Smart Electric Power Alliance

SEPA OVERVIEW

Accelerating Transformation

Regulatory and Business Innovation | Grid Integration | Electrification

Who Are We?

Smart Electric Power Alliance

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

Mission and Vision

Smart Electric Power Alliance

Mission

To accelerate the transformation to a carbon-free energy system through actionable solutions

Vision

A carbon-free energy system that is safe, affordable, reliable, resilient and equitable

Education

Smart Electric Power Alliance ONLINE LEARNING

- Workshops
- Bootcamps
- Webinars
- SEPA TV

- Events
  - EXECUTIVE FACT FINDING MISSION SEPA
  - UTILITY CONFERENCE
  - Utility Executive Exchange Forum
  - RE+ EVENTS

NEW in 2023 - BASIC TRAINING

Collaboration

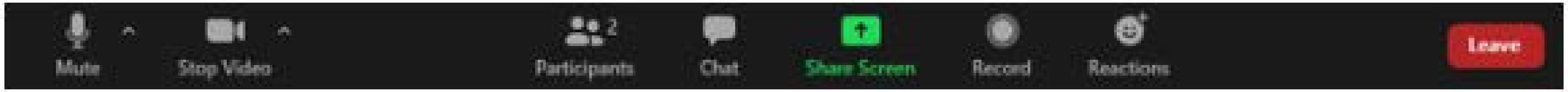
GROUPS
COMMUNITY and COLLABORATION by SEPA

- Community & Building Professional Networks
- Expert & Technical Assistance
- Stakeholder Engagement
- Custom Projects

- Working Groups
  - **8** Main Working Groups & **13** Sub-Groups & Task Forces
  - **2,500+** Members
  - **480+** Companies Represented
  - **200+** Meetings per Year

workinggroups@sepapower.org

Bootcamp Basics



Peter Kelly-Detwiler
Cofounder, NorthBridge Energy Partners

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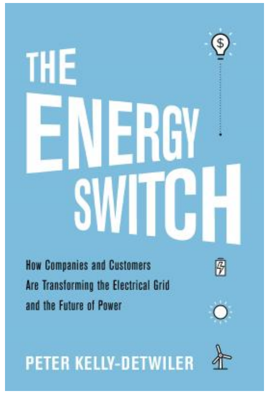
Your instructor is Peter Kelly-Detwiler, a strategist and communicator on the rapid pace of transformation to a sustainable energy economy with over 300 articles published on Forbes.com.

Peter Kelly-Detwiler has 30 years of experience in the electric energy arena. He's a former SVP at Constellation Energy, running their Demand Response Group. He's currently a strategist and communicator in the electric industry, focused on the rapid pace of transformation to a sustainable energy economy. Peter has written over 300 pieces on the topic for Forbes.com and others. He provides strategic advice to clients and investors, helping them to navigate this transitional period.



Peter has authored a book on the transformation of the electric power market, called "The Energy Switch," published by Prometheus Books in 2021.

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Electrification of Transportation Fundamentals Bootcamp

Accelerating Transformation

Regulatory and Business Innovation | Grid Integration | Electrification

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Day 1: Growth of EV, Technological Issues, and Customer Concerns

18 – 20 October 2022

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Setting the Stage: The Rise of Electric Vehicles

For Utilities (and Society), the Questions Are Pretty Simple

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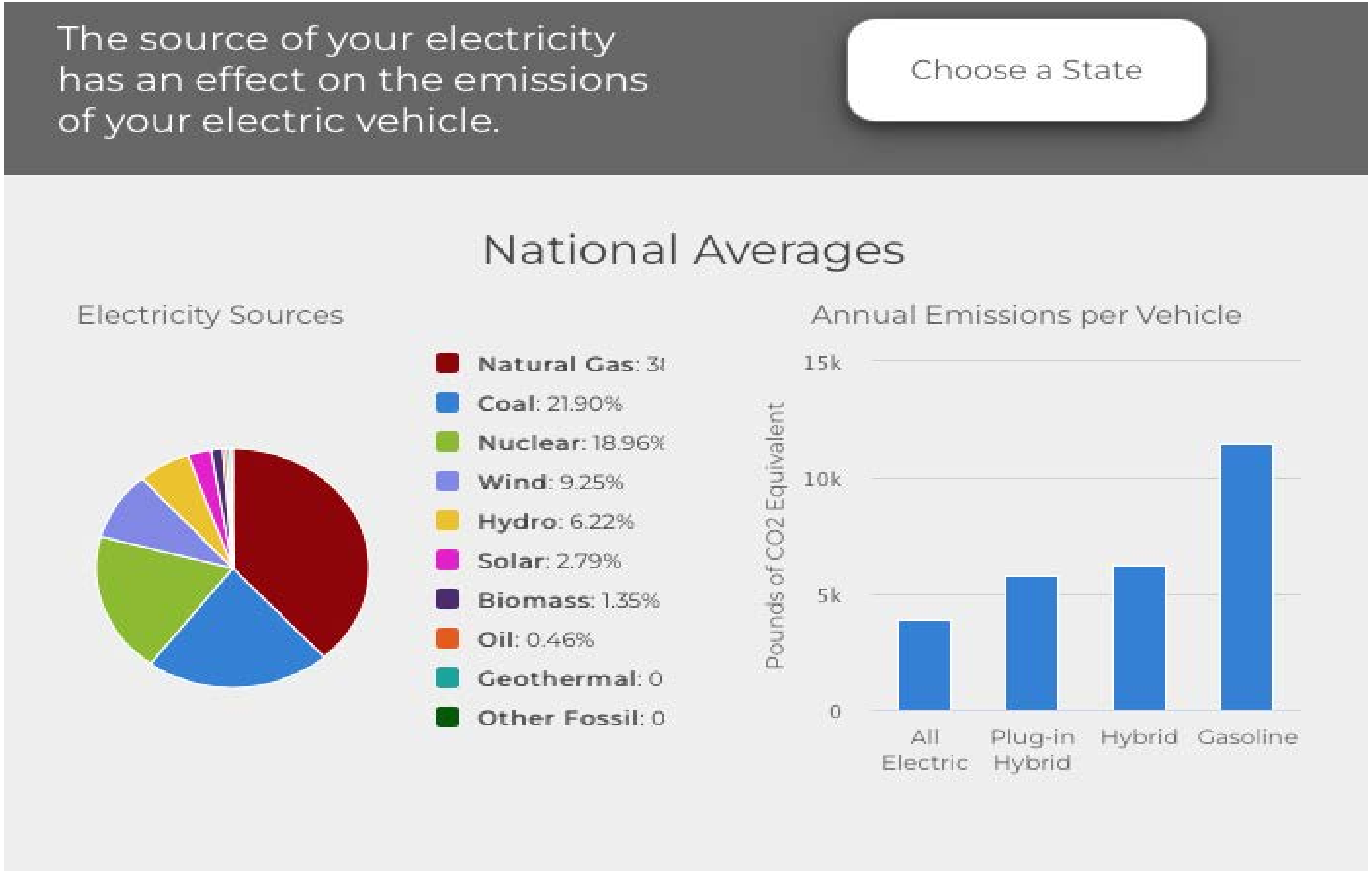
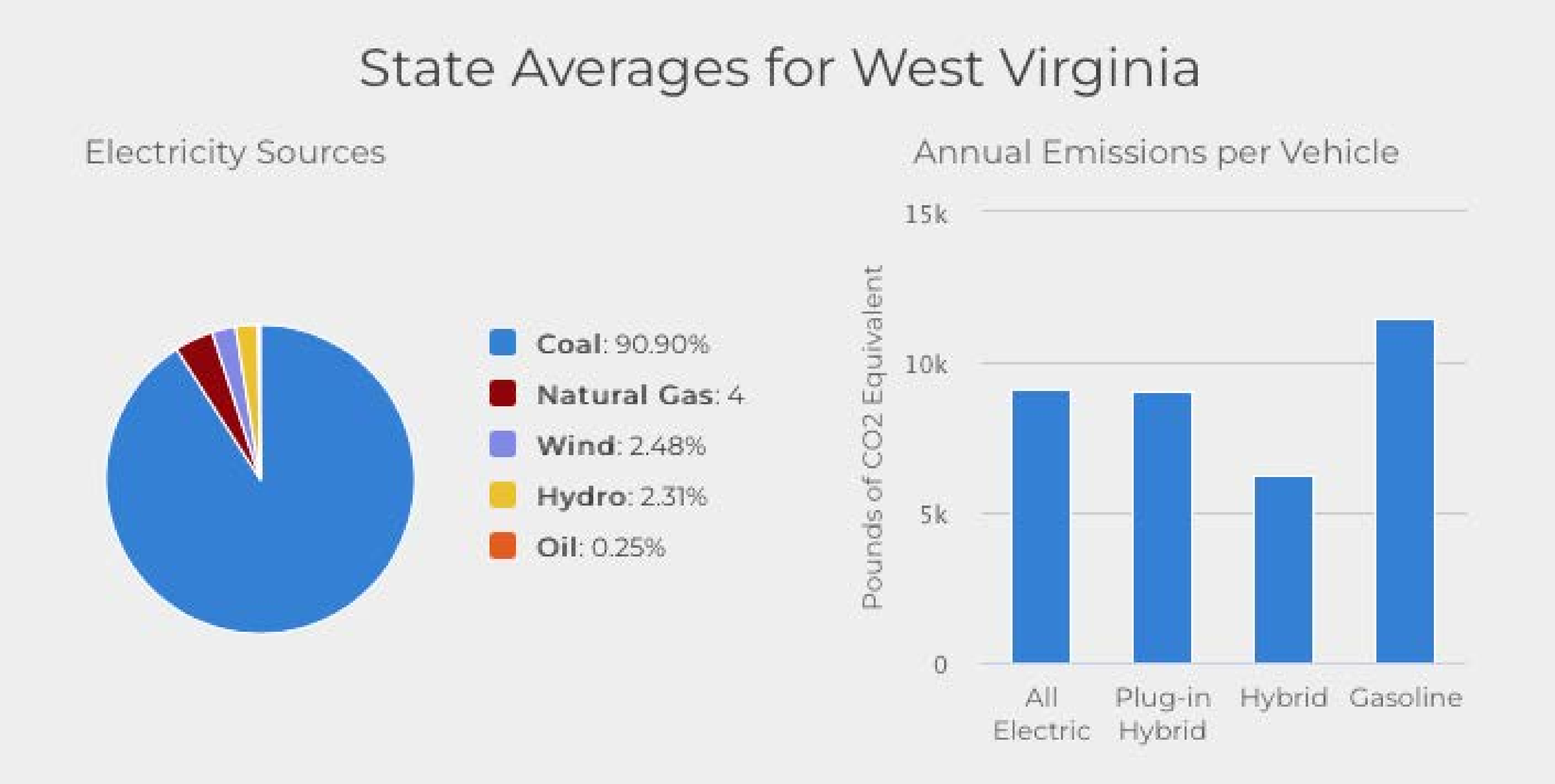
1. How Many EVs, and How Fast?
2. What's the Resulting Demand on Infrastructure (and Fuel)?
3. What Will That Cost?
4. How Do We Plan For the Build-Out?

From a Policy Perspective, The “Why”



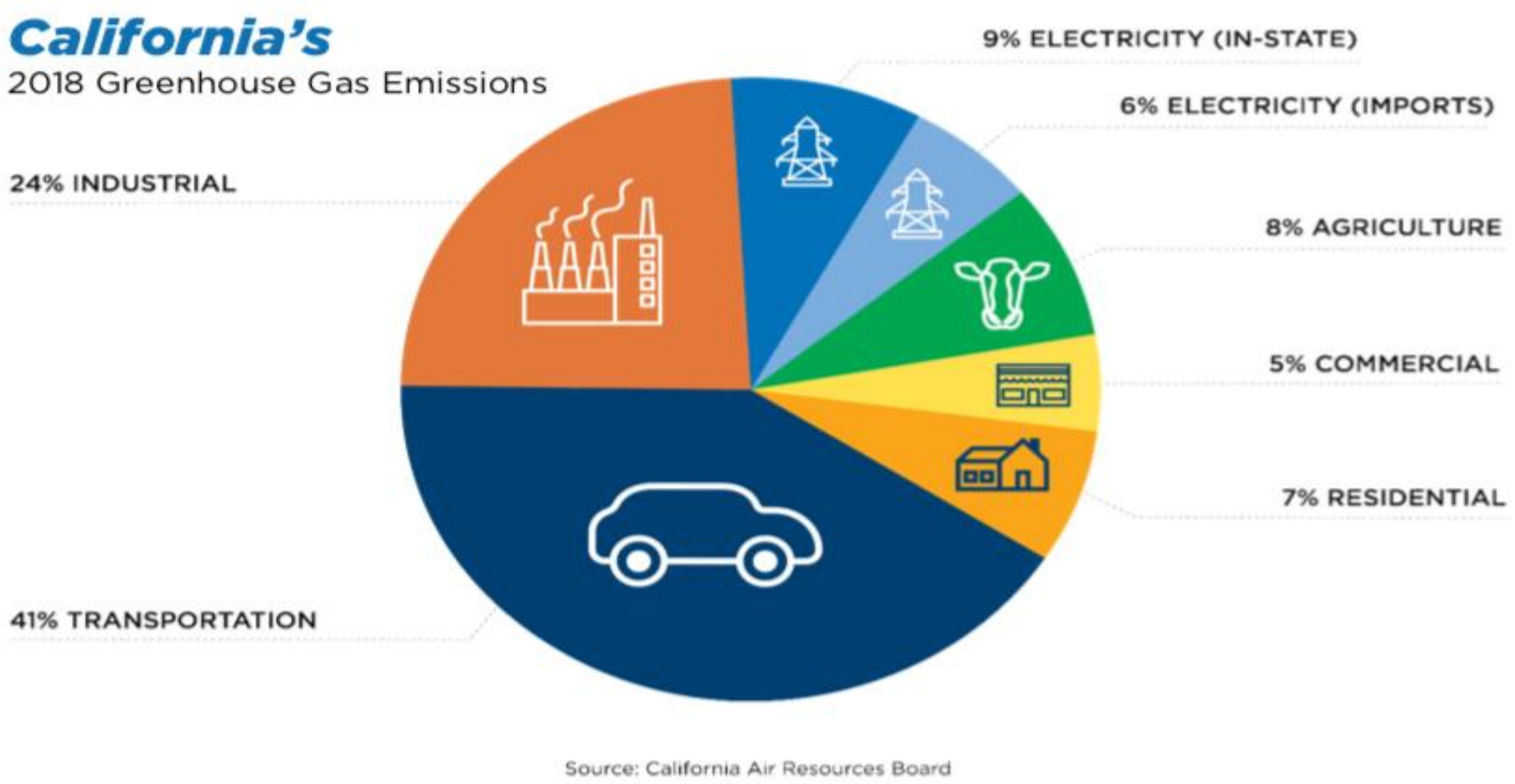
https://afdc.energy.gov/vehicles/electric_emissions.html

EVs Are Less Carbon-Intensive Than ICEs, Even in West Virginia



https://afdc.energy.gov/vehicles/electric_emissions.html

Transportation is a Big Source of GHG Emissions



https://www.energy.ca.gov/news/2021-03/california-releases-report-charting-path-100-percent-clean-electricity

What, Specifically, Are We Talking About? Plug-Ins

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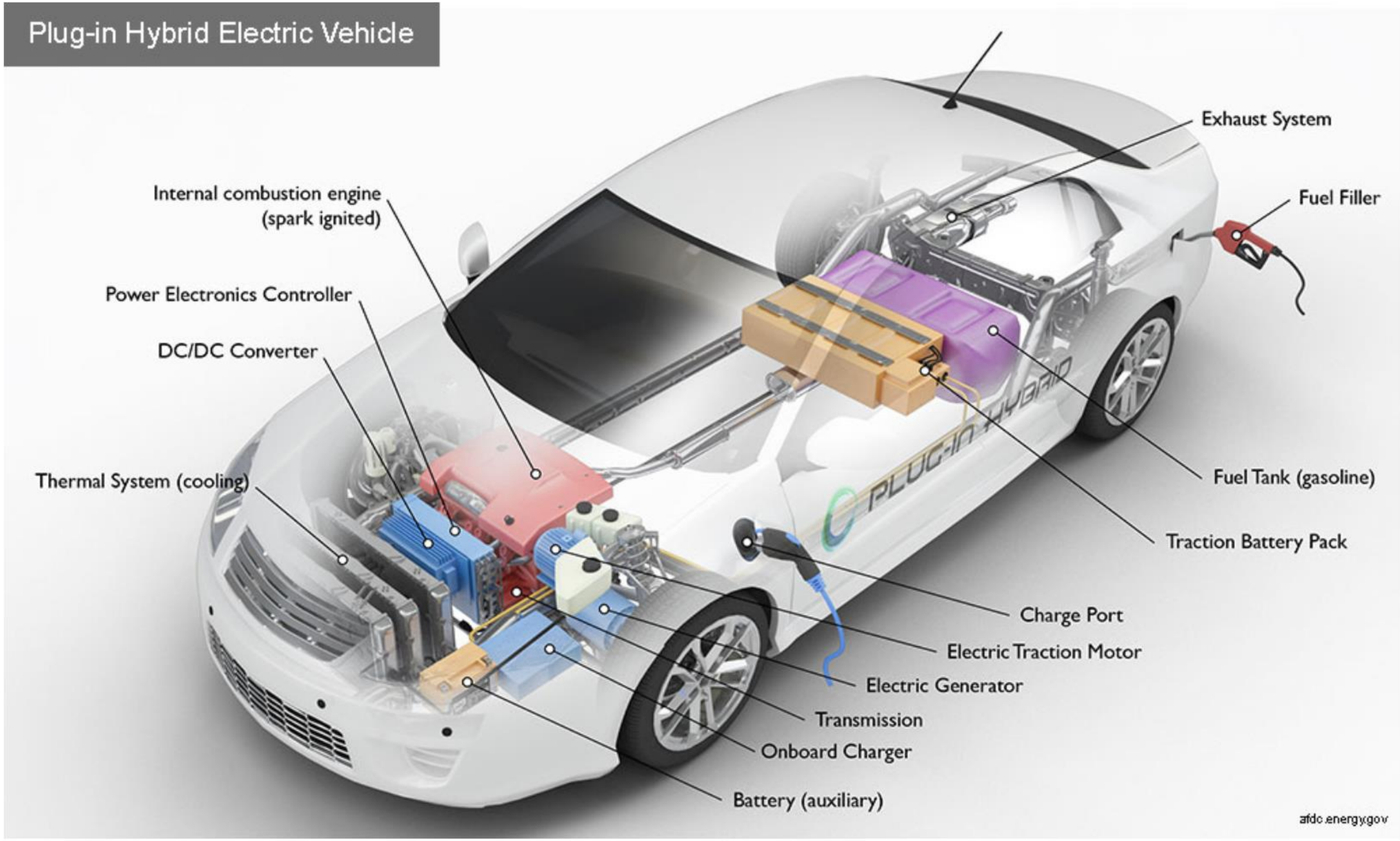

