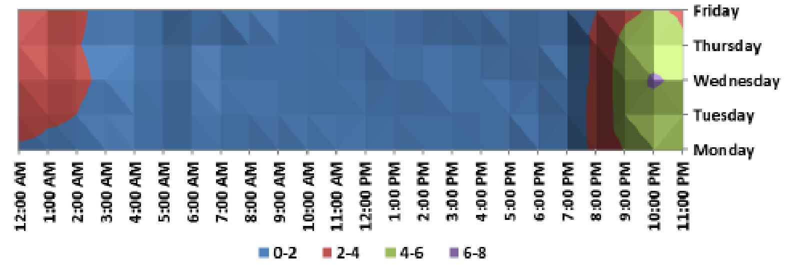


Source: McDougall, L., Donnelly, A. and Chandra, K. (2019) Austin Energy's Residential "Off Peak" Electric Vehicle Charging Subscription Pilot: Approach, Findings, and Utility Toolkit. EV360 Whitepaper. Austin Energy, Austin, TX.

Figure 11: Residential Station Usage, Oct 2019 – Apr 2020



Source: DTE Energy (2020) Charging Forward: Annual Status Report. May.



gure 4-1
erage weekly load shape (kW) for PIV customers

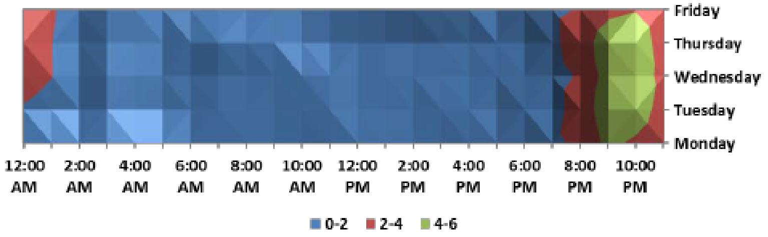


Figure 4-2
Average weekly load shape (kW) for PIV-Green Customers

Source: Dunckley, J. (2016) Pepco Demand Management Pilot for Plug-in Vehicle Charging in Maryland: Final Report - Results, Insights, and Customer Metrics. Electric Power Research Institute, Palo Alto, CA. May. 3002008798.

The higher the price ratio, the more off-peak charging is pursued

Tests of Pairwise Differences in Percentage Charging Shares Between Rates

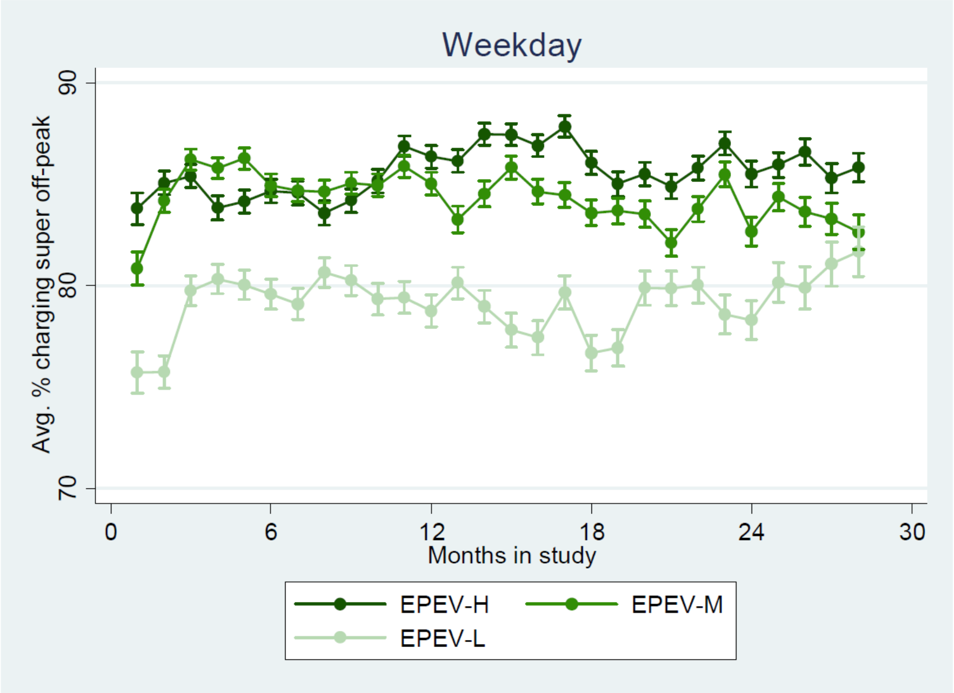
Day Type	Charging Share	EPEVL – EPEVM	EPEVL – EPEVH	EPEVM – EPEVH
Weekday	% Peak	1.8	3.08	1.29
	% Super Off-Peak	-4.16	-6.04	-1.87
Weekend	% Peak	2.33	3.25	0.92
	% Super Off-Peak	-4.06	-6.62	-2.55
	Significant @ 1%			
	Significant @ 5%			
	Not Significant @ 5%			