https://afdc.energy.gov/vehicles/how-do-plug-in-hybrid-electric-cars-work

Pure Electrics

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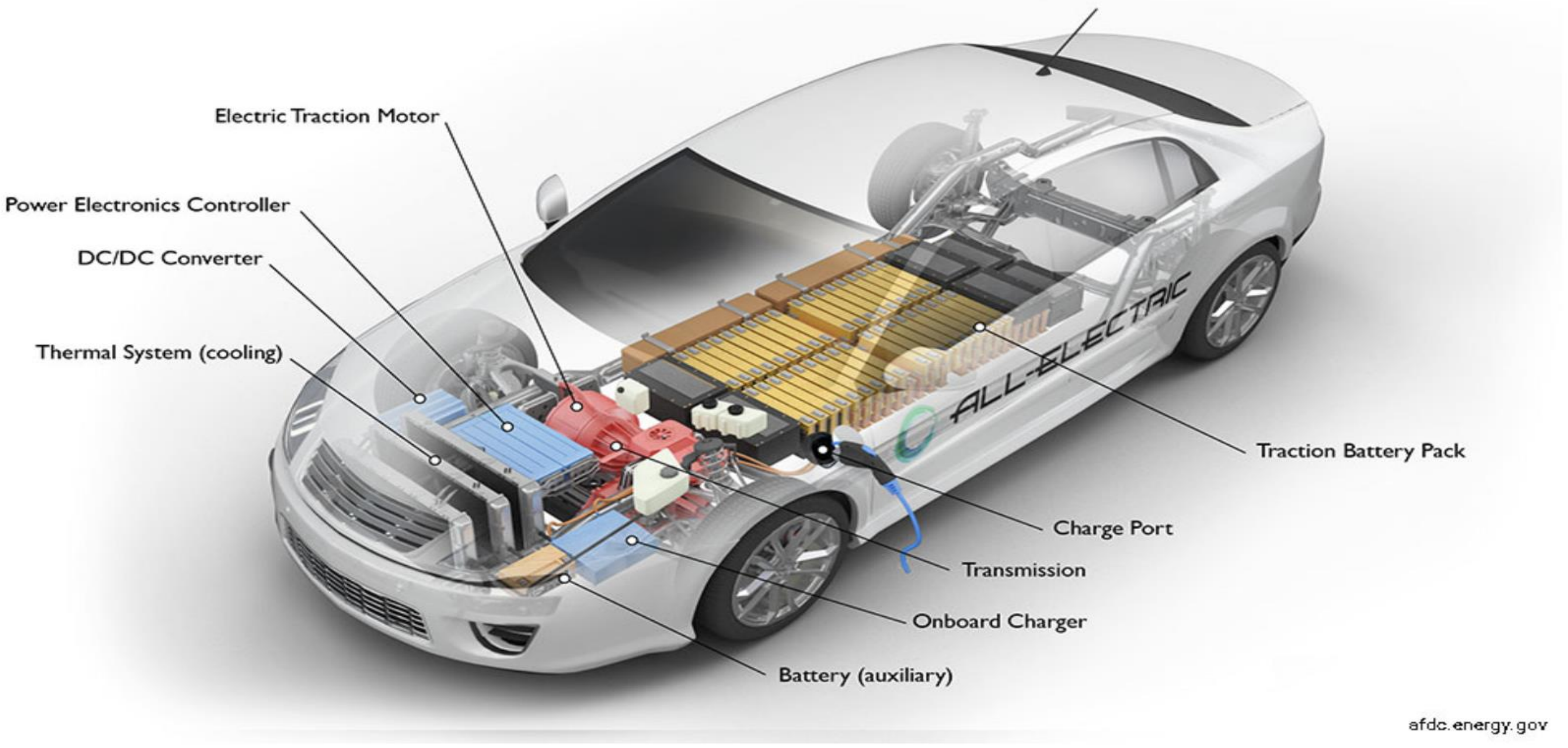
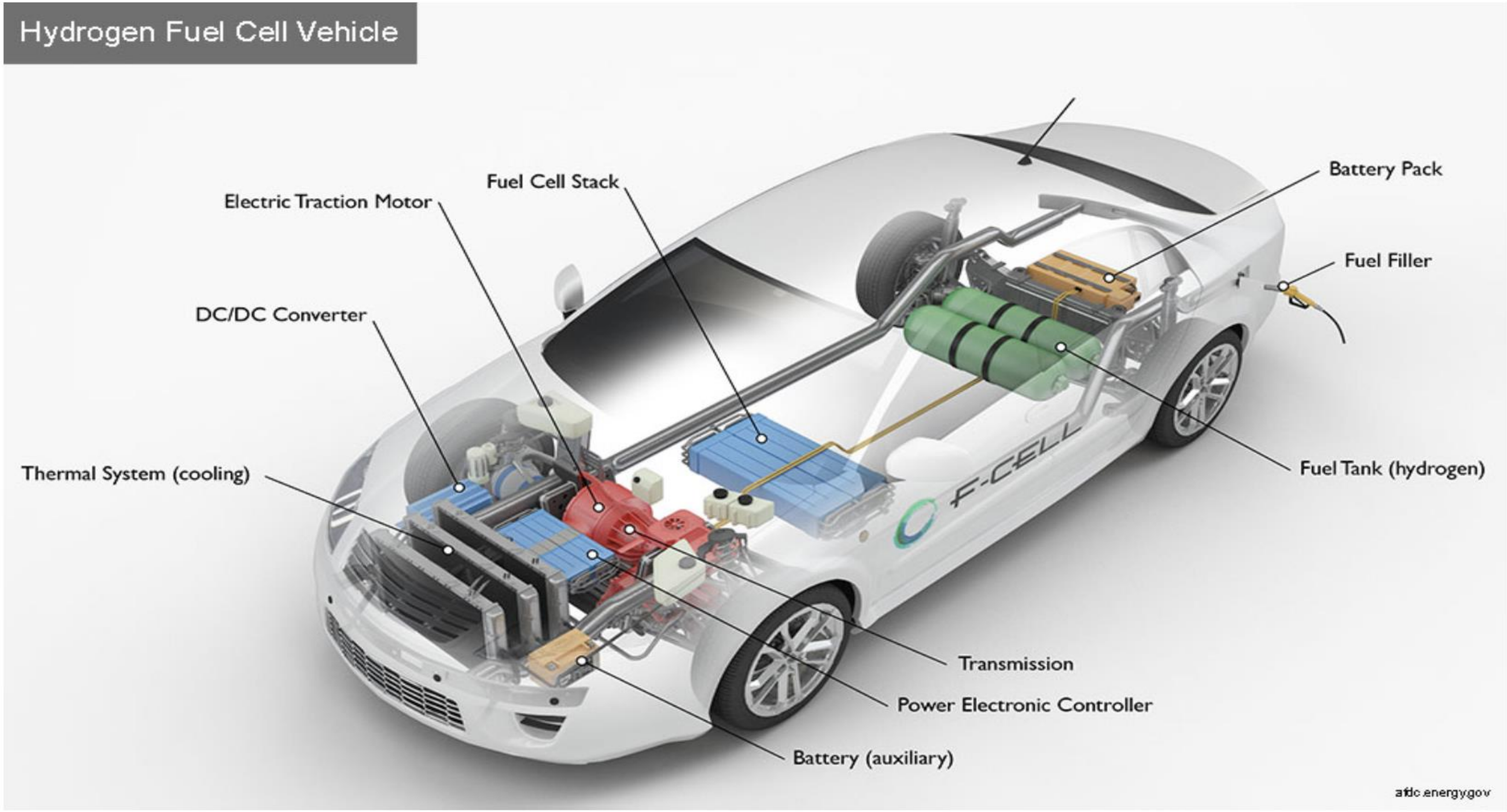
All-Electric Vehicle



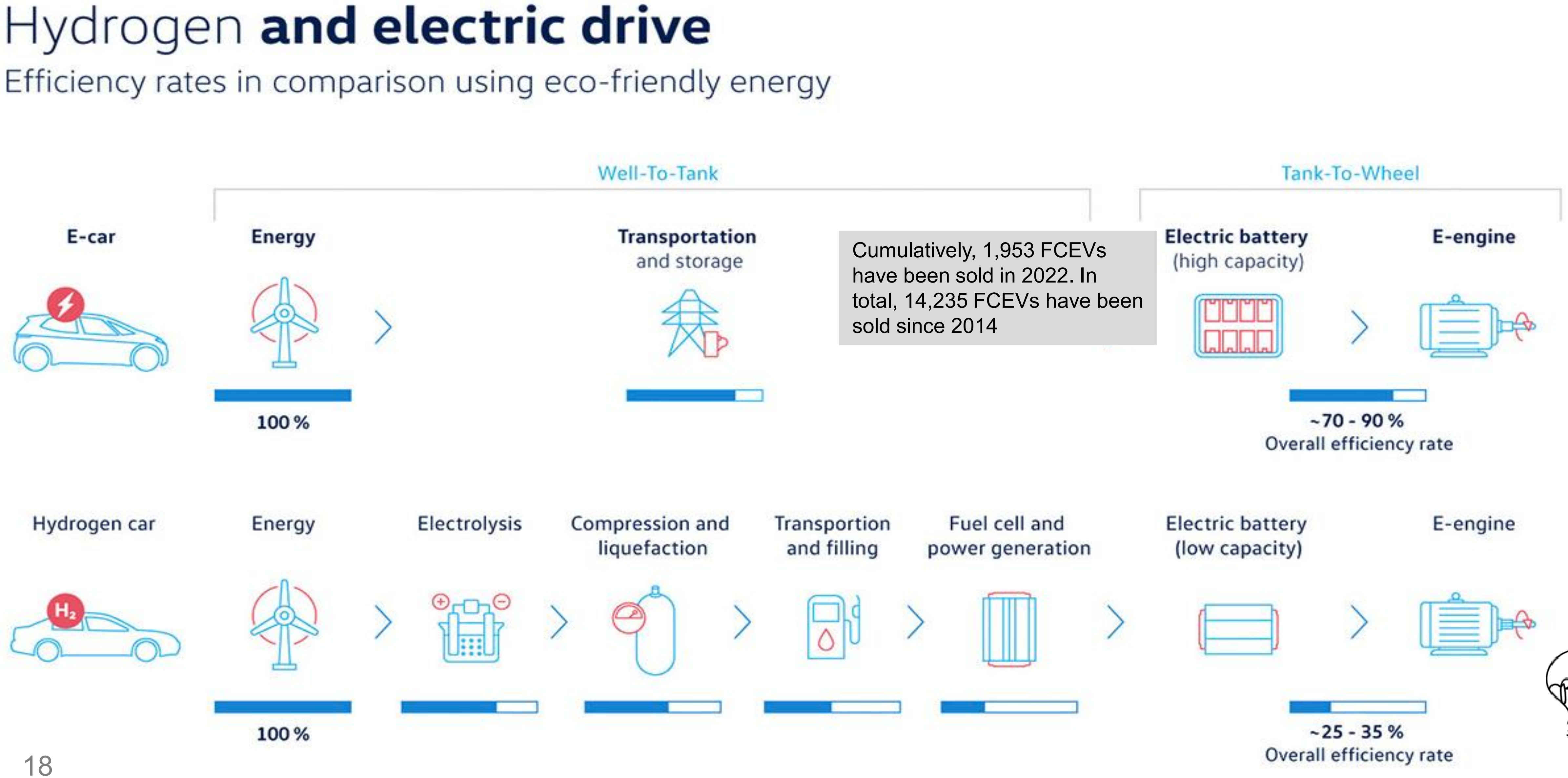
https://afdc.energy.gov/vehicles/how-do-all-electric-cars-work

Fuel Cell Vehicles (Use Electric Motors)



https://afdc.energy.gov/vehicles/how-do-fuel-cell-electric-cars-work

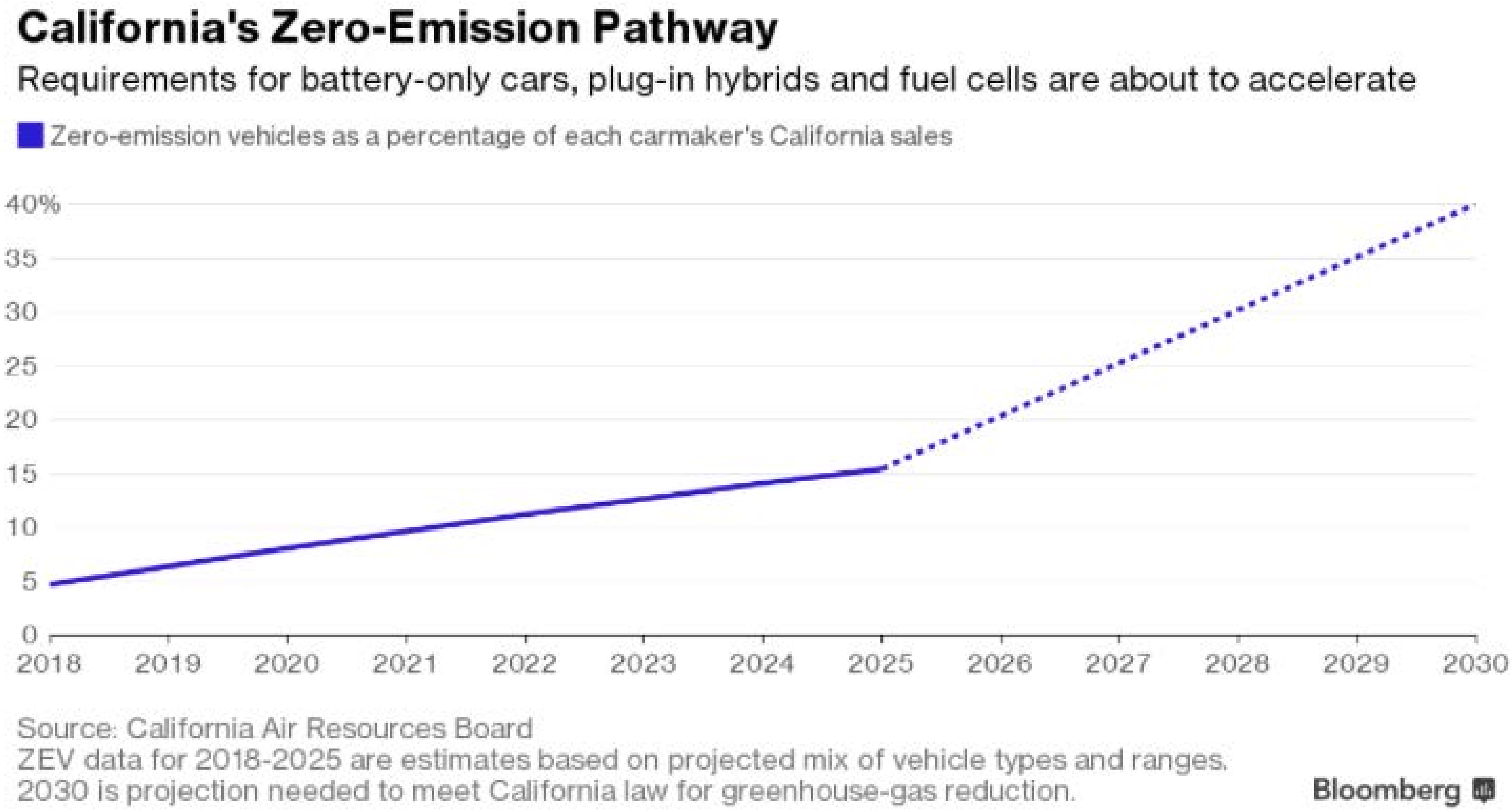
Why Hydrogen Is Likely Not the Answer



Cumulatively, 1,953 FCEVs have been sold in 2022. In total, 14,235 FCEVs have been sold since 2014

https://chargedevs.com/newswire/volkswagen-explains-why-batteries-not-fuel-cells-are-the-right-choice-for-passenger-cars/

In Some States, Compliance is a Big Deal



http://www.msn.com/en-us/money/companies/gm’s-ready-to-lose-dollar9000-a-pop-and-chase-electric-car-boom/ar-AAkWYW8

U.S. Sales Gains Have Been Solid

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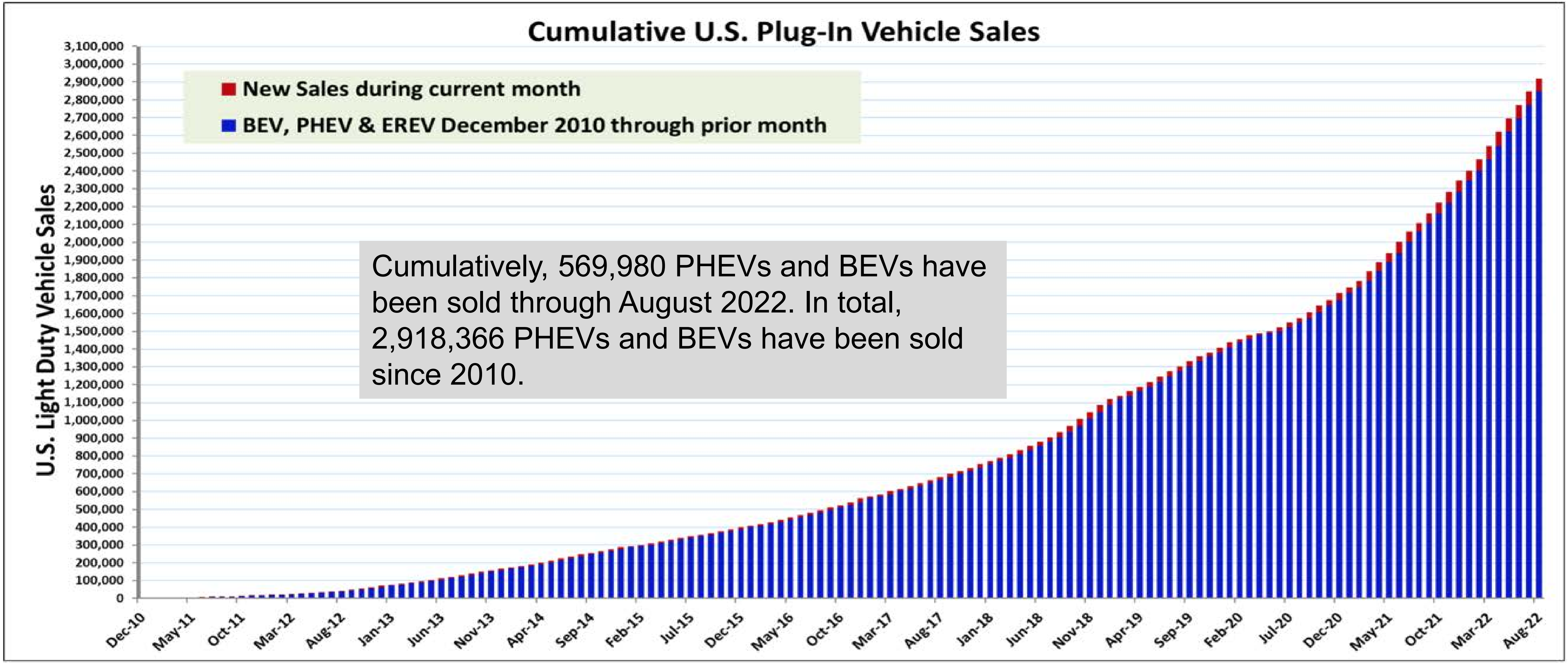
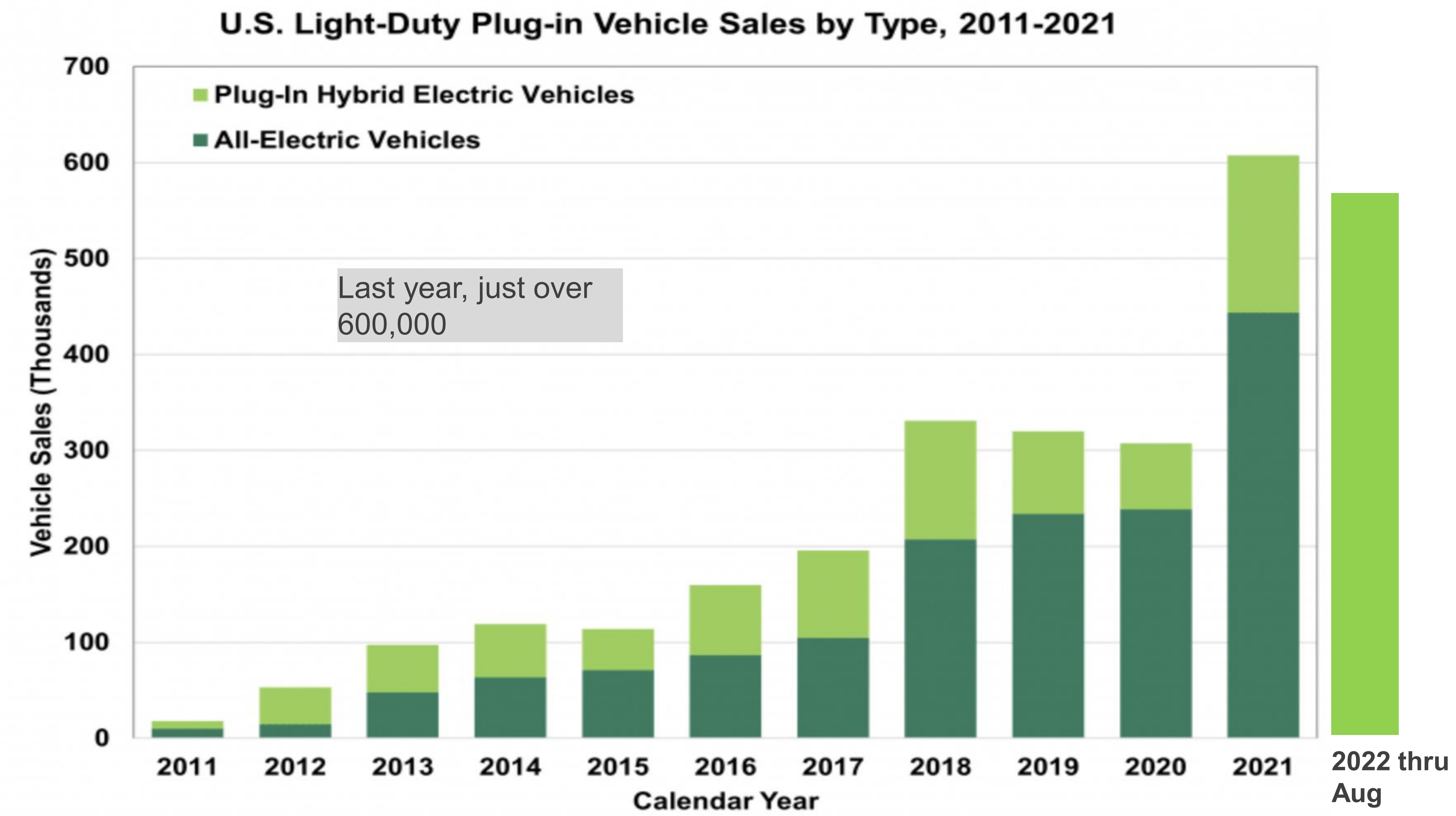


Cumulatively, 569,980 PHEVs and BEVs have been sold through August 2022. In total, 2,918,366 PHEVs and BEVs have been sold since 2010.