Rate Offering	Summer Price Ratio
EPEV-H	6.0
EPEV-M	4.0
EPEV-L	1.9

Source: Cook, J., Churchill, C. and George, S. (2014) Final Evaluation for San Diego Gas & Electric's Plug-in Electric Vehicle Tou Pricing and Technology Study. Nexant Inc. Prepared for San Diego Gas & Electric.

- Values in the table represent differences in the share of charging load for customers on different rates
- Comparing customers on lowest price ratio (EPEV-L) and customers on highest price ratio (EPEV-H) shows lowest price ratio customers had larger share of peak period consumption but highest price ratio customers had larger share of super off-peak consumption

The higher the price ratio, the quicker customers learn to shift charging to the off-peak period



Source: Cook, J., Churchill, C. and George, S. (2014) Final Evaluation for San Diego Gas & Electric's Plug-in Electric Vehicle Tou Pricing and Technology Study. Nexant Inc. Prepared for San Diego Gas & Electric.

Rate Offering	Summer Price Ratio
EPEV-H	6.0
EPEV-M	4.0
EPEV-L	1.9

- Figure depicts the monthly share of charging that occurred as a function of the number of months after a customer started in the study
- Customers on EPEV-H (highest price ratio) exhibited consistent charging behavior through the entire duration of the study
- Customers on EPEV-L and EPEV-M increased charging consumption in super off-peak period by 1.8%-2.9% per month for the first four months, but remained relatively stable thereafter

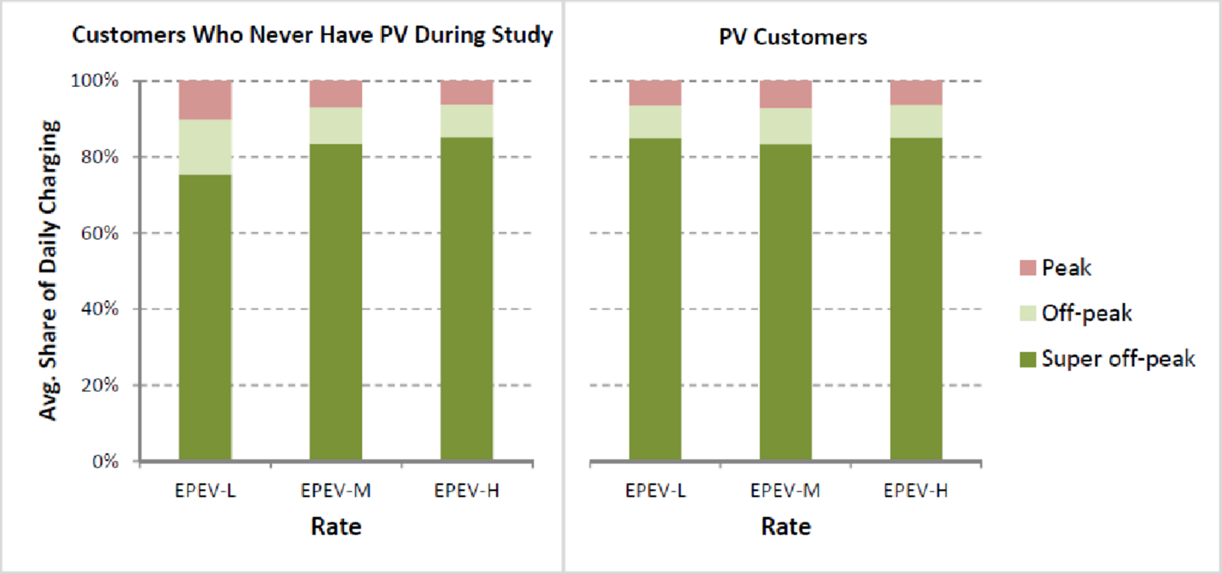
Customers are more responsive to changes in the peak or off-peak prices, but less so super off-peak