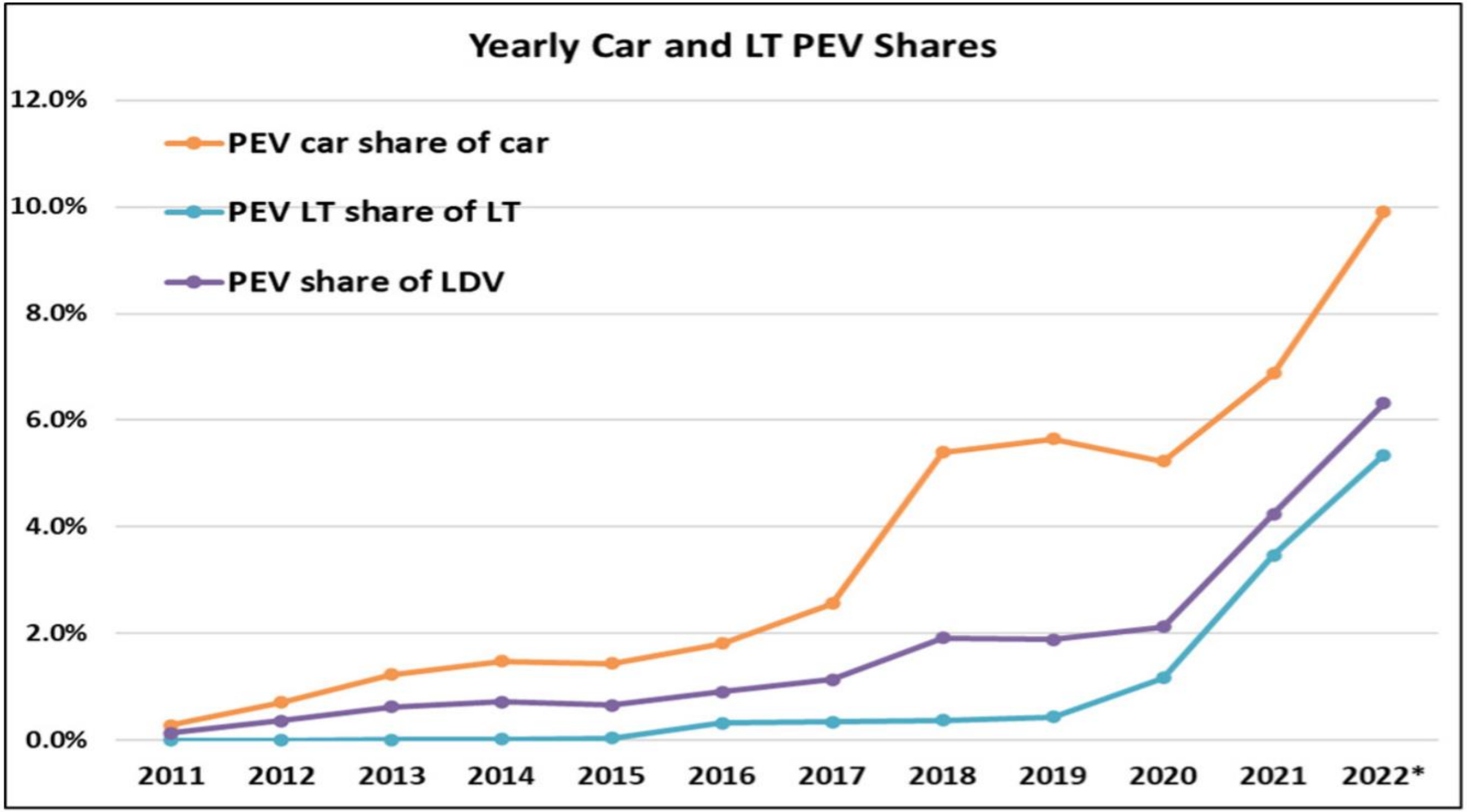
https://www.anl.gov/esia/light-duty-electric-drive-vehicles-monthly-sales-updates

Plug-In Hybrids vs Pure Electrics



https://www.energy.gov/eere/vehicles/articles/fotw-1227-february-28-2022-light-duty-plug-electric-vehicle-sales-united

Market Share Growing Quickly



*Through July

https://www.anl.gov/esia/light-duty-electric-drive-vehicles-monthly-sales-updates

How Big Could the Resource Become?

https://www.visualcapitalist.com/visualizing-the-global-electric-vehicle-market/

U.S. OEMs Ramp Up Production in Anticipation of Growth

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IRA Domestic Requirements Accelerates Dynamic

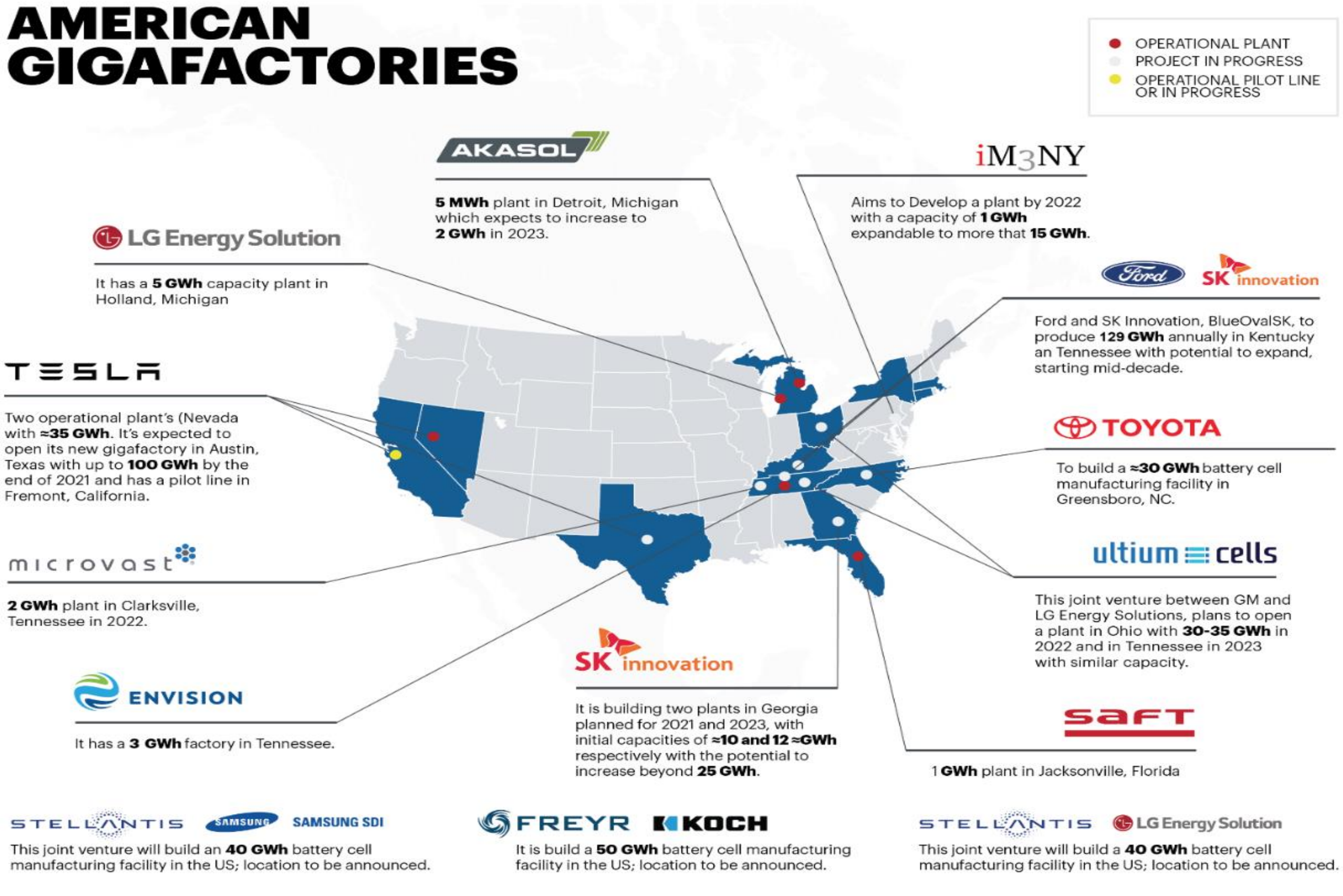

Figure 3 – Operating, Under Construction, or Announced U.S. Battery Manufacturing Capacity

Strong Estimated Financial Results With Potential For Extended Operational Life

https://piedmontlithium.com/piedmont-completes-bankable-feasiblity-study-of-the-carolina-lithium-project-with-positive-results/

Where Are They Being Sold?

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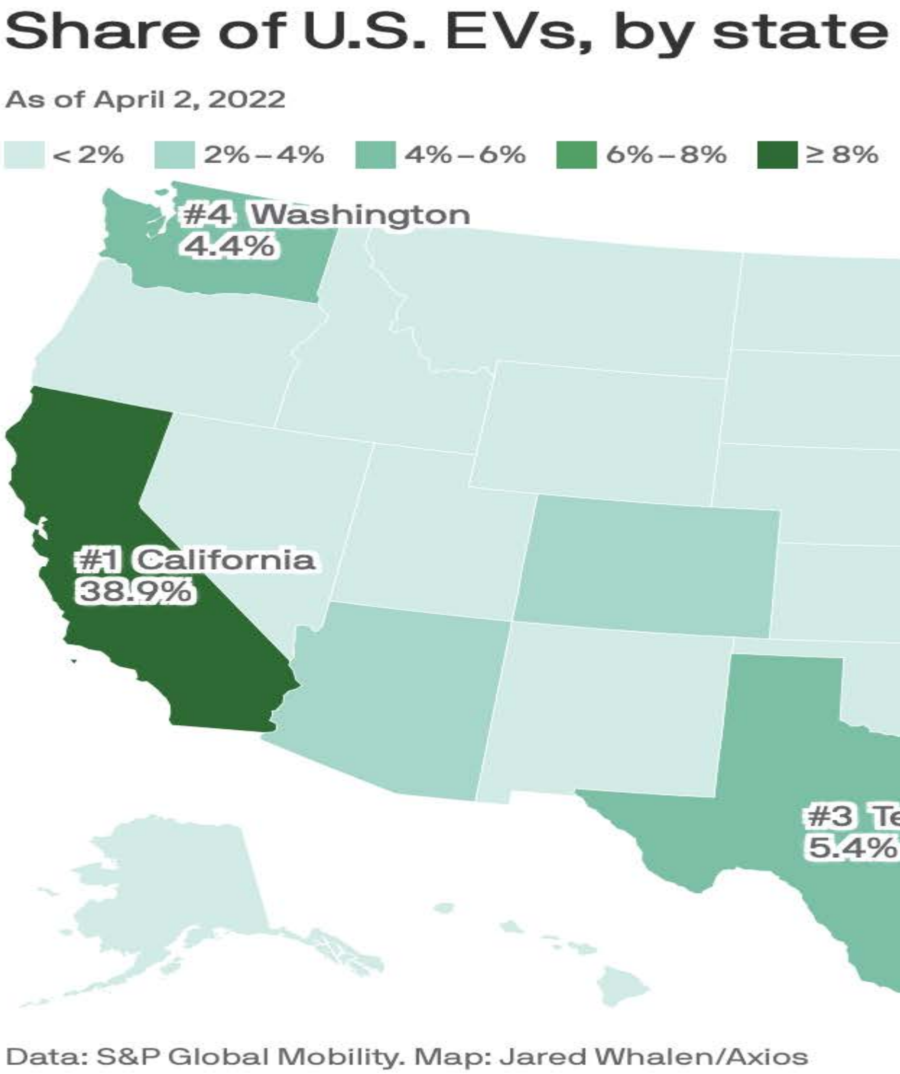

63 EVs on market by year's end, per S&P Global Mobility's forecast. 192 EVs by 2026, and 253 by the end of 2030.

https://www.axios.com/2022/08/01/states-ev-electric-cars?utm_medium=email

State Policies Matter

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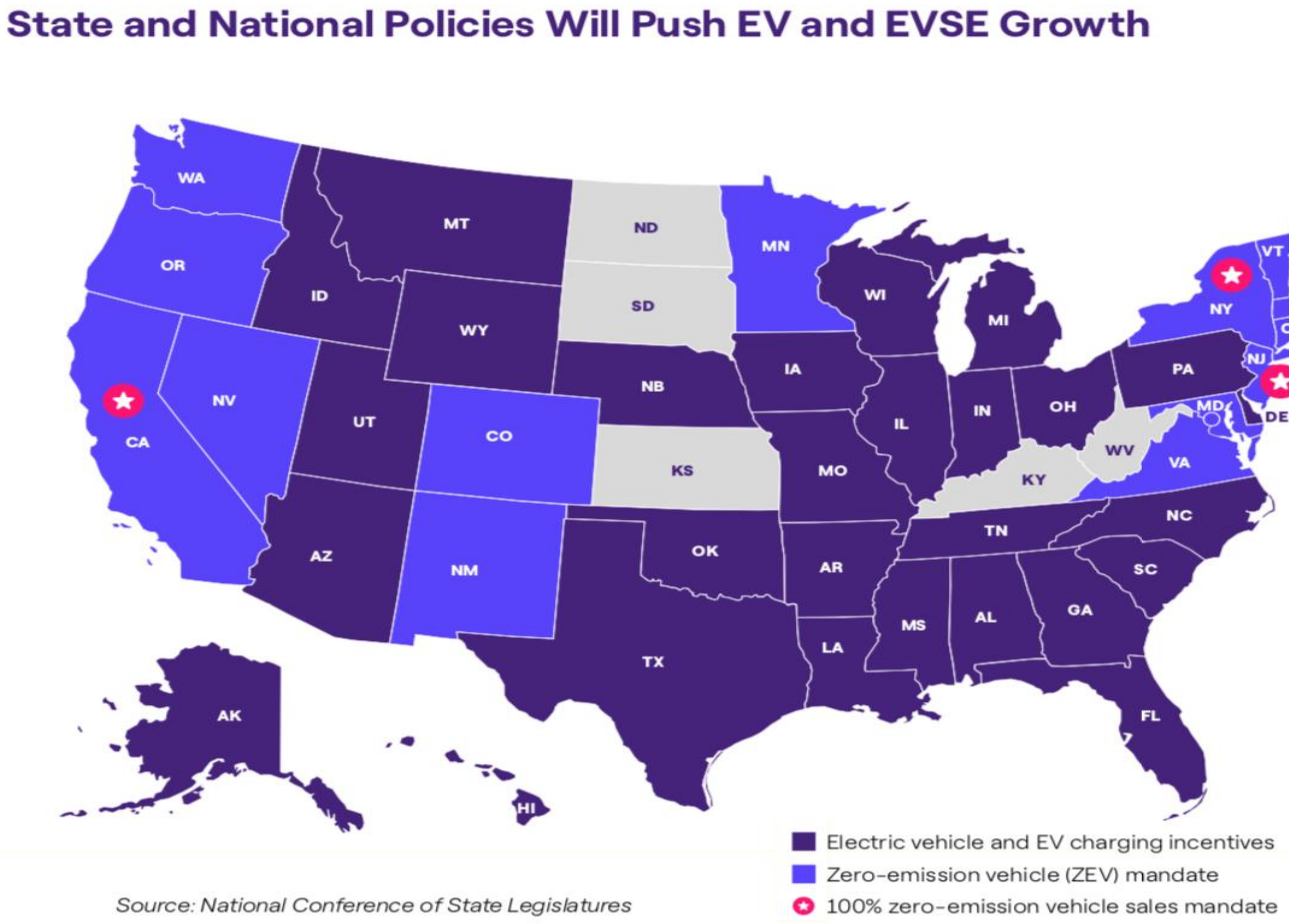
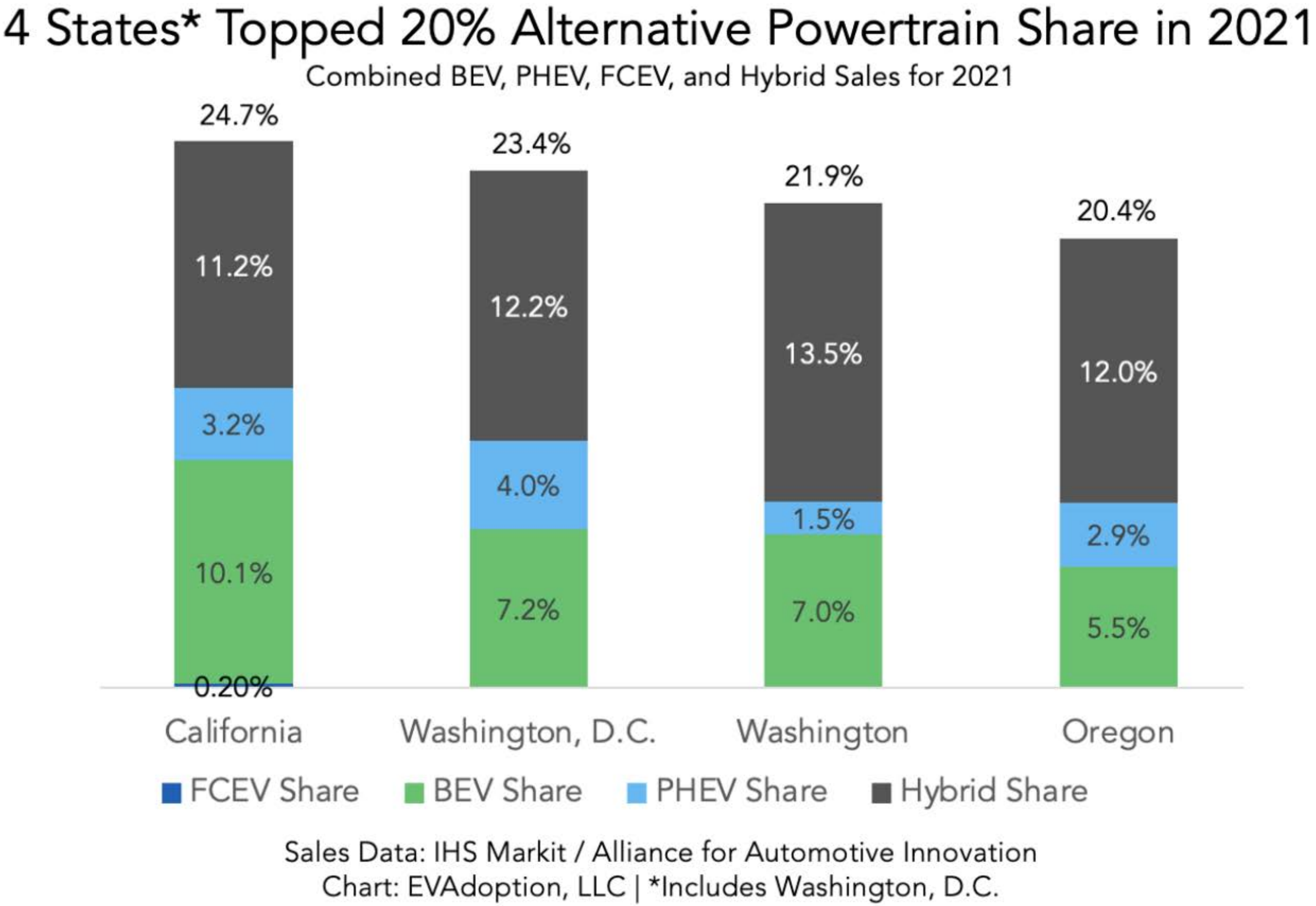


https://www.enelx.com/n-a/en/resources/ebooks-white-papers/fulfill/2022-energy-market-outlook

Distribution by State Varies, w/CA Well in the Lead



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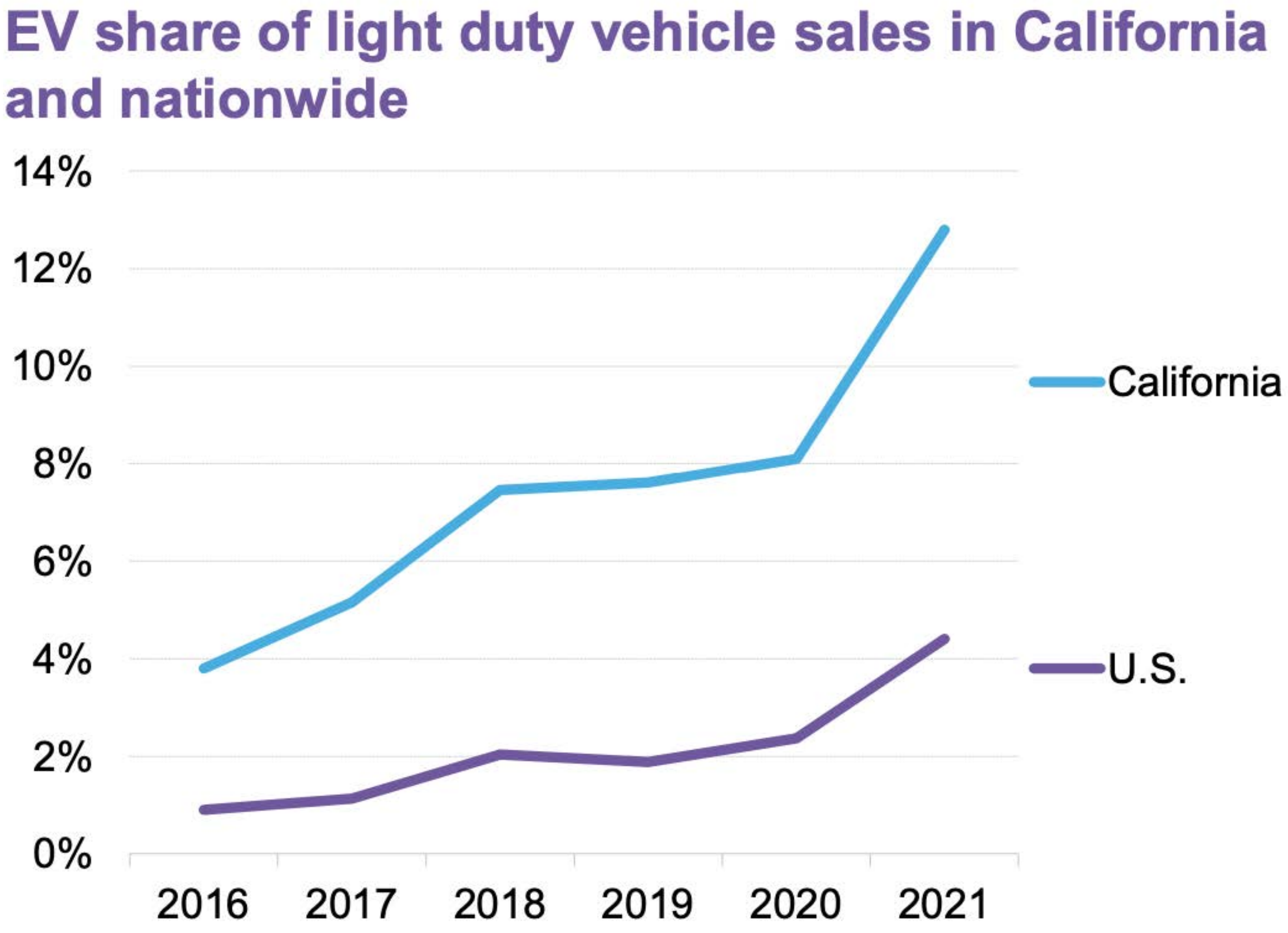
https://evadoption.com/54-percent-of-states-2021-bev-sales-share-of-less-than-2-percent-2021-state-ev-sales-data-now-available/

California Leads the Way



https://bcse.org/factbook/

U.S. – Tesla Dominates

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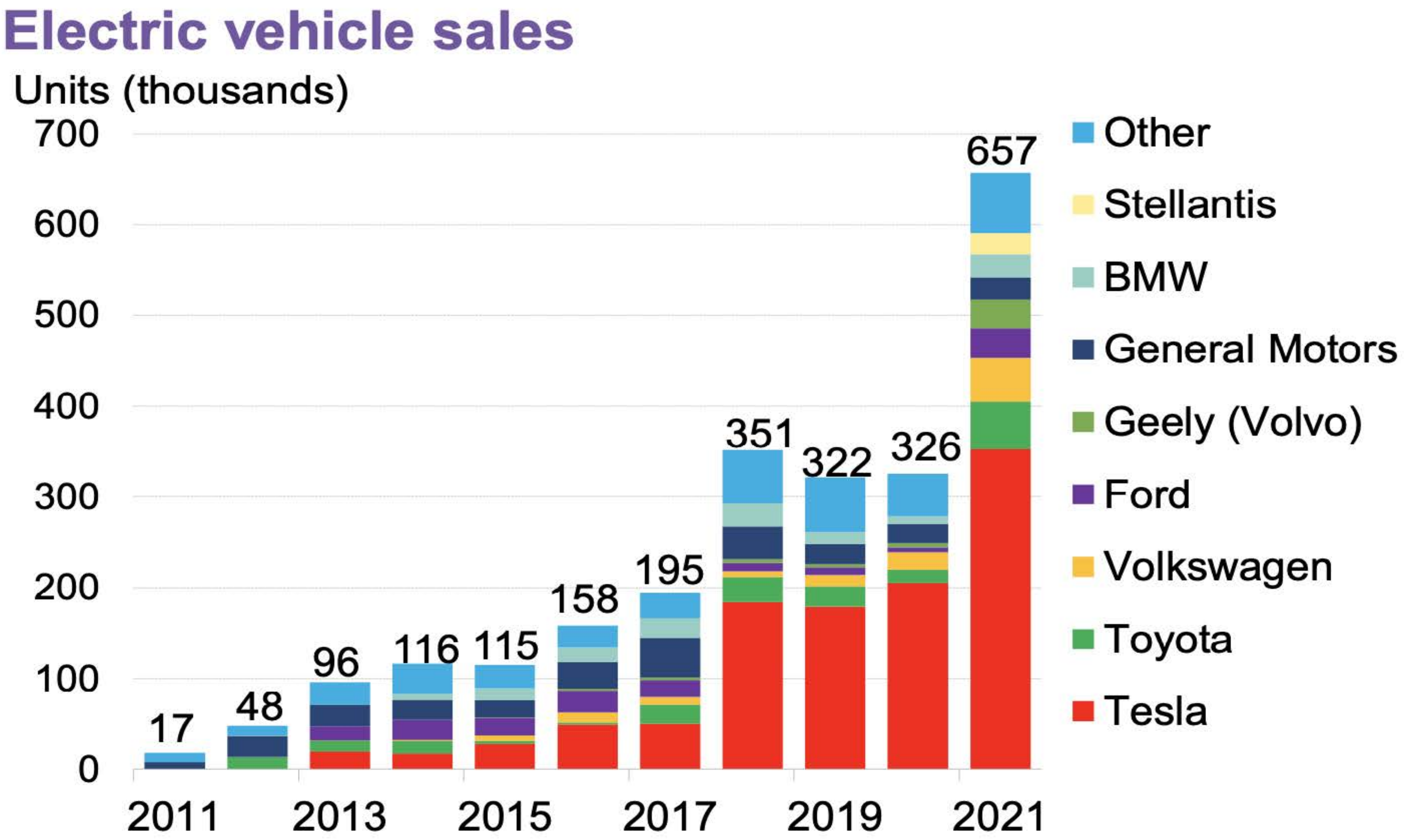

https://bcse.org/factbook/

The Adoption Dynamic is Hard to Predict – Multiple Factors

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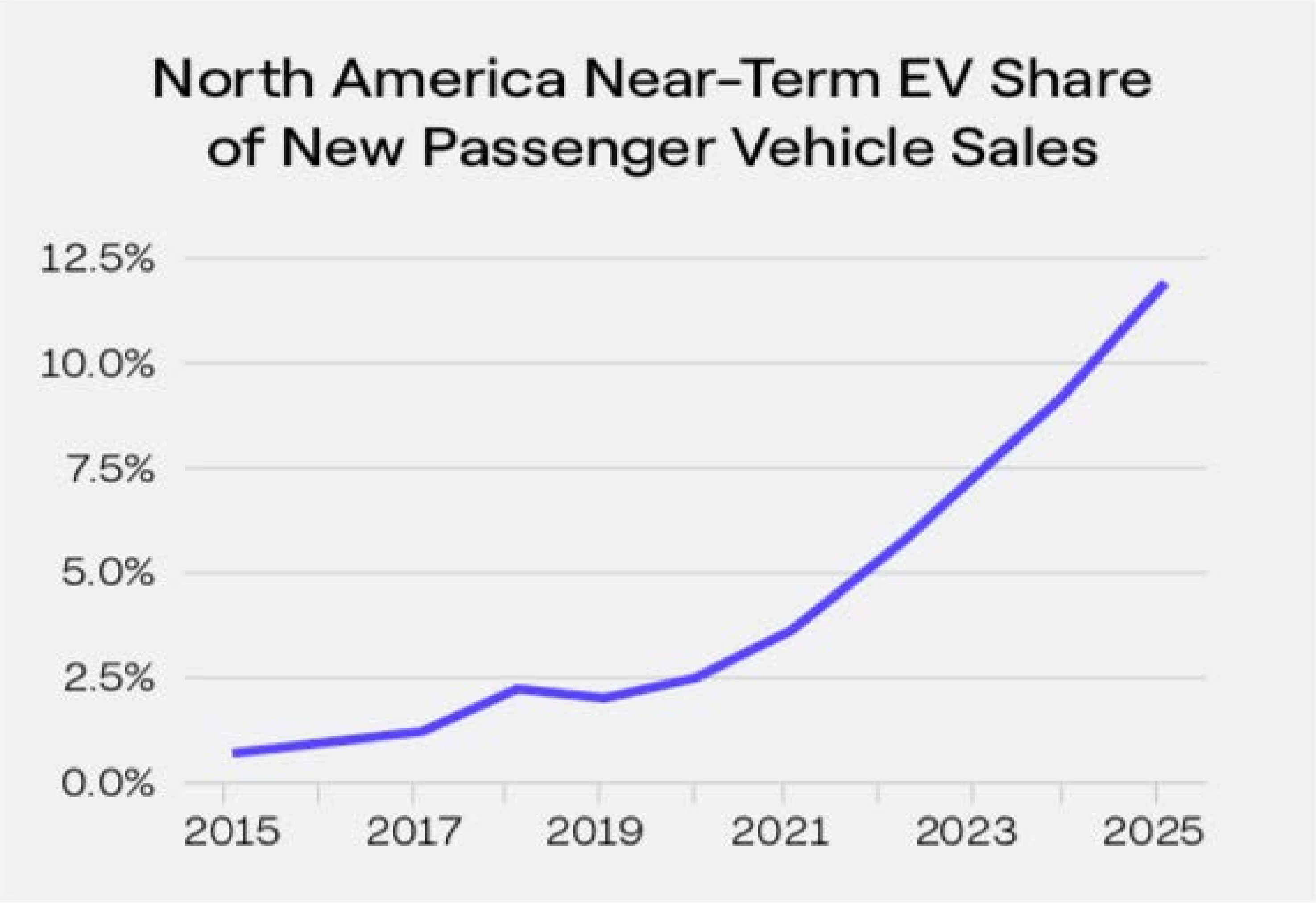
Factors Include:

1) Cost Differentials EV vs. ICE
2) Cost of gas/diesel vs. electricity
3) Subsidies
4) Available Models
5) Charging Infrastructure Availability
6) Charging Speeds/Convenience
7) Range
8) Vehicle Performance



Includes Canada and the U.S. EV includes battery-electric and plug-in hybrid electric vehicles. Source: BNEF.

https://www.enelx.com/n-a/en/resources/ebooks-white-papers/fulfill/2022-energy-market-outlook

How Quickly Will the New Technology Get Adopted?

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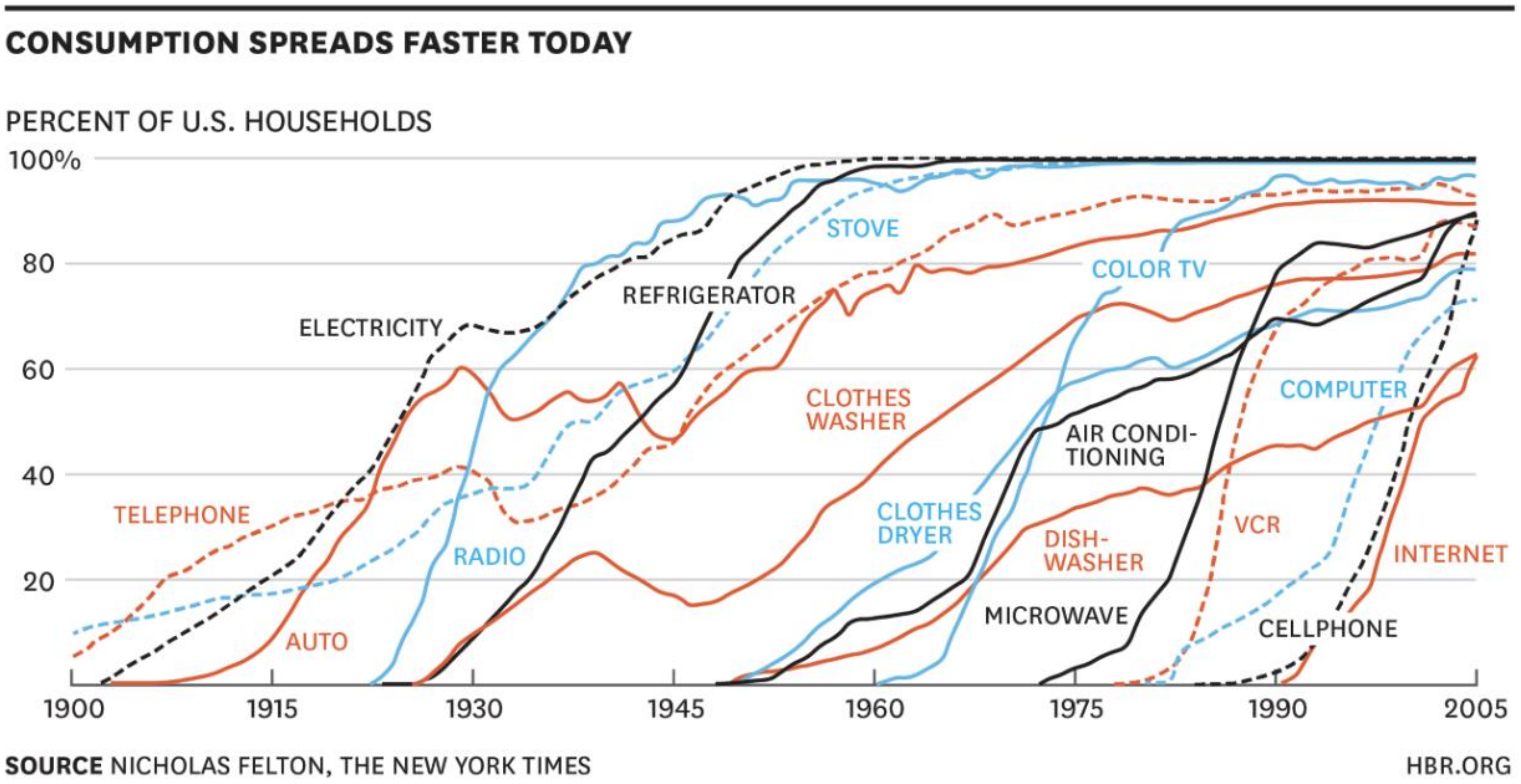

https://hbr.org/2013/11/the-pace-of-technology-adoption-is-speeding-up

One (Conservative?) View of Adoption Rates

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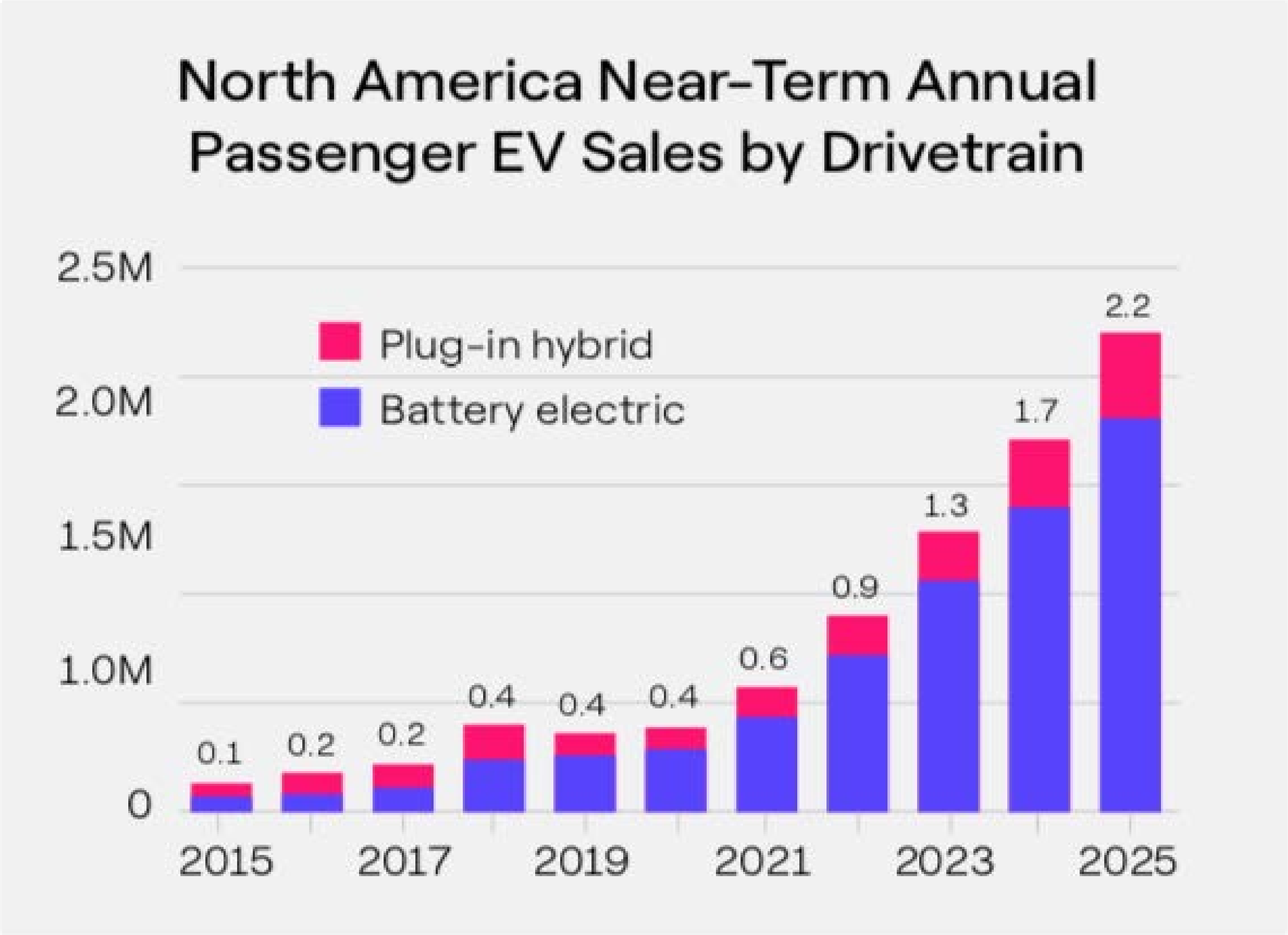

Includes Canada and the US. Source: BNEF.

https://www.enelx.com/n-a/en/resources/ebooks-white-papers/fulfill/2022-energy-market-outlook

Does the 5% Point Herald a Switch?

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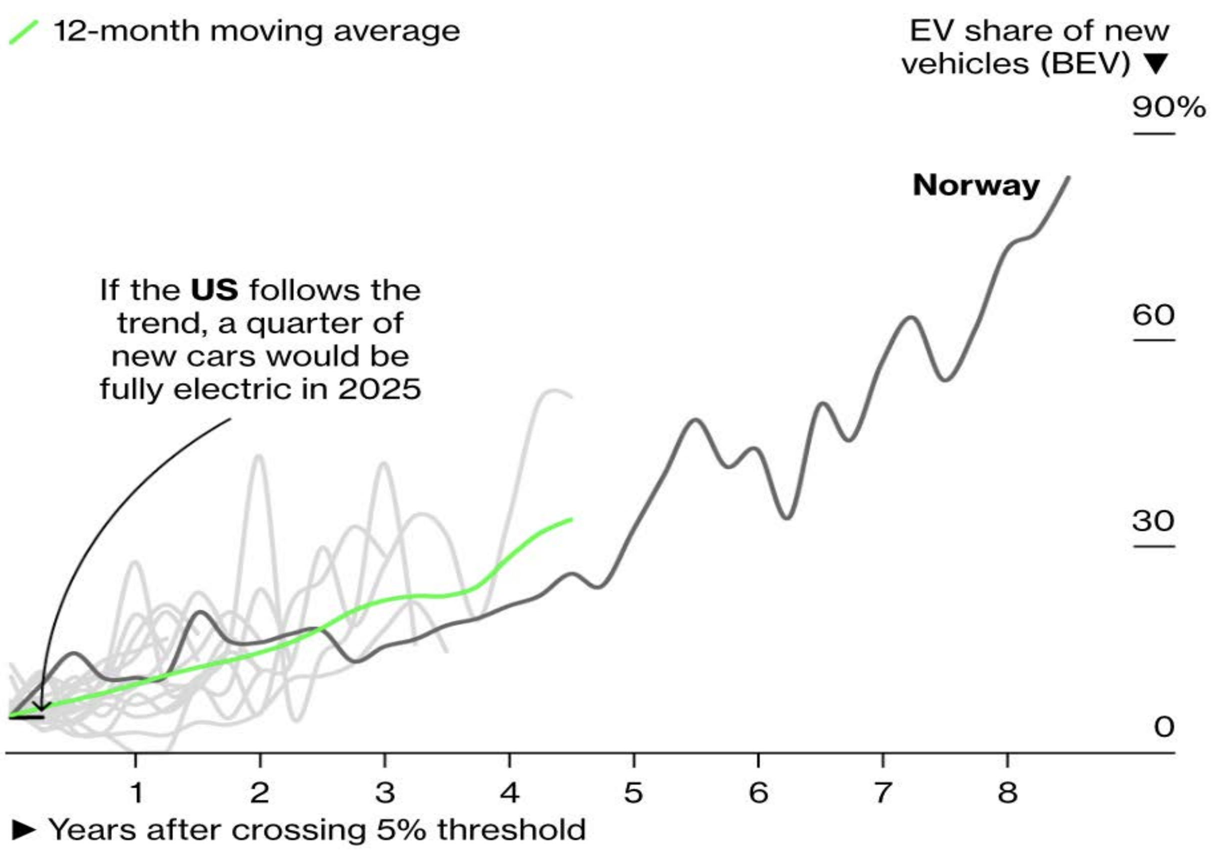
How Fast Is the Switch to Electric Cars?

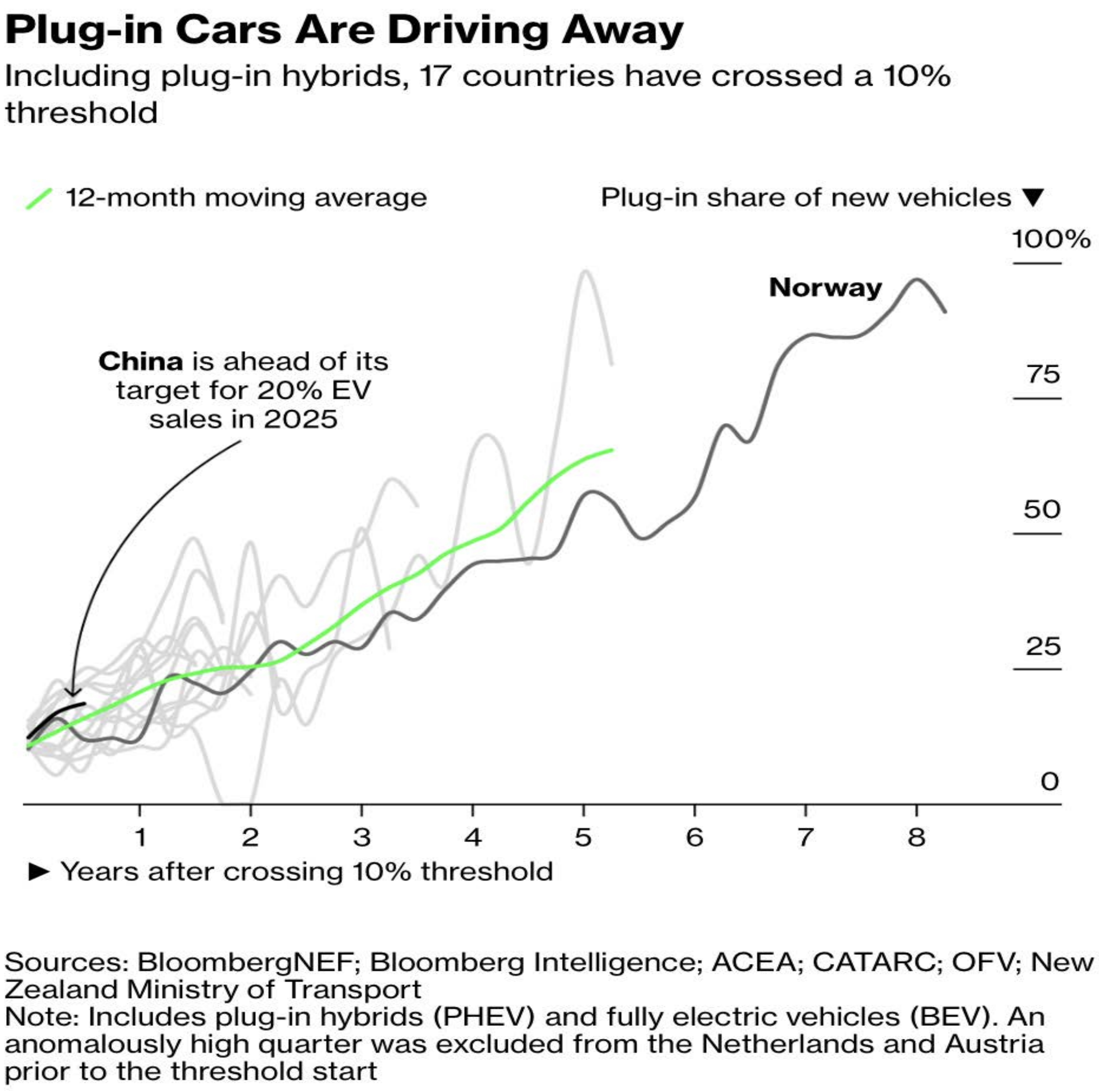
19 countries have reached the 5% tipping point—then everything changes



Sources: BloombergNEF; Bloomberg Intelligence; ACEA; CATARC; OFV; New Zealand Ministry of Transport

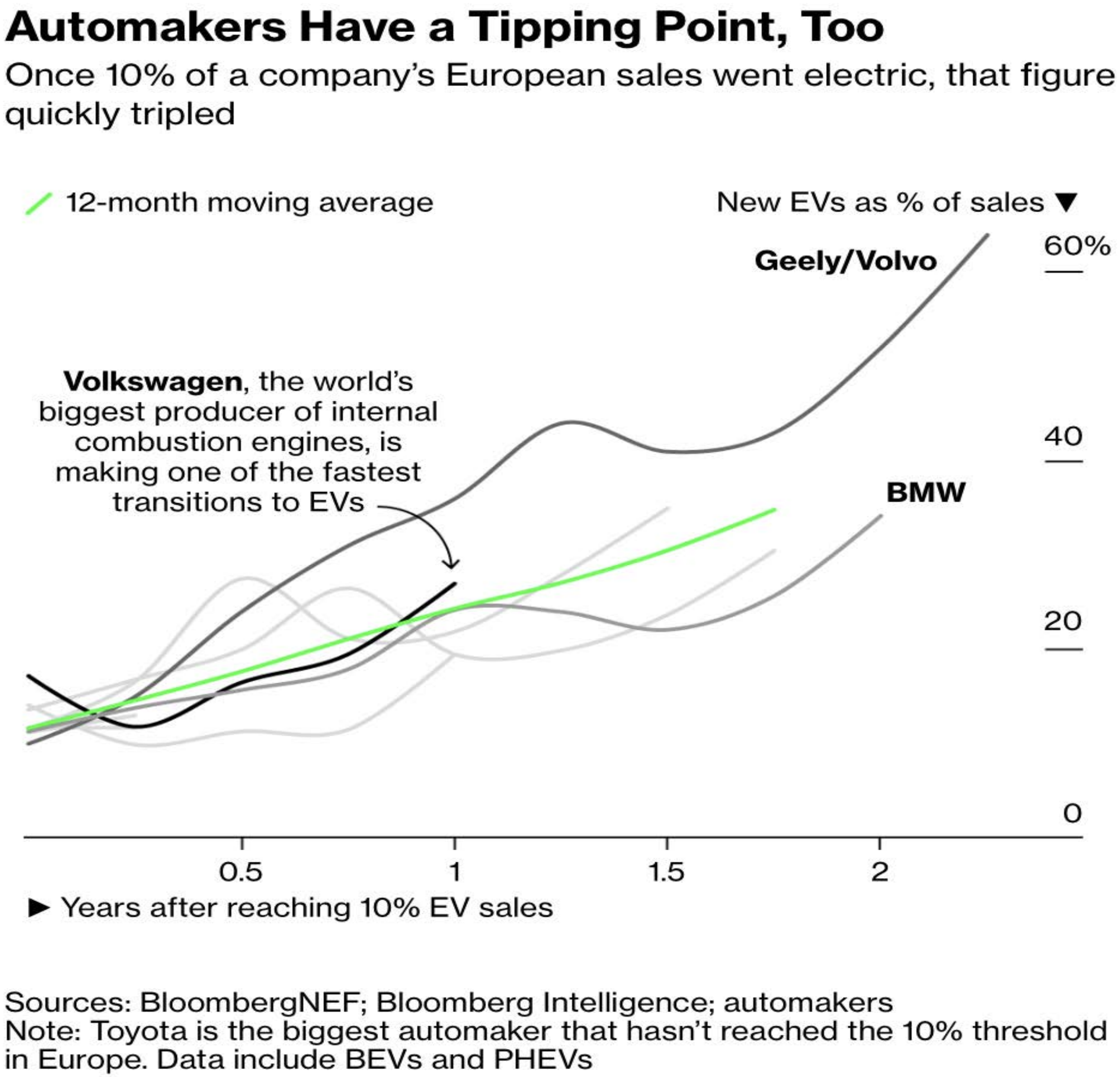
https://www.bloomberg.com/news/articles/2022-07-09/us-electric-car-sales-reach-key-milestone?sref=xfyiavTX

A Predictable Pattern Emerging?