- Charging timers likely made it easier for customers to charge in the overnight super off-peak hours (12-5AM)
- Customer schedules likely limited long charging events to the off-peak (5AM-12PM and 8PM-12AM) or especially the super off-peak period
- Customers also did not seem to differentiate much between the on-peak and off-peak period in their EV charging decisions

		Peak to Super Off-Peak Ratio	Peak to Off-Peak Ratio
Summer	EPEV-L	1.9	1.6
	EPEV-M	4.0	1.6
	EPEV-H	6.0	2.6
Winter	EPEV-L	1.3	1.1
	EPEV-M	2.9	1.4
	EPEV-H	4.6	2.5

Source: Cook, J., Churchill, C. and George, S. (2014) Final Evaluation for San Diego Gas & Electric's Plug-in Electric Vehicle Tou Pricing and Technology Study. Nexant Inc. Prepared for San Diego Gas & Electric.

Customers who owned a PV system are significantly less responsive to prices than their non-PV counterparts



Source: Cook, J., Churchill, C. and George, S. (2014) Final Evaluation for San Diego Gas & Electric's Plug-in Electric Vehicle Tou Pricing and Technology Study. Nexant Inc. Prepared for San Diego Gas & Electric.

- PV owners exhibit more consistent shares of charging by period across the three rates relative to non-PV owners
- Selling PV electricity back to the grid may be valued more highly by customers than using it to charge their EV
- PV owners may have certain characteristics that cause them to place an even higher premium on charging overnight regardless of the prices they face