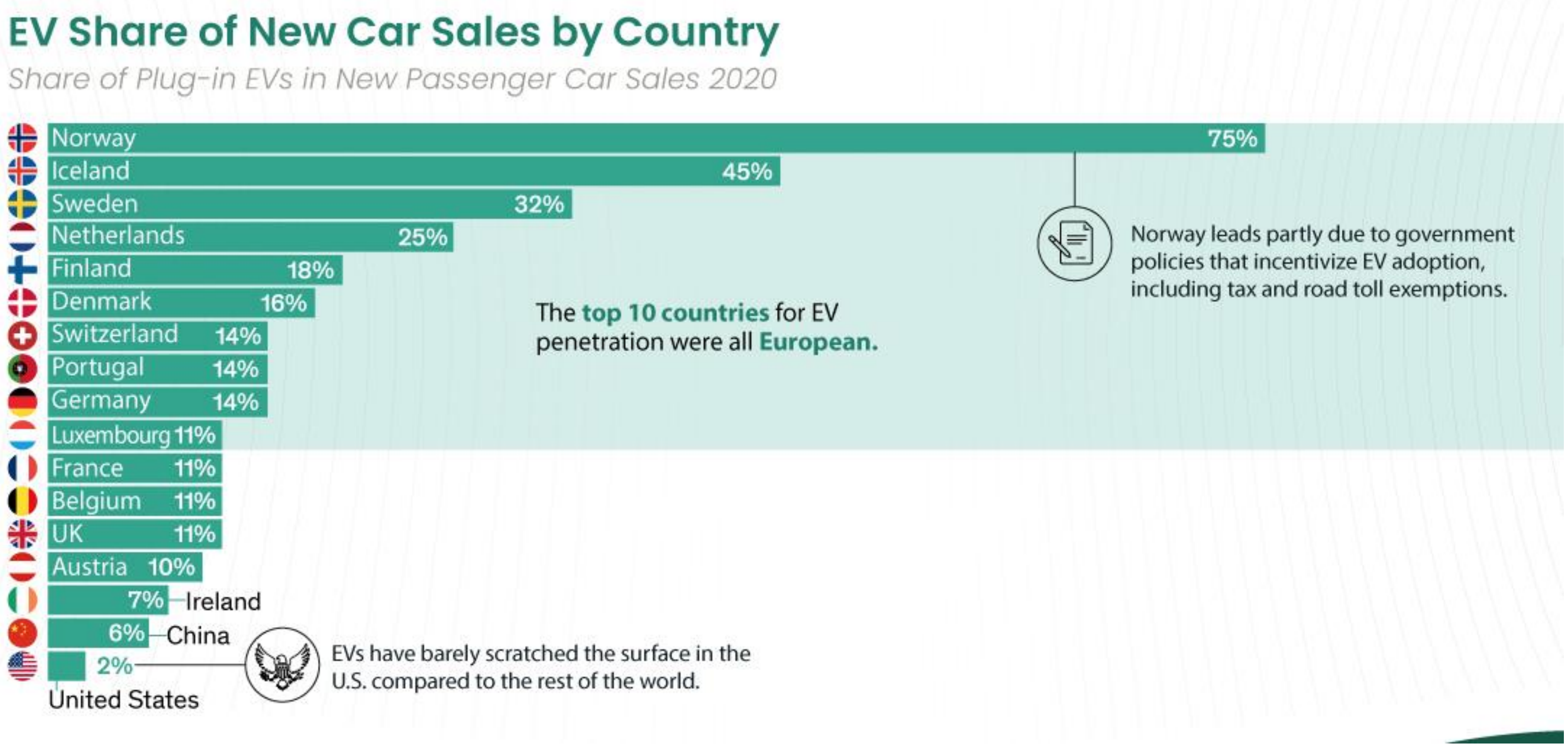
https://www.bloomberg.com/news/articles/2022-07-09/us-electric-car-sales-reach-key-milestone?sref=xfyiavTX

It’s Not Just Drivers



https://www.bloomberg.com/news/articles/2022-07-09/us-electric-car-sales-reach-key-milestone?sref=xfyiavTX

A Few Countries Point the Way Towards the Possible



https://www.visualcapitalist.com/visualizing-the-global-electric-vehicle-market/

No Story is Complete Without China

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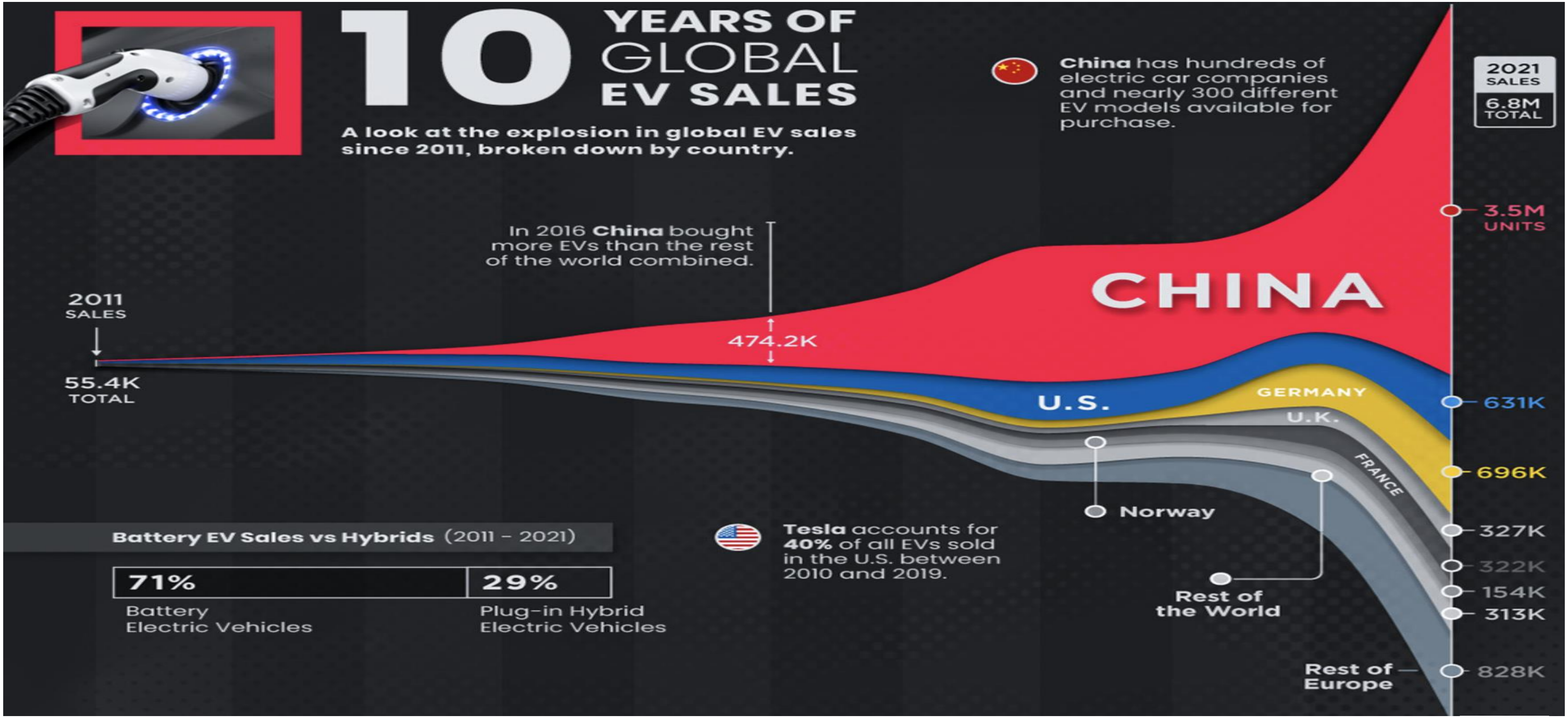
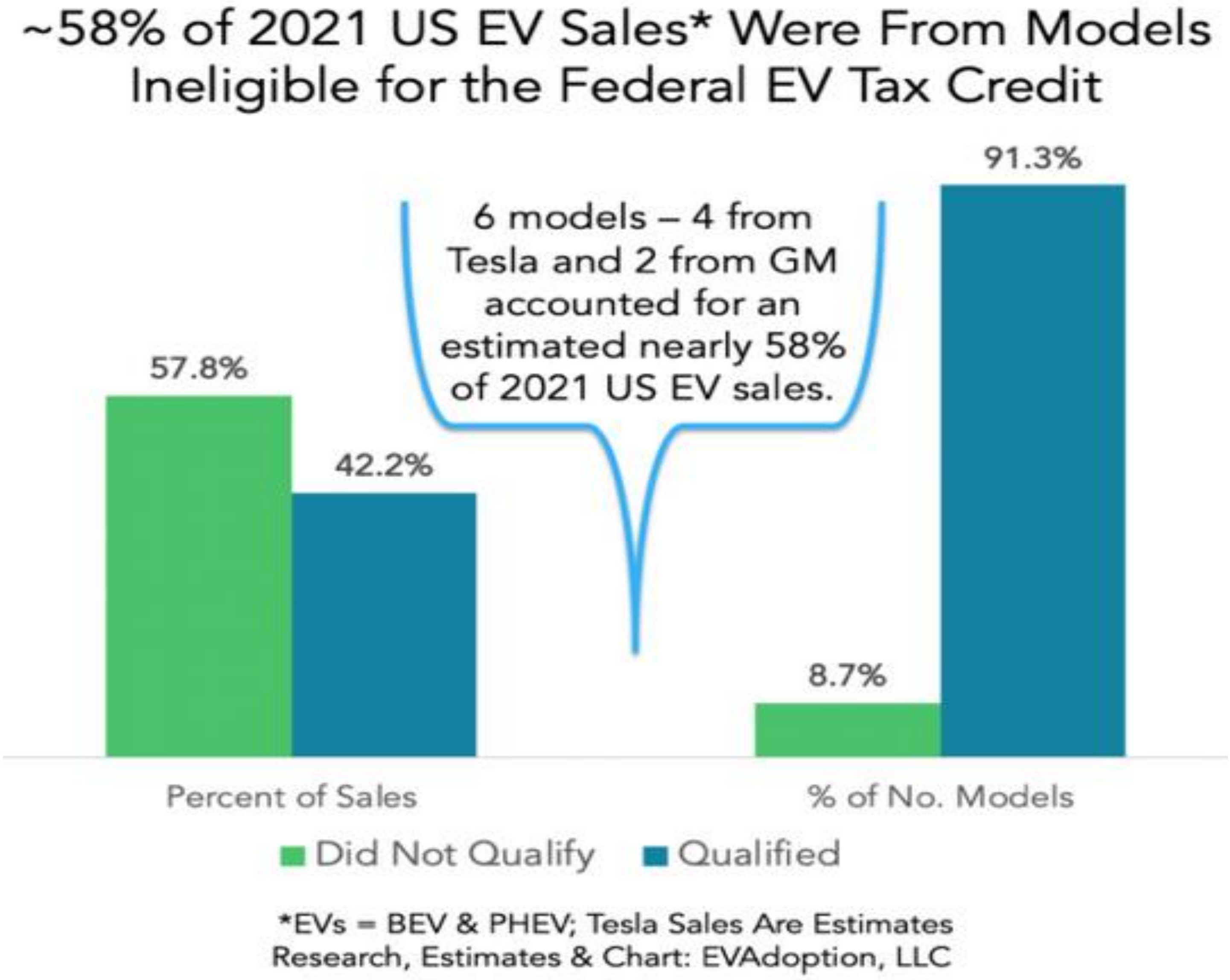


https://www.visualcapitalist.com/visualizing-10-years-of-global-ev-sales-by-country/

Incentives Help, But Don’t Appear to Drive Today’s Market



https://evadoption.com/dc-fast-charger-reliability-is-critical-for-mainstream-adoption-of-electric-vehicles/

Availability of New Models Will Help: EVs w/MSRP <$45,000

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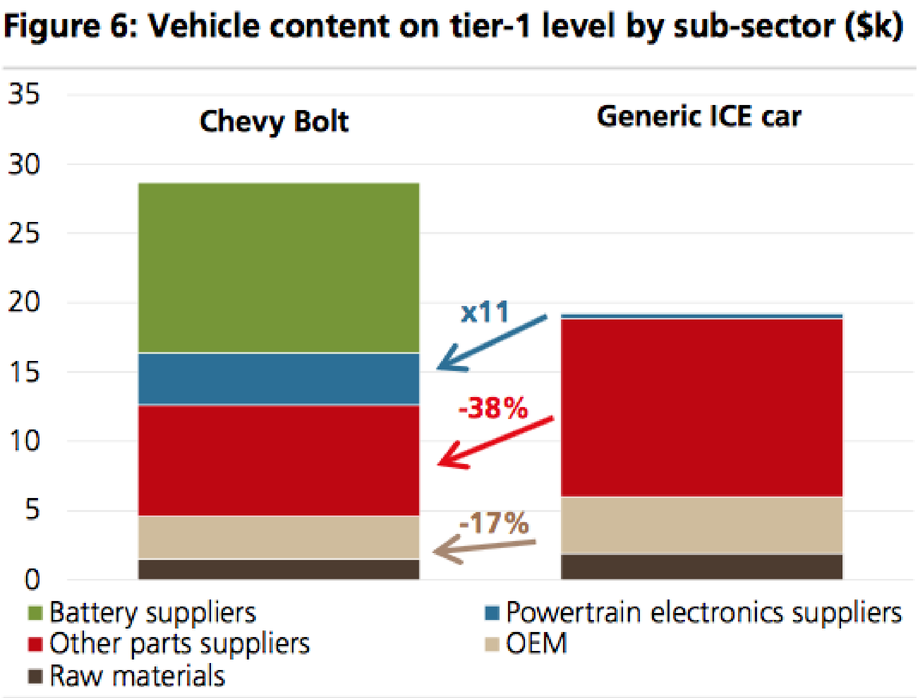
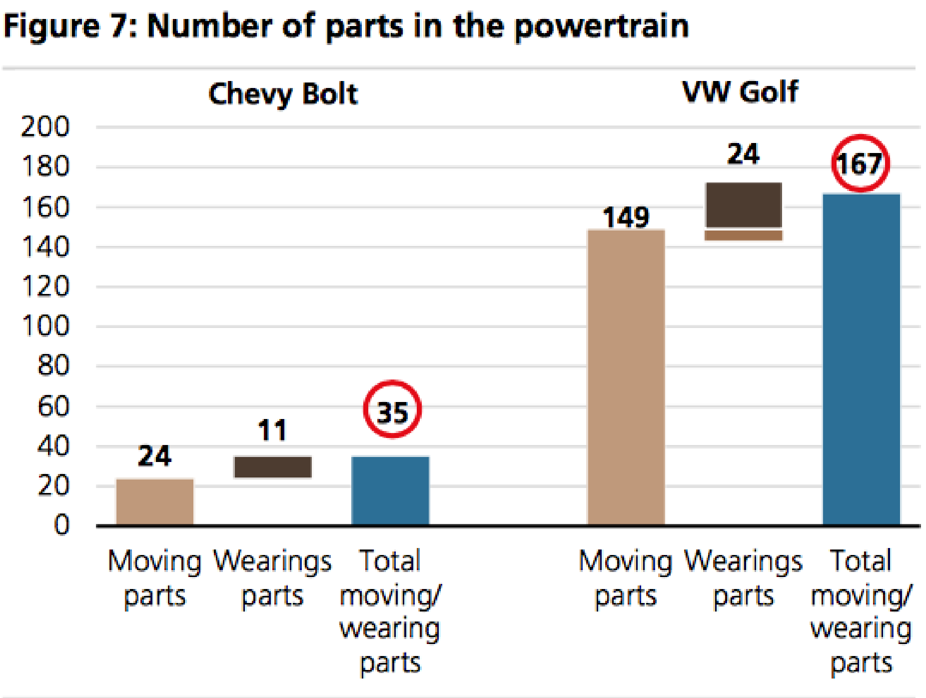
Make-Model	Base MSRP	EV Type	Range (miles)	MSRP/kWh	Fed. Tax Credit	After Fed. Tax Credit
BMW 330e	$42,950.00	PHEV	23	$3,579	$5,836.00	$37,114
Chevrolet Bolt EUV	$33,500.00	BEV	247	$558	$0.00	$33,500
Chevrolet Bolt EV	$31,500.00	BEV	259	$525	$0.00	$31,500
Ford Escape PHEV	$35,455.00	PHEV	37	$2,462	$6,837.00	$28,618
Ford F-150 Lightning Pro	$39,974.00	BEV	230	$0	$7,500.00	$32,474
Ford Mustang Mach-E Select	$42,895.00	BEV	230	$631	$7,500.00	$35,395
Hyundai IONIQ 5 SE RWD	$44,400.00	BEV	303	$574	$7,500.00	$36,900
Hyundai Kona Electric	$34,000.00	BEV	258	$531	$7,500.00	$26,500
Hyundai Santa Fe PHEV	$40,000.00	PHEV	30	$3,226	$6,587.00	$33,413
Hyundai Tuscon Plug-In Hybrid	$35,400.00	PHEV	33	$2,565	$6,587.00	$28,813
Kia EV6	$40,900.00	BEV	310	$528	$7,500.00	$33,400
Kia Niro EV	$39,990.00	BEV	239	$625	$7,500.00	$32,490
Kia Niro PHEV	$25,590.00	PHEV	26	$2,875	$4,585.00	$21,005
Mazda MX-30	$33,470.00	BEV	100	$943	$7,500.00	$25,970
Mini Cooper Electric SE Hardtop 2 door	$34,225.00	BEV	115	$1,037	$7,500.00	$26,725
Mini Countryman SE PHEV	$41,500.00	PHEV	18	$4,150	$5,002.00	$36,498
Mitsubishi Outlander PHEV	$36,995.00	PHEV	24	$2,681	$6,587.00	$30,408
Nissan LEAF S	$27,400.00	BEV	149	$685	$7,500.00	$19,900
Nissan LEAF S PLUS	$32,400.00	BEV	226	$523	$7,500.00	$24,900
Subaru Crosstrek PHEV	$36,345.00	PHEV	17	$4,130	$4,585.00	$31,760
Subaru Solterra	$44,995.00	BEV	220	$600	$7,500.00	$37,495
Toyota bZ4X	$42,000.00	BEV	252	$560	$7,500.00	$34,500
Toyota Prius Prime	$28,670.00	PHEV	25	$3,258	$4,585.00	$24,085
Toyota RAV4 Prime	$40,300.00	PHEV	42	$2,239	$7,500.00	$32,800
Volkswagen ID.4	$41,230.00	BEV	260	$535	$7,500.00	$33,730

https://evadoption.com/cost-parity-two-dozen-evs-available-in-the-us-start-at-less-than-45000/

Economic Value Proposition: Fewer Parts = Less to Go Wrong



Source: UBS estimates



Source: UBS estimates

http://www.advantagelithium.com/_resources/pdf/UBS-Article.pdf

Translates to Operational Savings

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Table 2.2. Lifetime Maintenance Costs by Powertrain[14]