TESLA

Tesla’s Mission

Accelerate the world's transition to sustainable energy

Tesla Charging Goals

Supply needed EV charging cleanly, conveniently, and cost-effectively

Where You Park

Destination Charging

Supercharging

EV Charging Use Cases

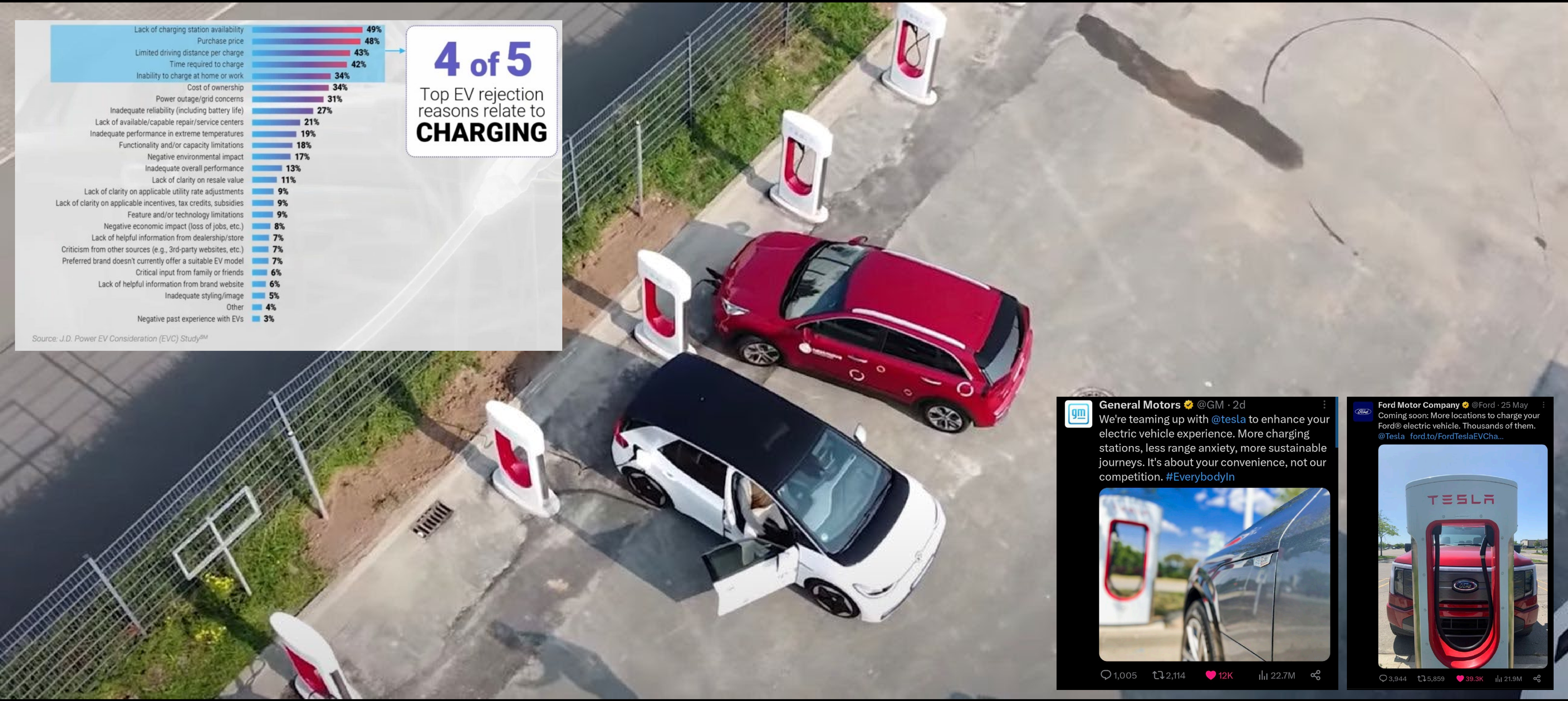
Commercial

- Public Charging (DC, L2)
- Workplace
- Fleet (DC, L2)
- Medium/Heavy-Duty

Residential

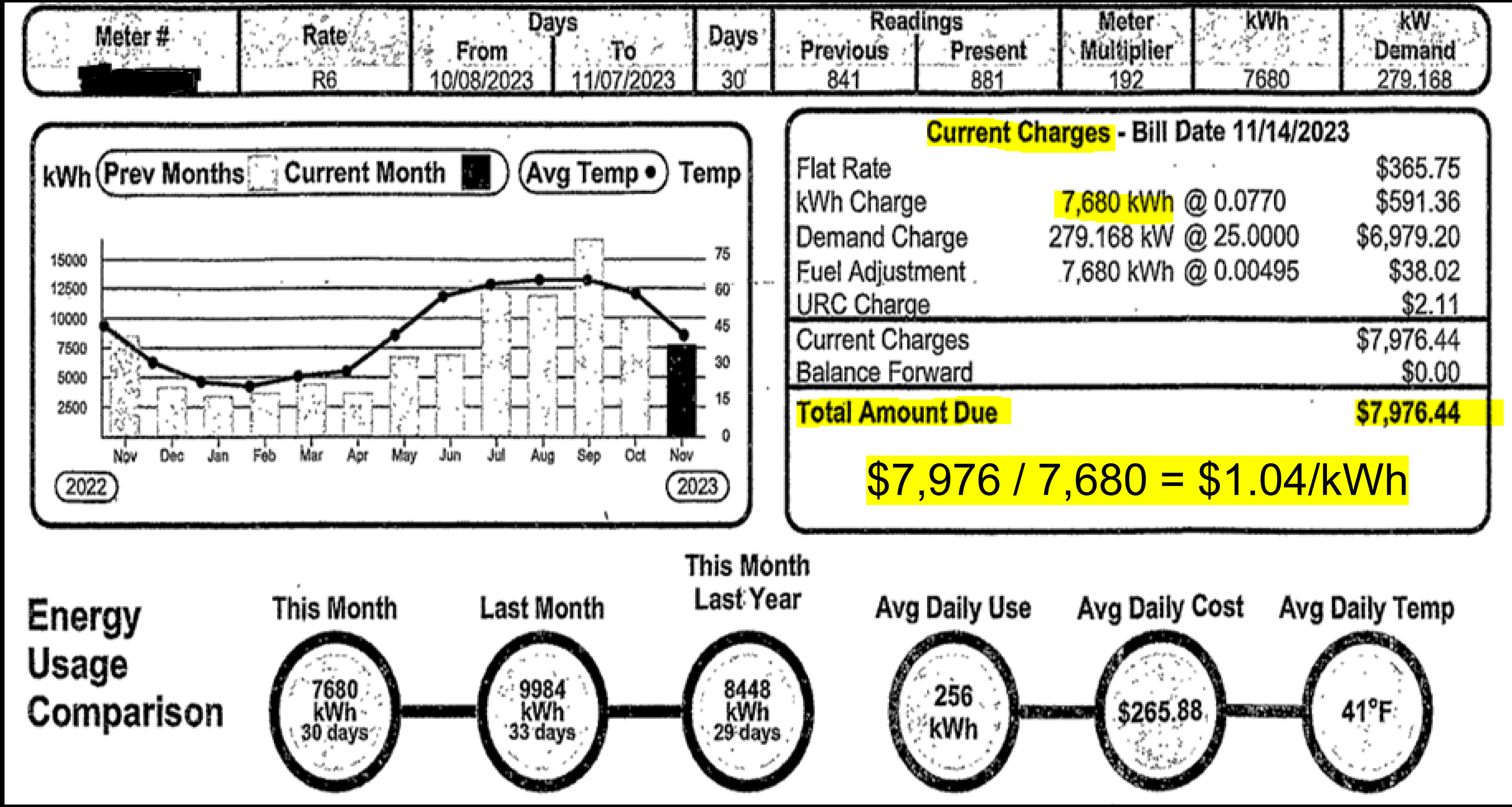
- Residential Single-Family
- Multi-Unit Dwelling (MUD)
- Low-Moderate Income (LMI)