Powertrain Type	Lifetime Maintenance and Repair Cost	Lifetime Savings vs. ICE
ICE	$9,200	
BEV	$4,600	$4,600
PHEV	$4,600	$4,600

https://advocacy.consumerreports.org/wp-content/uploads/2020/10/EV-Ownership-Cost-Final-Report-1.pdf

What About Fueling Costs? Depends How Much One Uses Public Chargers…

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Table 3.1 BEV Utility Factor as a Function of BEV Range

BEV Range	Utility Factor	Percentage of Charging at Home[19]	Estimated DC Fast-Charging Sessions for 15K Miles[20]
100	78%	70%	56
150	88%	84%	20
200	92%	89%	11
250	95%	92%	6
300	96%	94%	4

Utility Factor = Miles You Can Cover w/EV vs w/ICE

https://advocacy.consumerreports.org/wp-content/uploads/2020/10/EV-Ownership-Cost-Final-Report-1.pdf

And Relative Efficiencies

Table 3.2. Average Vehicle Efficiencies by Vehicle Class

Class	Electric Efficiency (MPGe[30])	Gasoline Efficiency (mpg)
Car	120	32
Crossover/SUV	97	24
Pickup	76	20

https://advocacy.consumerreports.org/wp-content/uploads/2020/10/EV-Ownership-Cost-Final-Report-1.pdf

Estimated Fuel Cost Savings vs. ICE (15K Miles)

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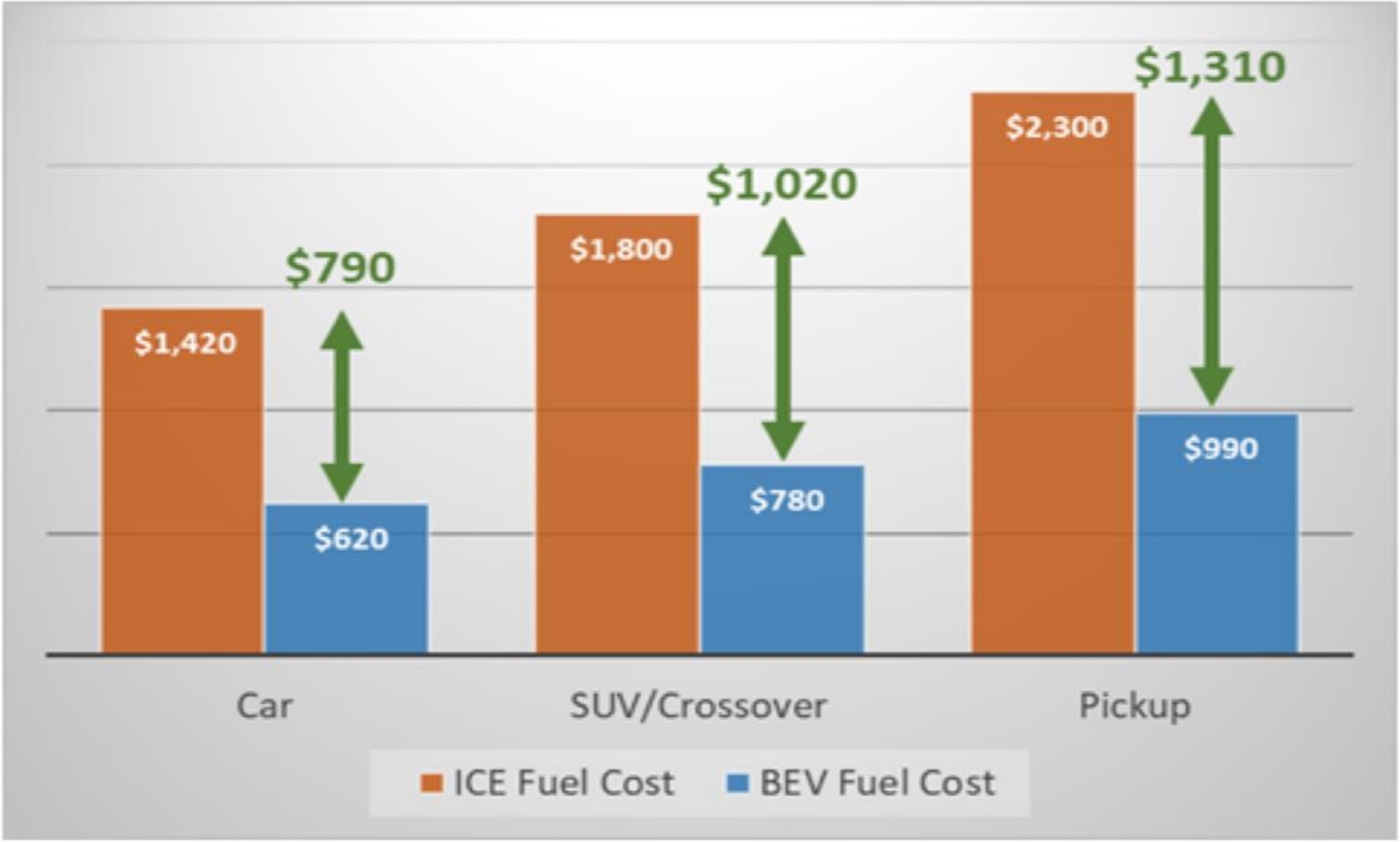

Figure 3.1. Estimated Fuel Cost for 15,000 Miles by Vehicle Class

https://advocacy.consumerreports.org/wp-content/uploads/2020/10/EV-Ownership-Cost-Final-Report-1.pdf

Estimated Lifetime Fuel Cost Savings

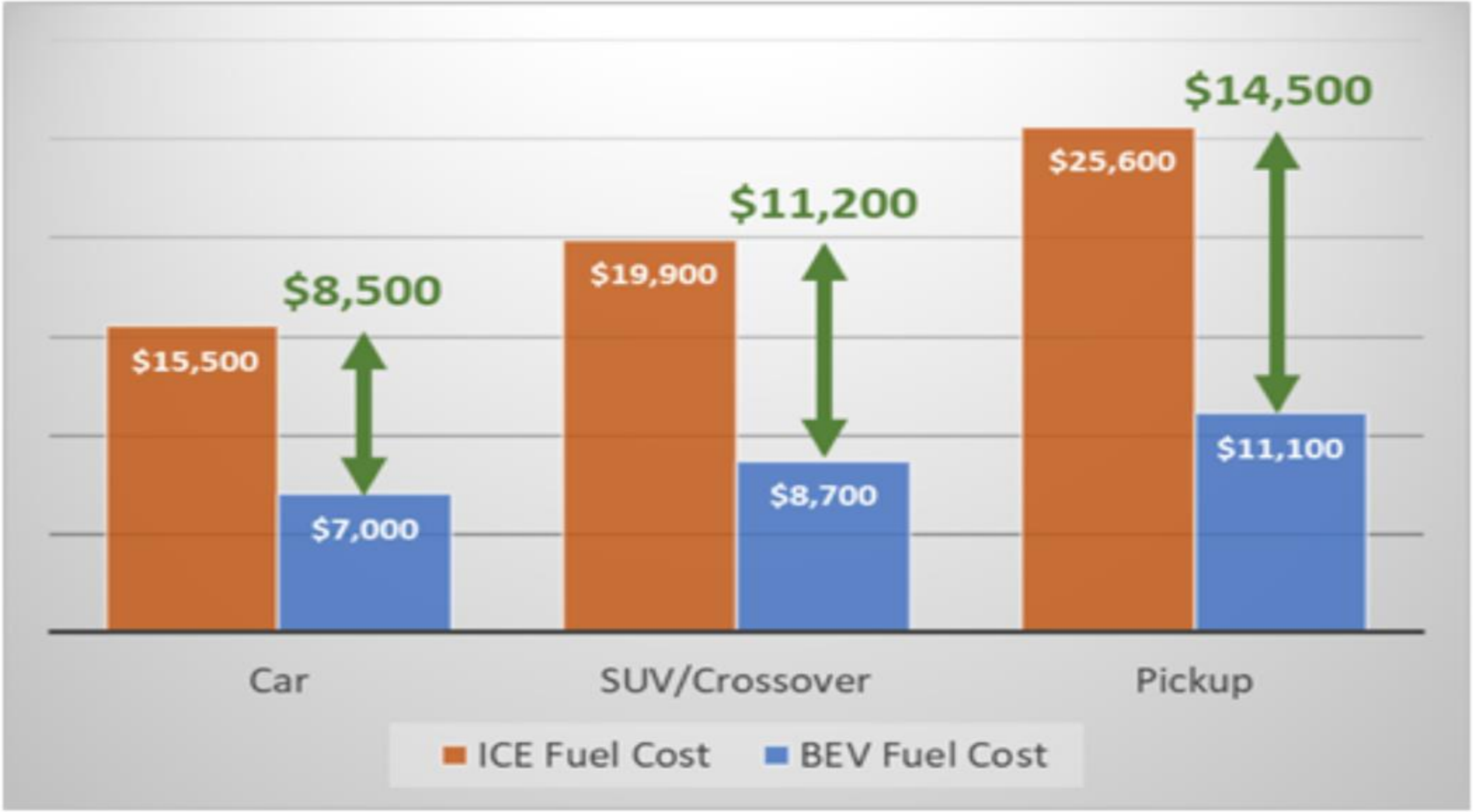

Figure 3.3. Discounted Lifetime Fuel Costs for Average BEV and ICE by Vehicle Class[37]

https://advocacy.consumerreports.org/wp-content/uploads/2020/10/EV-Ownership-Cost-Final-Report-1.pdf

Estimated Total Cost of Ownership Savings

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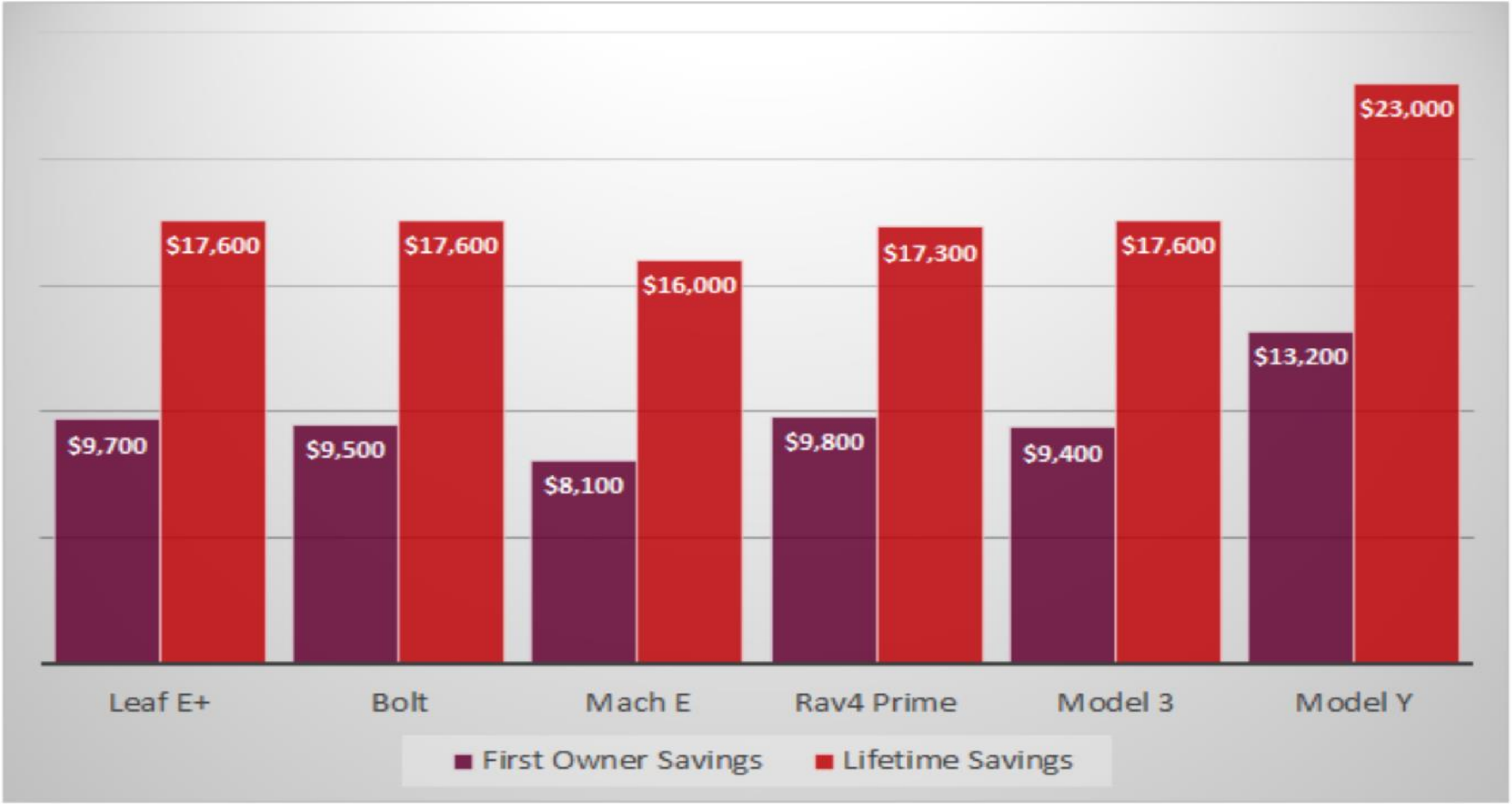

Figure 4.4. First Owner and Lifetime Savings From EVs vs. ICE That Matches Acceleration[61]

https://advocacy.consumerreports.org/wp-content/uploads/2020/10/EV-Ownership-Cost-Final-Report-1.pdf

Fleets: Companies are Beginning to Make the Commitments

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https://ngtnews.com/sysco-set-to-purchase-close-to-800-freightliner-ecascadias-from-daimler

USPS Ups First Order to 25K; Commits to 40% of New Purchases

https://electrek.co/2022/03/25/usps-doubles-order-electric-vehicles-but-buying-inefficient-gas-trucks/

Municipalities Committing as Well: Transit Buses

https://www.electrive.com/2022/06/23/wireless-chargers-help-to-halve-operating-costs-for-link-transit/

And School Buses

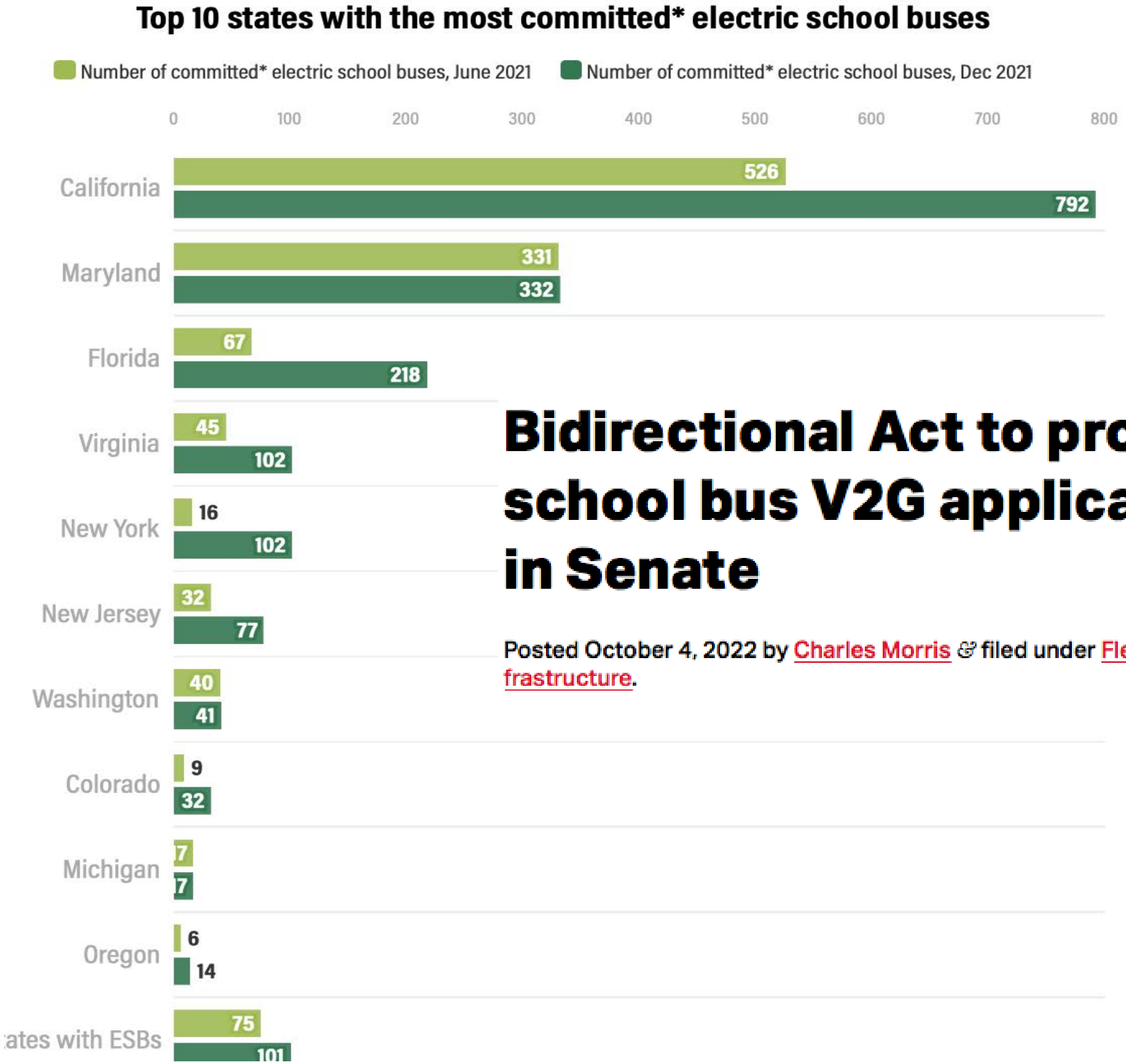
Boston will move to 100% electric school buses by 2030

Michelle Lewis - Apr. 13th 2022 9:13 am PT @michelle0728

https://electrek.co/2022/04/13/boston-will-move-to-100-electric-school-buses-by-2030/

The Number of School Buses is Growing Rapidly

Approximately 500,000 school buses in the U.S



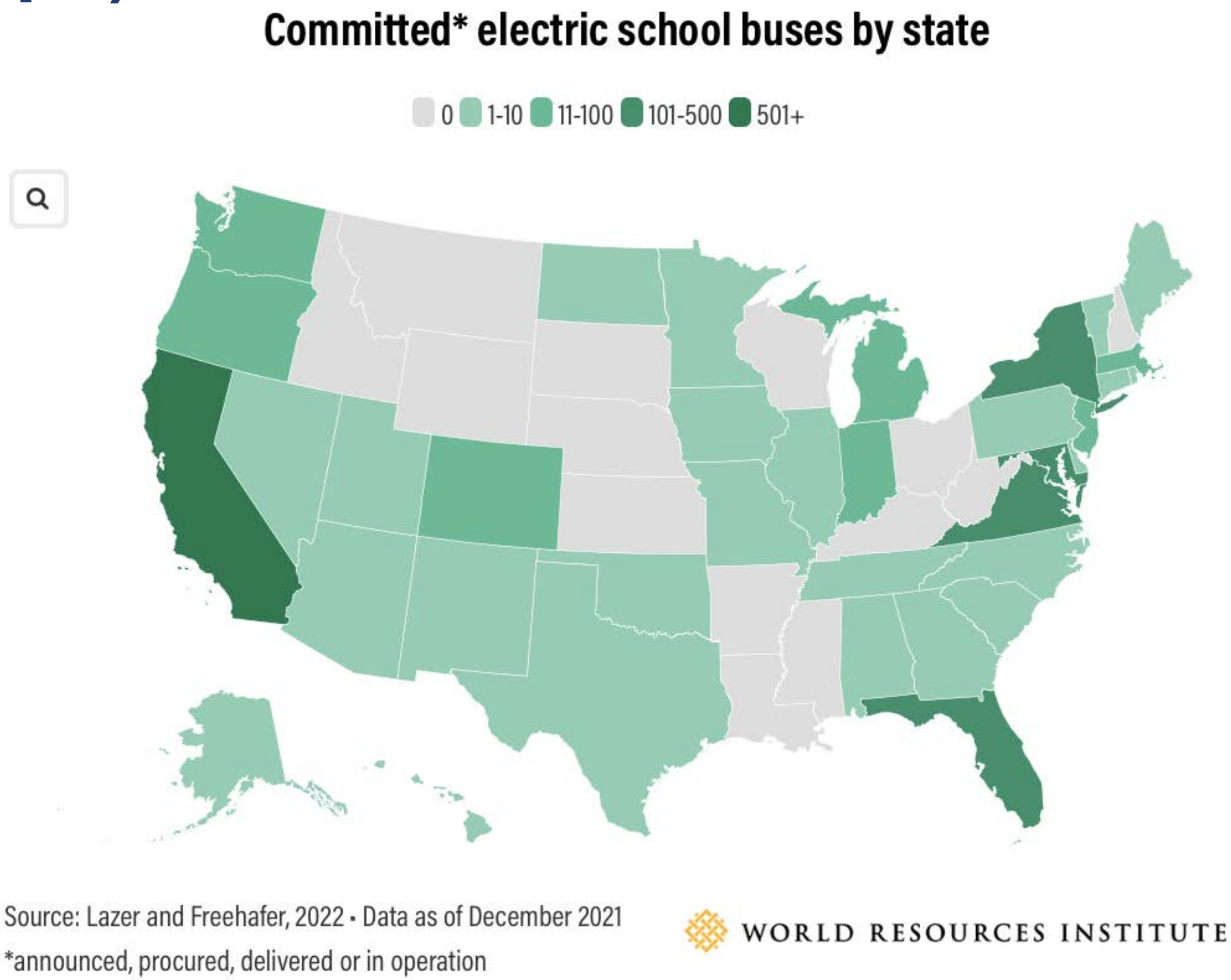
Bidirectional Act to promote electric school bus V2G applications introduced in Senate

Posted October 4, 2022 by Charles Morris & filed under Fleets and Infrastructure, Newswire, The Infrastructure.

https://www.wri.org/insights/where-electric-school-buses-us

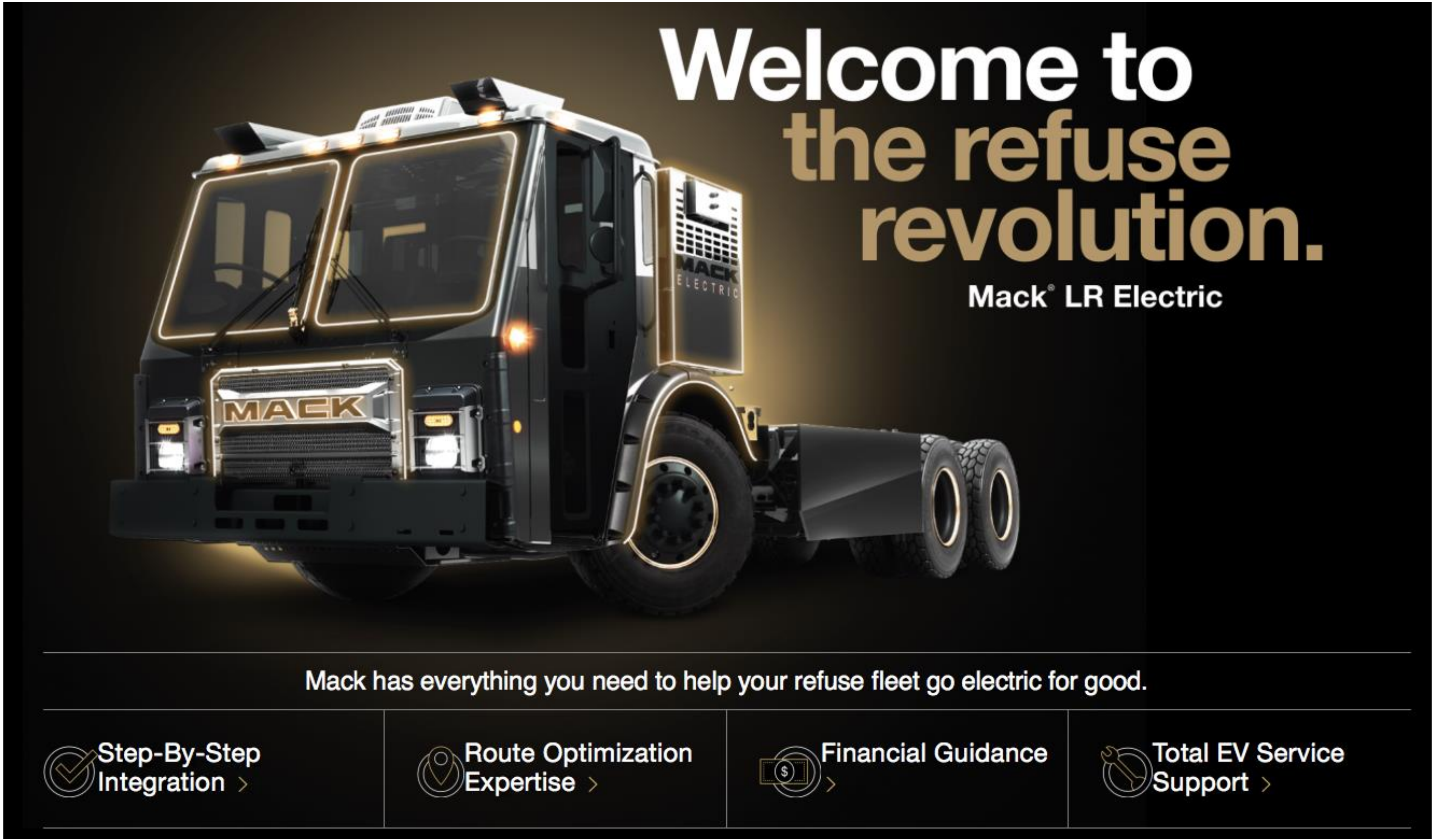
More States Are Adopting e-Buses (Financing Helps)

Smart Electric Power Alliance ONLINE LEARNING



https://www.wri.org/insights/where-electric-school-buses-us

When Has Garbage Hauling Ever Looked This Good?



As-A-Service Models Gaining Traction (owing to capital/complexity)

Smart Electric Power Alliance ONLINE LEARNING

Pick how you plug in.

Vehicle as a Service (VaaS)

We take care of everything. Mack works with you to wrap your EV lease, energy upgrades and EV support into a single monthly payment.

Infrastructure as a Service (IaaS)

Mack guides you during your transition to complete ownership of the truck and charging infrastructure including comprehensive EV support.

VaaS includes: +

IaaS includes: +

Port Vehicles – Leasing & As-A-Service

Smart Electric Power Alliance ONLINE LEARNING

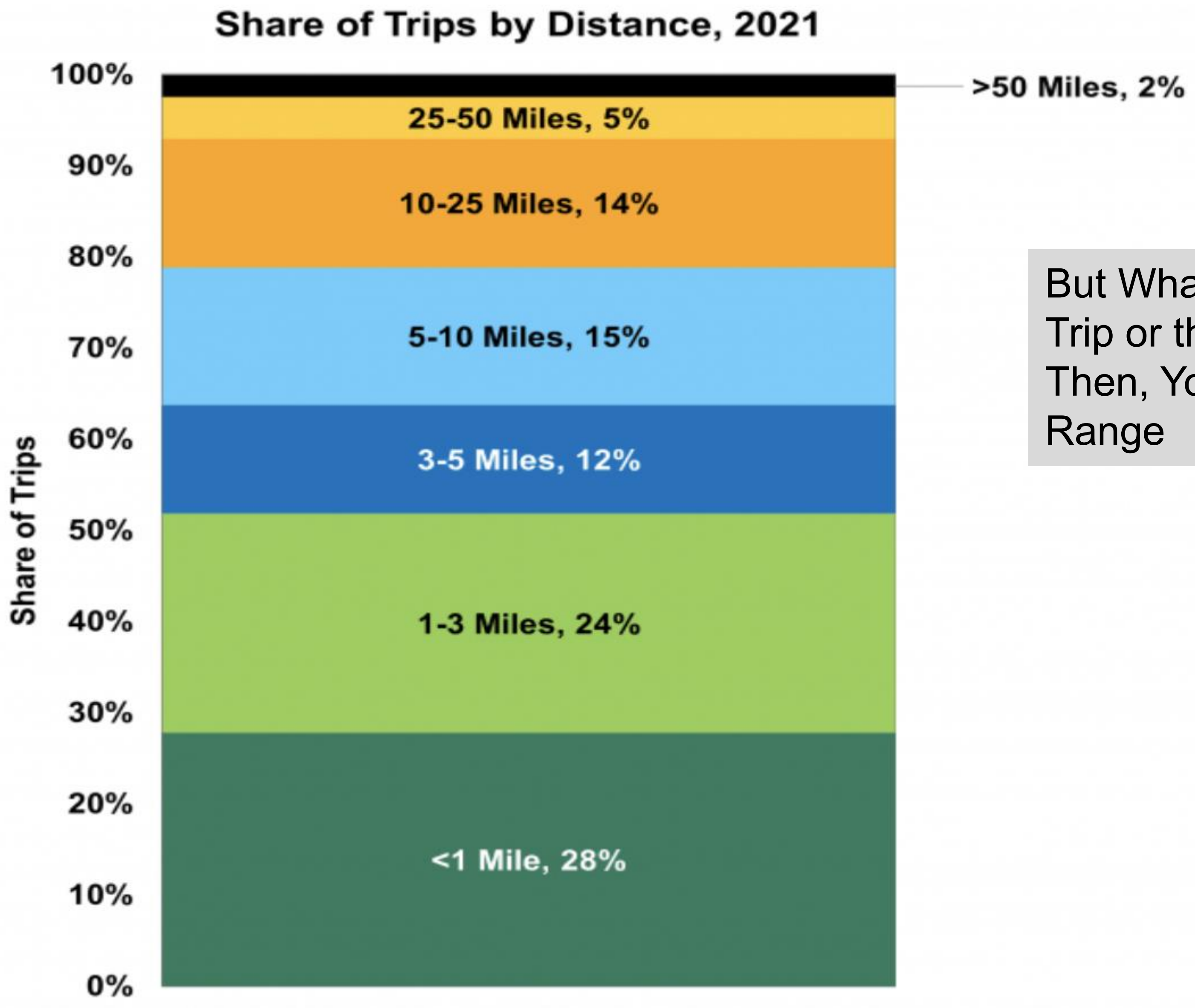
https://orangeev.com/orange-ev-news/penske-offers-orange-ev/

Smart Electric Power Alliance ONLINE LEARNING

Critical Issues Related to Customer Adoption

EVs Can Cover the Vast Majority of American Trips

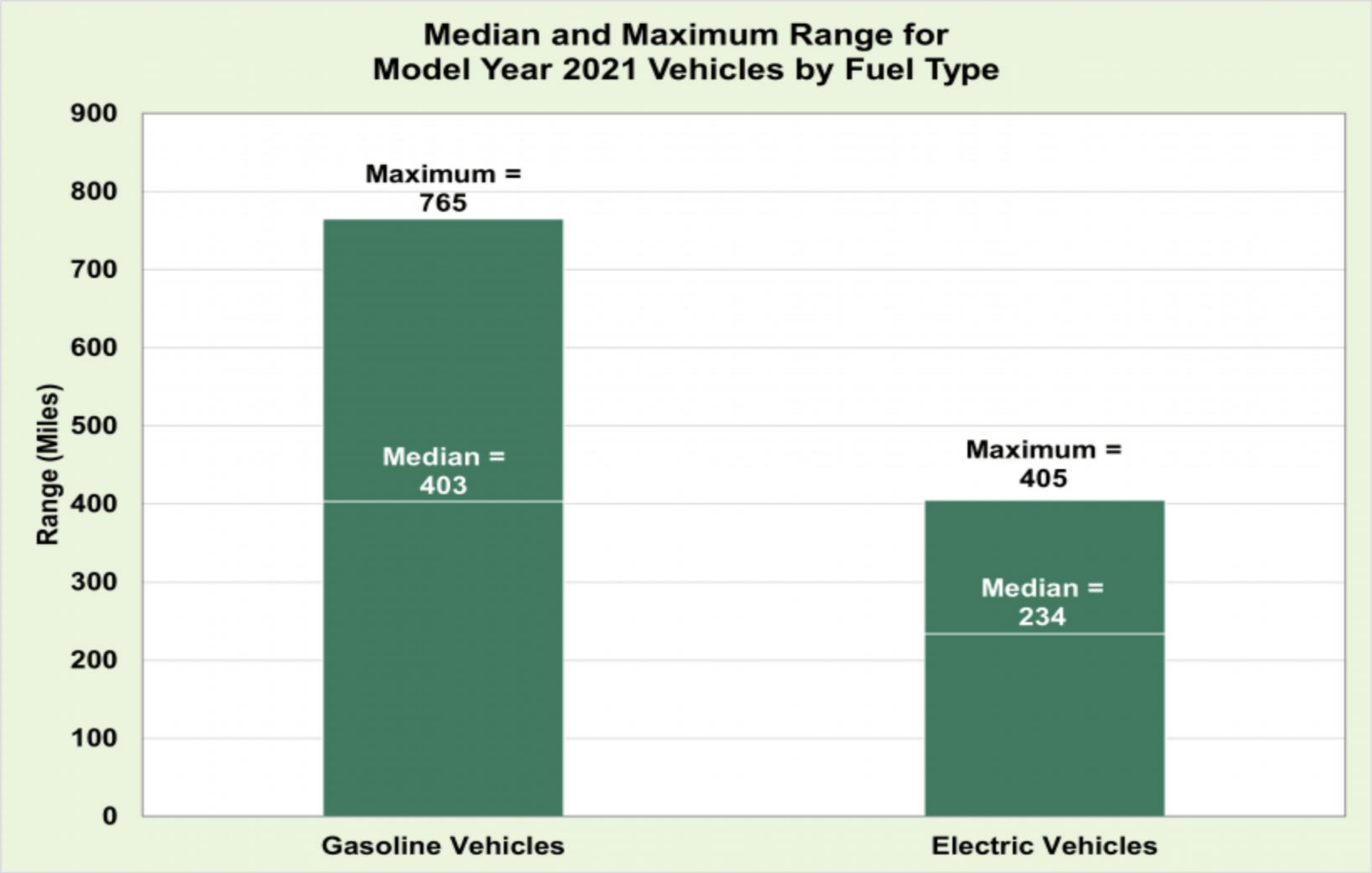
Smart Electric Power Alliance ONLINE LEARNING



But What About the Ski Trip or the Vacation? Then, You Need the Range

https://www.energy.gov/eere/vehicles/articles/fotw-1230-march-21-2022-more-half-all-daily-trips-were-less-three-miles-2021

Range is an Issue: A Function of Charging Speed and Battery



https://www.energy.gov/eere/vehicles/articles/fotw-1221-january-17-2022-model-year-2021-all-electric-vehicles-had-median

Batteries Become More Powerful/Energy Dense

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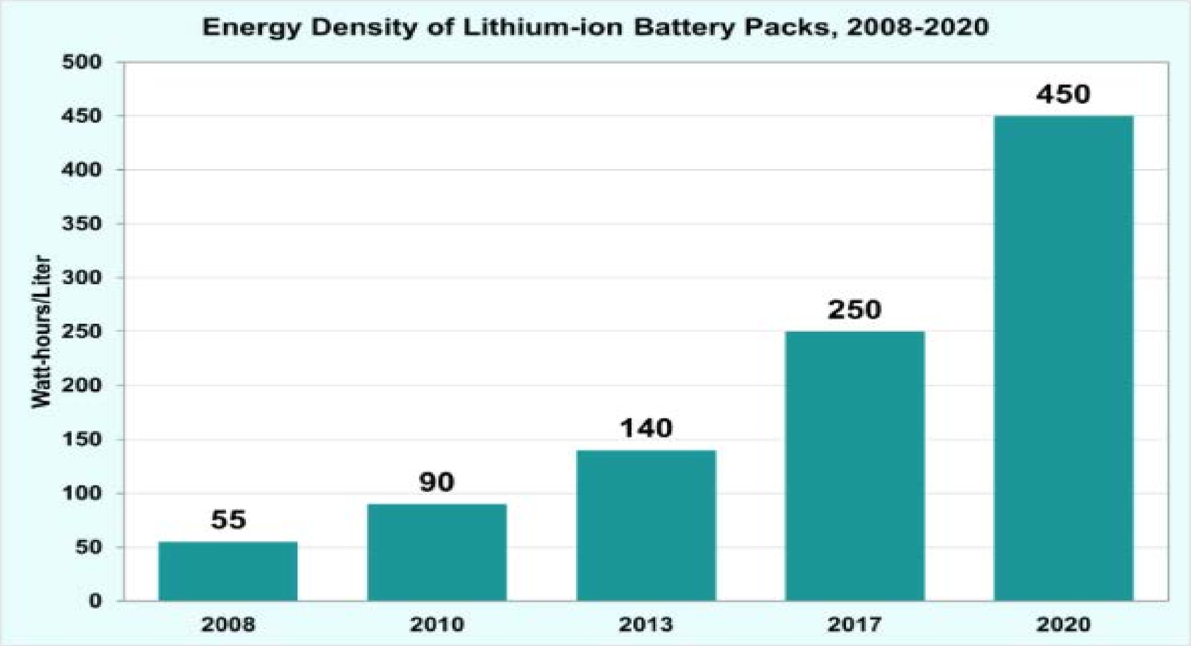
Volumetric Energy Density of Lithium-ion Batteries Increased by More than Eight Times Between 2008 and 2020

Volumetric energy density refers to the amount of energy that can be contained within a given volume. Increasing the volumetric energy density of batteries allows electric vehicles (EVs) to travel further without increasing the size of the battery pack. Conversely, it can allow an EV to travel the same distance with a smaller battery pack, thus saving space, weight, and manufacturing costs. Given the enormous benefit of increasing the energy density of batteries for EVs, there has been heavy investment in battery development by the Department of Energy and private industry that has yielded impressive gains. In 2008, lithium-ion batteries had a volumetric energy density of 55 watt-hours per liter; by 2020, that had increased to 450 watt-hours per liter.



Source: Nitin Muralidharan, Ethan C. Self, Marm Dixit, Zhijia Du, Rachid Essehli, Ruhul Amin, Jagjit Nanda, Ilias Belharouak, Advanced Energy Materials, *Next-Generation Cobalt-Free Cathodes – A Prospective Solution to the Battery Industry's Cobalt Problem*, January 2022.

https://www.energy.gov/eere/vehicles/articles/fotw-1234-april-18-2022-volumetric-energy-density-lithium-ion-batteries

The Trajectory Has Been Clear

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Nissan LEAF Passenger EV	**2010** **24 kWh**
	2016 **30 kWh**
	2018 **40 kWh**
	2019 **62 kWh**
Rivian R1T Electric Pickup Truck	**2020 onward** **105 – 180 kWh**

Projected increase in battery size from 2010 to 2020 onward

Enel X 2022 Smart-EV-Load-Management-eBook.pdf

So, Range Has Increased Significantly in Recent Years

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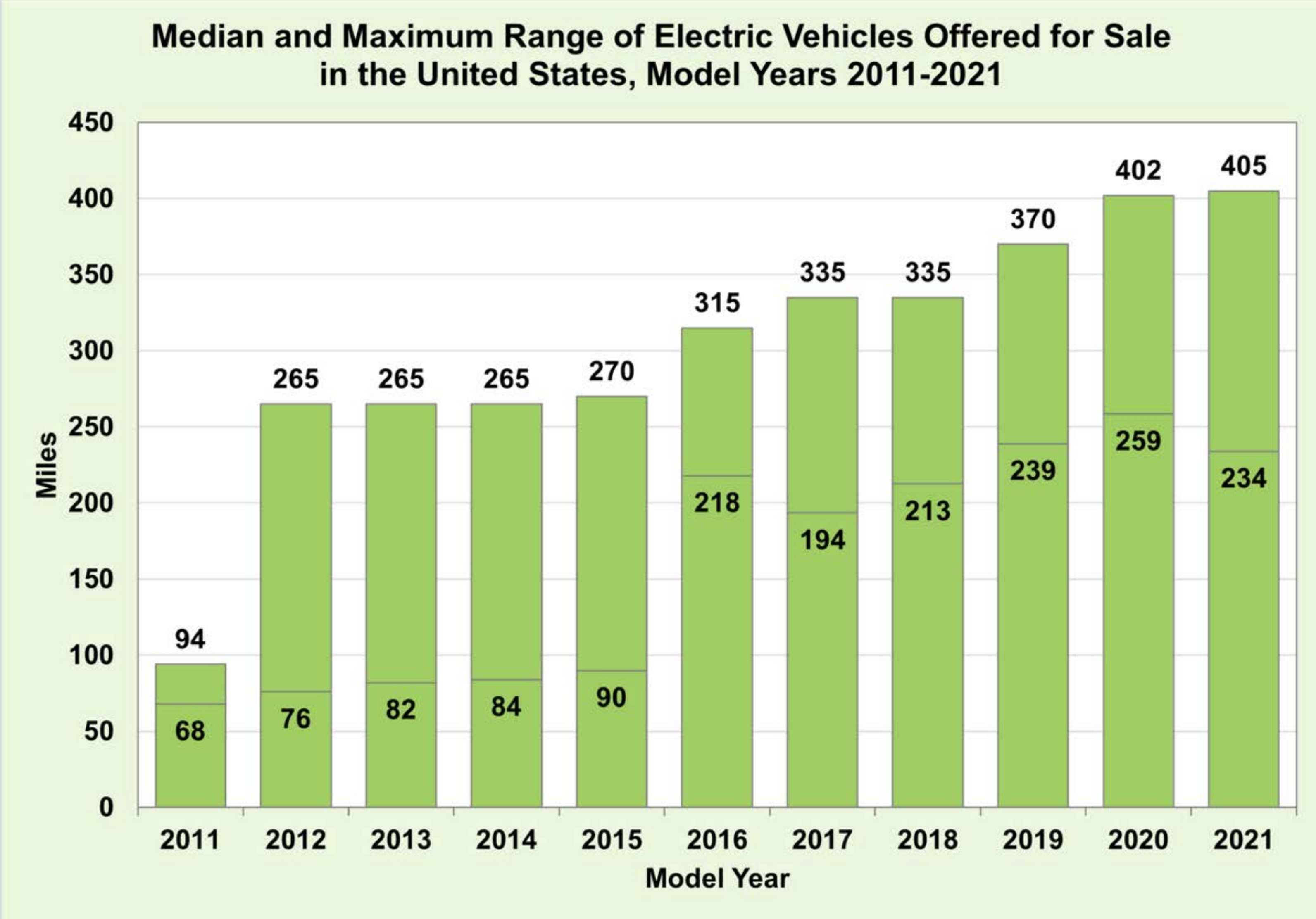
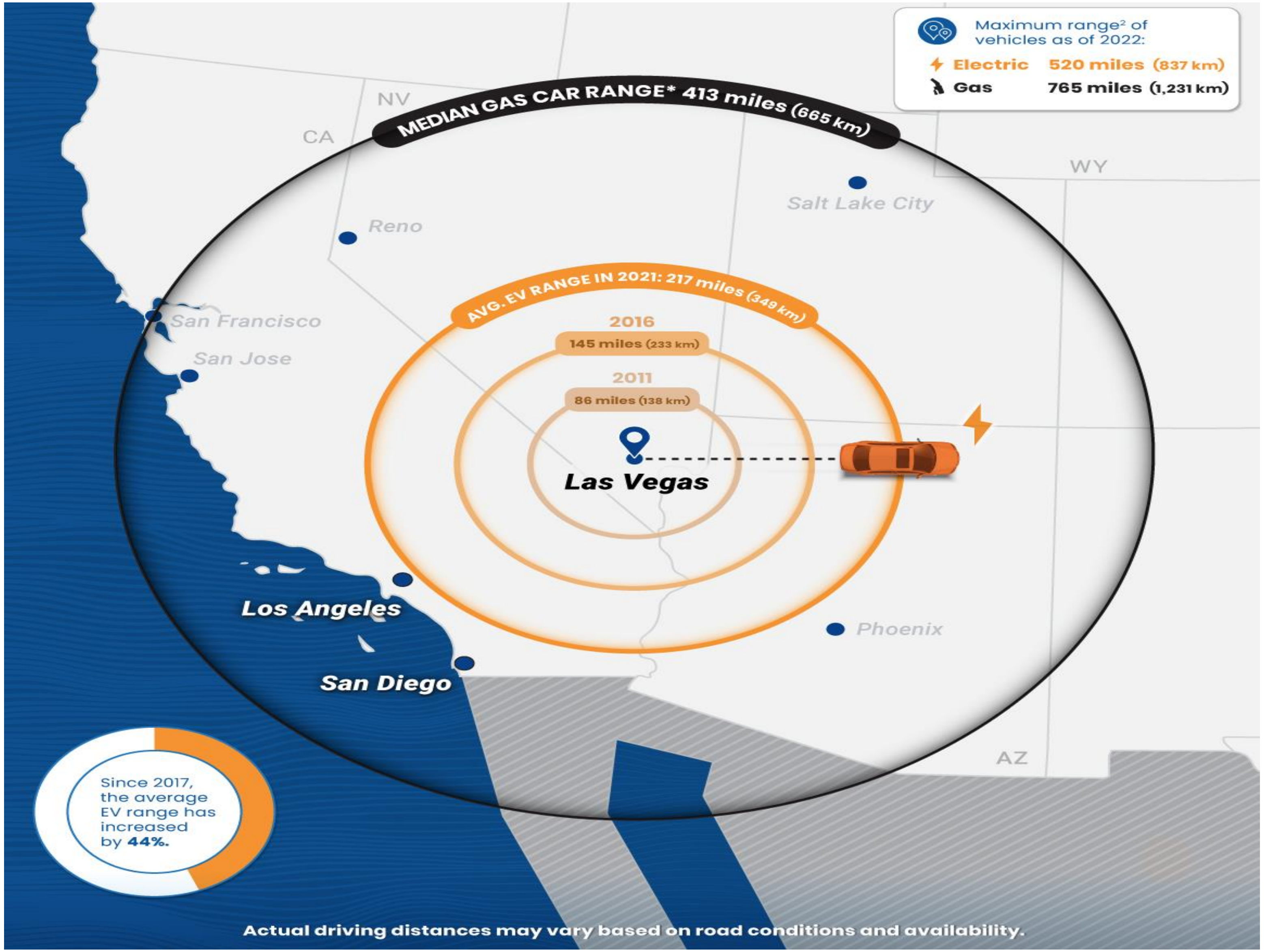


https://www.energy.gov/eere/vehicles/articles/fotw-1220-january-10-2022-model-year-2021-electric-vehicle-longest-range