Provide Charging for All



Why Commercial EV Rates?

Demand charges applied to public DC fast charging can result in high costs per kWH.



Meter #	Rate	Days From	Days To	Days	Readings Previous	Readings Present	Meter Multiplier	kWh	kW Demand
[redacted]	R6	10/08/2023	11/07/2023	30	841	881	192	7680	279.168

Current Charges - Bill Date 11/14/2023

Flat Rate		$365.75
kWh Charge	7,680 kWh @ 0.0770	$591.36
Demand Charge	279.168 kW @ 25.0000	$6,979.20
Fuel Adjustment	7,680 kWh @ 0.00495	$38.02
URC Charge		$2.11
Current Charges		$7,976.44
Balance Forward		$0.00
Total Amount Due		**$7,976.44**

$7,976 / 7,680 = $1.04/kWh

Energy Usage Comparison

This Month	Last Month	This Month Last Year	Avg Daily Use	Avg Daily Cost	Avg Daily Temp
7680 kWh 30 days	9984 kWh 33 days	8448 kWh 29 days	256 kWh	$265.88	41°F

87% of bill costs are demand charges

Why are demand charges problematic for public DC fast charging sites?

DC fast charging sites have lower utilization (aka "load factors") than average commercial customer.

2022 Total Electric Industry- Average Retail Price (cents/kWh)

(Data from forms EIA-861- schedules 4A-D, EIA-861S and EIA-861U)

State	Residential	Commercial	Industrial	Transportation	Total
New England	**24.73**	**18.13**	**15.02**	**11.37**	**20.47**
Connecticut	24.61	18.54	15.07	18.07	21.08
Maine	22.44	15.40	11.03	.	17.44
Massachusetts	25.97	18.67	17.06	7.08	21.27
New Hampshire	25.46	18.69	15.15	.	21.07
Rhode Island	23.21	16.23	17.96	17.52	19.30
Vermont	19.93	17.29	11.88	.	16.99
Middle Atlantic	**18.43**	**15.17**	**8.42**	**12.82**	**15.02**
New Jersey	16.74	13.75	12.12	12.90	14.80
New York	22.08	18.19	7.55	13.84	18.33
Pennsylvania	15.94	10.73	8.21	7.81	11.86
East North Central	**15.36**	**11.61**	**8.24**	**7.51**	**11.77**
Illinois	15.65	11.32	8.57	7.21	11.94
Indiana	14.59	12.86	8.65	13.03	11.66
Michigan	17.86	12.55	8.33	12.35	13.20
Ohio	13.85	10.39	7.45	8.54	10.64
Wisconsin	15.62	11.85	8.49	16.55	11.95

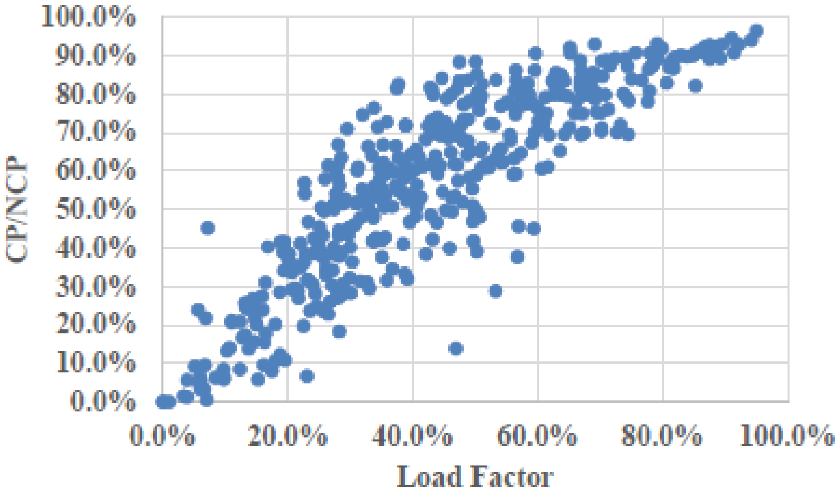
Public DC fast charging site from previous slide had very low utilization (load factor ~4%).

Do public DC fast chargers contribute to system peaks?

Due to the generally lower utilization ("load factor") of public DC fast chargers, contribution is lower.

OREGON PACIFIC POWER DATA

Figure 2. Schedule 23, 28 and 30 Coincidence with Monthly System Peaks as Compared to Individual Customer Load Factor



XCEL ENERGY COLORADO S-EV 2.0

S-EV 2.0

Cost Allocation Results

- 36 percent lower overall rates
- 56 percent lower demand charge
- Forecasted bill savings range from 34 to 44 percent
- Why? - Contribution to summer coincident peak (4CP) is substantially lower than other C&I customers

	SG Total	SG Unitized Load
Individual Max Demand	4,142,632 kW	1.00 kW
Annual Energy	12,658,300,130 kWh	3,056 kWh
Load Factor	34.9%	34.9%
4CP - AED	2,268,867 kW	0.55 kW
NCP	2,723,015 kW	0.66 kW

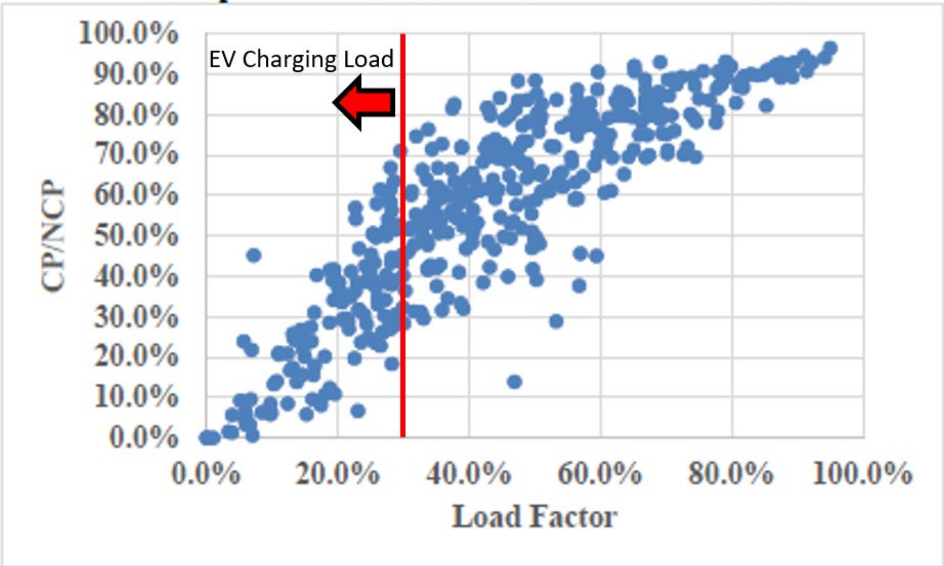
	EV Charging Total	S-EV Unitized Data
Individual Max Demand	6,571 kW	1.00 kW
Annual Energy	5,704,906 kWh	868 kWh
Load Factor	9.9%	9.9%
4CP - AED	1,235 kW	0.19 kW
NCP	2,625 kW	0.40 kW

DC fast charging ranges from <5% load factor up to 30% load factor on the high end.

CASE STUDY: Pacific Power Oregon (Schedule 29)

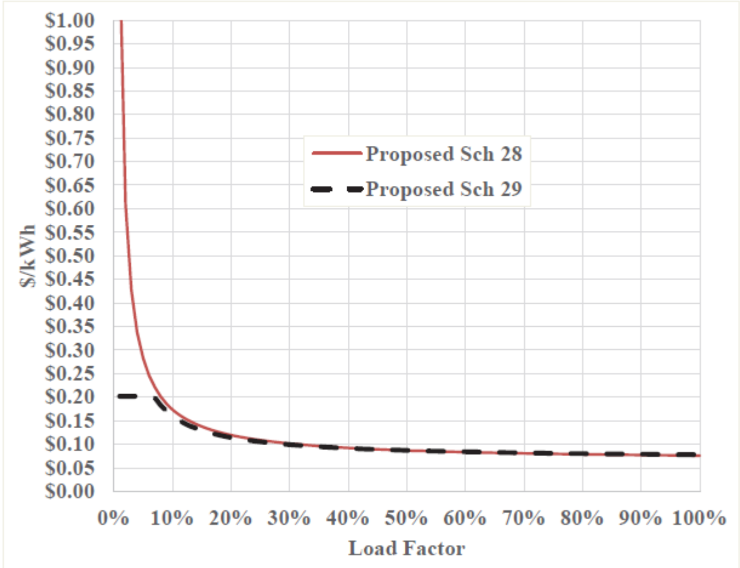
Existing Real-World Data

Figure 2. Schedule 23, 28 and 30 Coincidence with Monthly System Peaks as Compared to Individual Customer Load Factor



Customer Rate Solution

1 **Figure 4. Comparison of Proposed Schedule 29 Price to Average Energy and Demand Cost.**



"Contribution to Summer peaks is substantially lower than other C&I customers"

XCEL ENERGY COLORADO S-EV 2.0

S-EV 2.0

Cost Allocation Results

- 36 percent lower overall rates
- 56 percent lower demand charge
- Forecasted bill savings range from 34 to 44 percent
- Why? - Contribution to summer coincident peak (4CP) is substantially lower than other C&I customers

	SG Total	SG Unitized Load
Individual Max Demand	4,142,632 kW	1.00 kW
Annual Energy	12,658,300,130 kWh	3,056 kWh
Load Factor	34.9%	34.9%
4CP - AED	2,268,867 kW	0.55 kW
NCP	2,723,015 kW	0.66 kW

	EV Charging Total	S-EV Unitized Data
Individual Max Demand	6,571 kW	1.00 kW
Annual Energy	5,704,906 kWh	868 kWh
Load Factor	9.9%	9.9%
4CP - AED	1,235 kW	0.19 kW
NCP	2,625 kW	0.40 kW

“A rose by any other name . . .”

EV Rate Structure / Approach	State Examples	Utility Examples
EV Time-of-Use (TOU) Rates	CO, KS	• Xcel Colorado (S-EV) • Evergy Kansas (BEVCS)
Demand Charge Holiday/Discount	CA, MD, NJ, PA, WA	• SCE (EV-TOU-9) • MD EDCs Demand Charge Discount • NJ (PSE&G and JCP&L) • PECO (EV-FC)
Demand Limiters and kWh-per-kW blocks	FL, MN, OR, UT, WY	• FPL • Xcel MN (Rule of 100) • Pacific Power OR (Schedule 29) • RMP Wyoming (Schedule 29)
Load Factor Tranches	MA, NY	• Massachusetts (Eversource & NatGrid) • New York (Joint Utilities)

**Honorable mention:* (1) all-volumetric rates, (2) system coincident peak contribution demand charges, and (3) opening existing small commercial rate to EV charging.

EV TOU Example: Evergy

- Low demand charge ~$3/kW of Demand
- Three-period time-of-use (TOU) rate
  - On-Peak, Off-Peak, Super Off-Peak
- 4-month summer season
- 2pm to 8pm Weekday On-Peak, year round
- **Strong** On-Peak price signal
- **Strong** Super Off-Peak price signal
- SIMPLE AND STRAIGHTFORWARD!

No supplement or separate understanding shall modify the tariff as shown hereon.

Sheet 2 of 4 Sheets

BUSINESS EV CHARGING SERVICE

RATE FOR SERVICE

		Summer Season	Winter Season
A.	Customer Charge (Per Month)		$ 105.97
B.	Facility Charge (Per kW of Billing Demand per month)		$ 3.069
C.	Energy Charge per Pricing Period (Per kWh)		
	On-Peak Period	$0.17979	$0.11522
	Off-Peak Period	$0.08298	$0.05458
	Super Off-Peak Period	$0.02755	$0.02416
D.	Carbon Free Energy Option Charge (Per kWh)	$0.00250	

MINIMUM MONTHLY BILL

The Minimum Monthly Bill shall be equal to the sum of the Customer Charge and Facilities Charge.

SEASONS

The Summer Season is four consecutive months, beginning and effective June 1 and ending September 30 inclusive. The Winter Season is eight consecutive months, beginning and effective October 1 and ending May 31. Customer bills for meter reading periods including one or more days in both seasons will reflect the usage in each season.

BUSINESS EV CHARGING SERVICE

PRICING PERIODS

Pricing periods are established in Central Time year-round. The hours for each pricing period are as follows:

On-Peak:	2 p.m. – 8 p.m., Monday through Friday, excluding Holidays
Super Off-Peak	12 a.m. – 6 a.m. every day
Off- Peak Period:	All other hours

Volumetric Example: Eversource CT

Eversource Connecticut's Electric Vehicle Rate Rider:

- *IF "a rate component of such schedule is priced on a demand basis (i.e., per kW or per kVA), the EV customer under this Rider will be subject to a charge determined on an equivalent per kWh basis using the corresponding average price of such rate component."*
- EV Rate Rider converts rate components billed on a demand basis to a customer average kWh value
    - Based on what an average customer would pay per kWh for these demand components – effectively converts demand components to **ALL-VOLUMETRIC kWh** basis at the **commercial customer class avg load factor.**
- Applies the customer average kWh value to the EV charging customer.

Load Factor Limits: APS Rate Rider DCFC

- Similar to Ameren's Rider EVCP
- Limits Billing Demand based on declining Load Factor conversion over 10 years.
- Starts at 25% Load Factor Limit
- Equivalent to 182.5 hour "demand limiter"
- A customer who uses 18,250 kWh per month would pay NO MORE THAN 18,250 kWh / 182.5 hr = <u>100 kW billed demand</u>
- A customer who uses 36,500 kWh per month would pay NO MORE THAN 36,500 kWh / 182.5 hr = <u>200 kW billed demand</u>

<u>LOAD FACTOR LIMITS</u>

Monthly billing demands are limited to a kW no higher than that which would result in the applicable load factor limit, based on the customer's kWh usage, and billing days during the month. The monthly load factor limits are:

	Monthly Cycle Bills beginning with cycle 1 Between	Load Factor Limit
Period One	July 1, 2021 through June 30, 2025	25%
Period Two	July 1, 2025 through June 30, 2028	20%
Period Three	July 1, 2028 through June 30, 2031	15%

The monthly billing demand shall be the lower of:

1. The Billing Demand metered and calculated according to the parent rate schedule, or
2. The Limited Demand which equals:
   a. Period One - (Monthly Billed kWh) / [25%*Days*24 hours]
   b. Period Two - (Monthly Billed kWh) / [20%*Days*24 hours]
   c. Period Three - (Monthly Billed kWh) / [15%*Days*24 hours]

Rate Limiter: Dominion VA

GS-2 Intermediate General Service Schedule

- Regular commercial rate that is beneficial for EV charging.
- Technology neutral rate, applicable to all non-residential customers,
- GS-2 is billed as an all-volumetric rate at usage levels below 200 kWh per kW (~27% load factor)
- Above 200 kWh per kW (~27% load factor) rate is automatically billed with a demand charge and correspondingly lower energy charge.
- Very simple rate for customers with automatic switchover point for their benefit.

Load Factor Tranches: National Grid MA & ConEd NY

Load Factor ("LF") Threshold	Enrollment Years	Demand Charge Discount
None	1	100%
LF <= 5%	2 to 9	100%
5% < LF <= 10%	2 to 9	75%
10% < LF <= 15%	2 to 9	50%
LF > 15%	2 to 9	0%

$$\text{Load factor} = \frac{\text{Billed Energy in kWh}}{\text{Billed Demand in kWh x Hours in Billing Period}}$$

nationalgrid

conEdison

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.

Case 22-E-0236

CECONY EV Phase-In Rates Summary for SC9 Rate I & II (Based on 2022 Rate Level)

	Customer Charge	100%	100%	100%	100%
	Energy Charge	100%	75%	50%	25%
	Demand Charge	0%	25%	50%	75%
		LF <= 10%	10% < LF <= 15%	15% < LF <= 20%	20% < LF < 25%
SC9 Rate I (LT)		Tier 1	Tier 2	Tier 3	Tier 4

EV RATE DESIGN PRINCIPLES

<u>Non-residential EV rate(s):</u>

- Technology agnostic and accessible to all non-residential EV customers.
- Available to new and existing stations.
- Optional
- Consider the needs of all use cases, including fleet charging.
- Incentivize intelligent and manageable scheduling where appropriate.
- Provide certainty and stability for long-term investments.

Thank You for Joining!

MPSC
MICHIGAN PUBLIC SERVICE COMMISSION