Though Still Less Than ICEs



https://elements.visualcapitalist.com/range-of-electric-cars-vs-gas/

Understanding the Basics of Charging

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EV Charging Basics

Type	Miles of Range Per Hour of Charging (RPH)	Time to Fully Charge	When to Use	Connector
Level 1, Standard Wall Outlet (AC)	5 RPH	+ 16 hours for an 80-mile battery + 40 hours for a 200-mile battery	+ Get some charge while you sleep Note: slower for cars with large batteries	Note: you'll need your own cable to plug in to the wall for Level 1
Level 2 Charging Station (AC)	+ 12 RPH for cars with 3.7 kW on-board charger + 25 RPH for cars with 6.6 kW on-board charger	+ 3.5 hours for an 80-mile battery + 8 hours for a 200-mile battery	+ At work + While you sleep + Topping up around town	J1772 connector
DC Fast Charging	100 RPH or more, depending on the power level of the charger + 24 kW (up to 100 RPH) + 44 to 50 kW (up to 200 RPH)	Depends on the power level of the charger and car model, but could be 80% charged within 30 minutes	+ Short stops + Express Corridor locations	SAE Combo (CCS) CHAdeMO Tesla

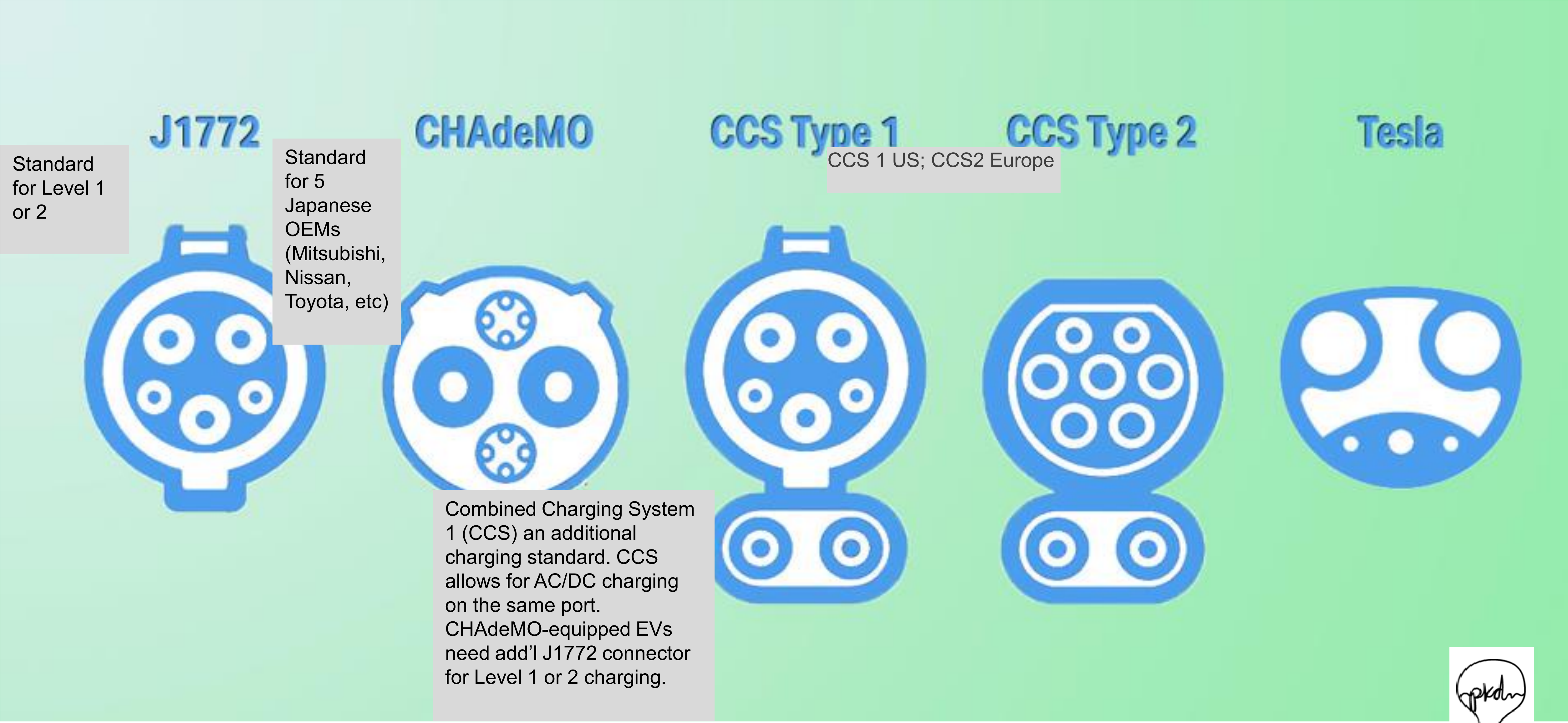
"If the battery capacity of your 2021 Mustang Mach-E is 88kWh, you're looking at days to charge, not hours. Nearly 63 hours by our count."

"If you're boasting around 7.7 kW max power at 240V, you can charge that Mustang Mach-E significantly quicker. 11.5 hours sounds a lot better than 63 hours, no?"

DC fast chargers can offer 50-350 kW of power; some in Europe are even reaching 400 kW. Depending on the power available, a Level 3 charger can fully replenish your EV in twenty to thirty minutes.

www.chargepoint.com and https://electrek.co/2021/10/22/electric-vehicle-ev-charging-standards-and-how-they-differ/

The Sockets/Connectors



Standard for Level 1 or 2

Standard for 5 Japanese OEMs (Mitsubishi, Nissan, Toyota, etc)

CCS 1 US; CCS2 Europe

Combined Charging System 1 (CCS) an additional charging standard. CCS allows for AC/DC charging on the same port. CHAdeMO-equipped EVs need add’l J1772 connector for Level 1 or 2 charging.

https://electrek.co/2021/10/22/electric-vehicle-ev-charging-standards-and-how-they-differ/

Connectors Vary by Region Across the Globe

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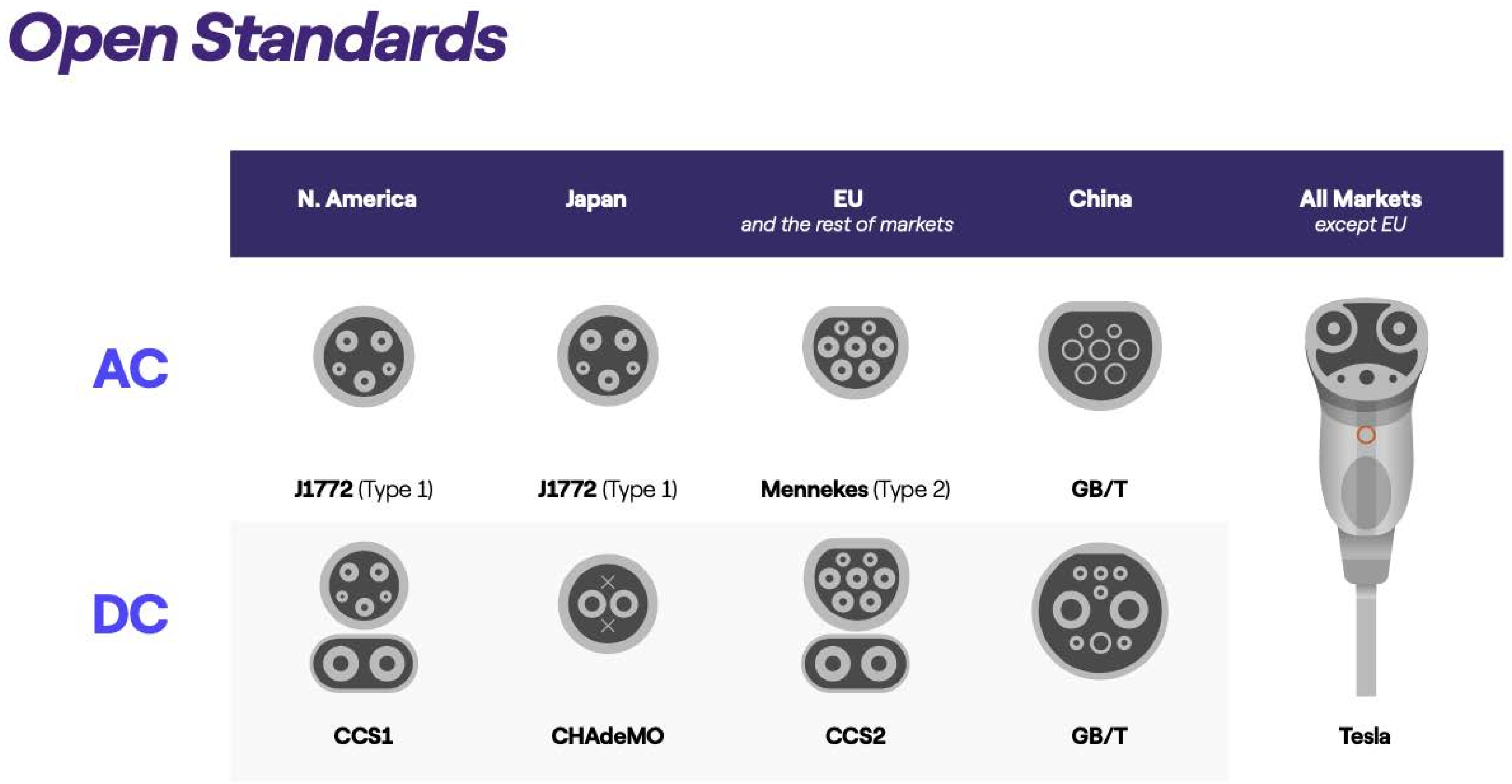

Enel X 2022 Smart-EV-Load-Management-eBook.pdf

And In the U.S., Many Don’t Work These Days

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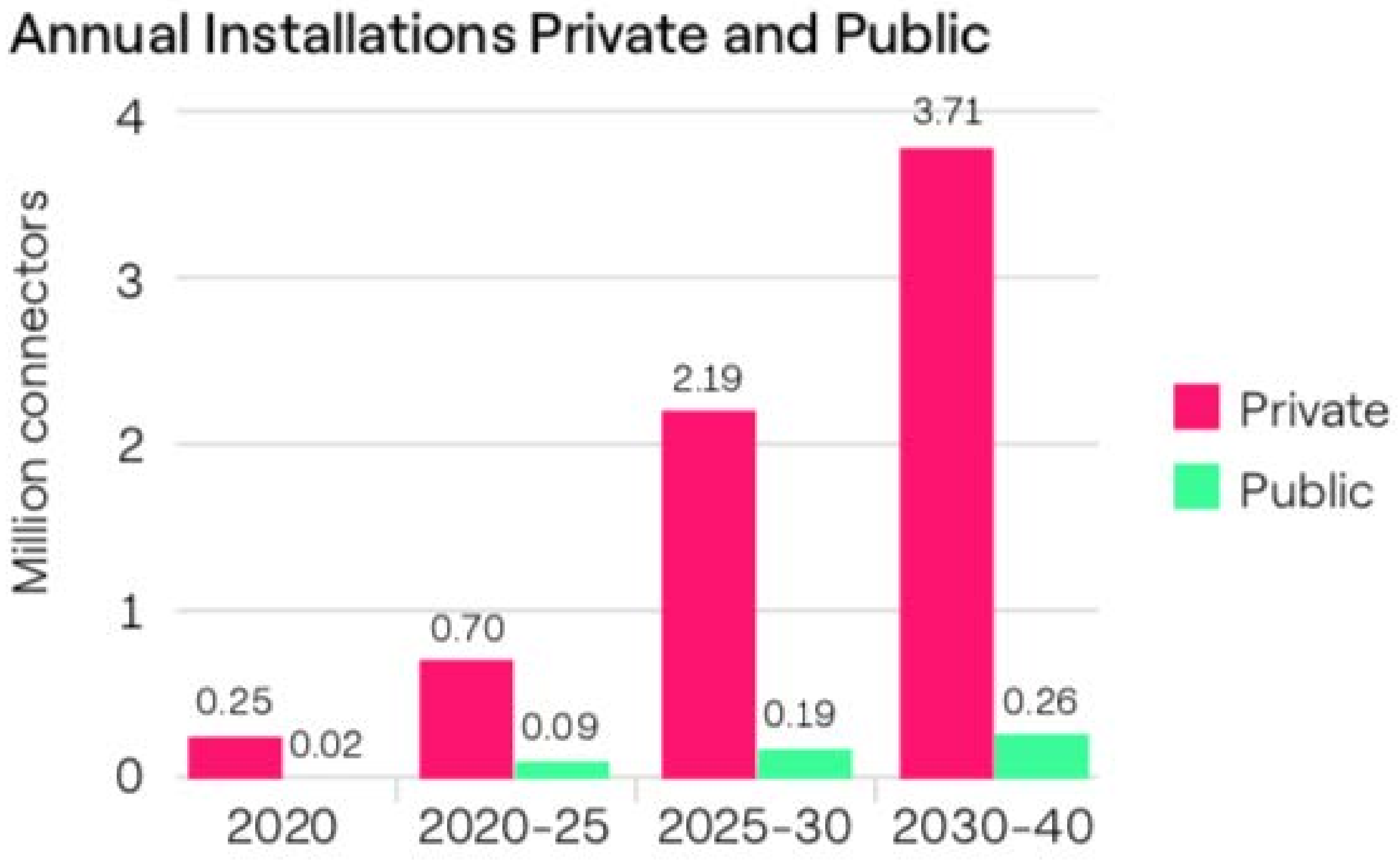
Reliability of EV Direct Current Fast Chargers								
	ChargePoint		Electrify America		EVgo		Total No.	Total %
Functioning	**No.**	**%**	**No.**	**%**	**No.**	**%**		
Charged for 2 minutes	21	47.70%	228	60.20%	120	55.60%	369	57.7%
Occupied by EV and charging	6	13.60%	52	13.70%	37	17.10%	95	14.9%
Total Functioning	27	61.40%	280	73.90%	157	72.70%	464	72.6%
Not Functioning								
Connector broken	0	0.00%	2	0.50%	3	1.40%	5	0.8%
Blank or non-responsive screen	4	9.10%	13	3.40%	5	2.30%	22	3.4%
Error message on screen	4	9.10%	17	4.50%	3	1.40%	24	3.8%
Connection error	0	0.00%	0	0.00%	6	2.80%	6	0.9%
Payment system failure	3	6.80%	25	6.60%	16	7.40%	44	6.9%
Charge initiation failure	5	11.40%	15	4.00%	22	10.20%	42	6.6%
Total	16	36.40%	72	19.00%	55	25.50%	143	22.4%
Station Design Failure				1				
Cable would not reach	1	2.30%	27	7.10%	4	1.90%	32	5.0%
TOTAL	**44**	**100%**	**379**	**100%**	**216**	**100%**	639	100.0%

David Rempel, Department of Bioengineering, University of California, Berkeley; Cool The Earth; SLAC National Accelerator Laboratory, GISMo Group I Chart: EVAdoption, LLC

https://evadoption.com/dc-fast-charger-reliability-is-critical-for-mainstream-adoption-of-electric-vehicles/

Charging Infrastructure: More is Needed



https://www.enelx.com/n-a/en/resources/ebooks-white-papers/fulfill/2022-energy-market-outlook

But Many More Companies Jumping Into the Charging Game

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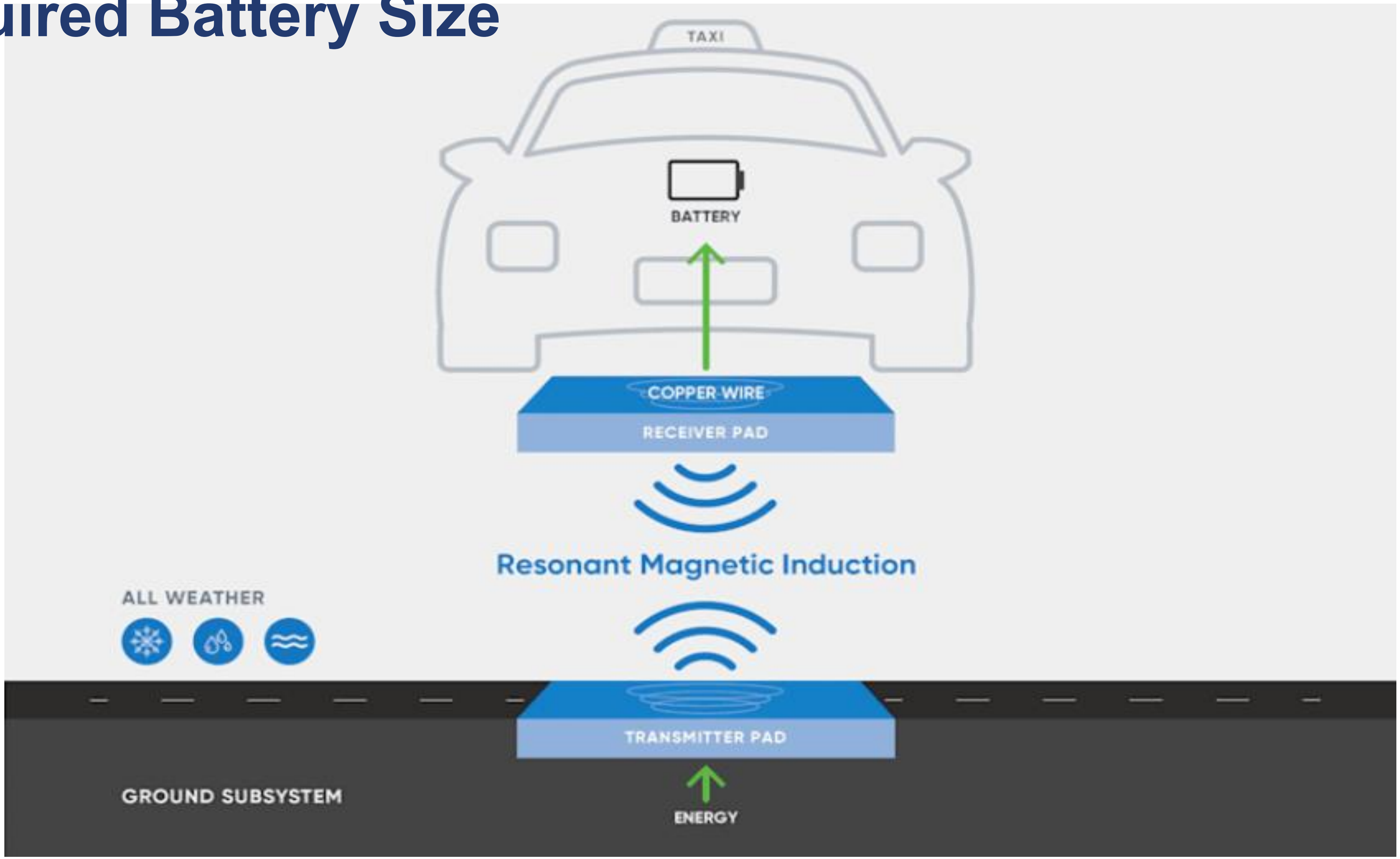
Announced Private Investment for EV Charging in the U.S. to Date

Parent Company	U.S. Investment (million $)
Volkswagen AG	$2,225,000,000
ChargePoint	$1,137,850,000
General Motors Company	$750,000,000
EVgo	$675,000,000
Mercedes-Benz	$650,000,000
Volta Charging	$250,970,000
Siemens	$225,000,000
Tesla Motors	$183,040,000
FreeWire Technologies	$165,000,000
EVCS	$68,000,000
EV Connect	$33,400,000
Royal Dutch Shell Co.	$25,000,000
Amply Power	$17,000,000
Other	$15,950,000
Grand Total	$6,421,210,000

This table summarizes private investment in charging infrastructure in the U.S. raised or committed to date. Data is sourced from public announcements and press releases by charging companies and automakers. Investment includes both equity and/or debt financing raised by EV charging companies, as well as explicit charging infrastructure investment commitments from automakers. Source: Atlas EV Hub.

https://www.canarymedia.com/articles/ev-charging/terawatt-infrastructure-snags-1b-for-ev-charging-buildout (09/13/2022)

Wireless Charging Could Greatly Minimize Required Battery Size



https://www.drive.com.au/news/wireless-electric-car-charging/

The General Set-Up for Wireless

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https://www.drive.com.au/news/wireless-electric-car-charging/

Wireless Charging Shorter “Sips” and Longer Operating Hours

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MARKETS > AUTOMOTIVE

Wireless Charging for EV Taxis Launches in Gothenburg

April 8, 2022

https://www.electronicdesign.com/markets/automotive/article/21237878/electronic-design-wireless-charging-for-ev-taxis-launches-in-gothenburg

A Future Scenario From Australia

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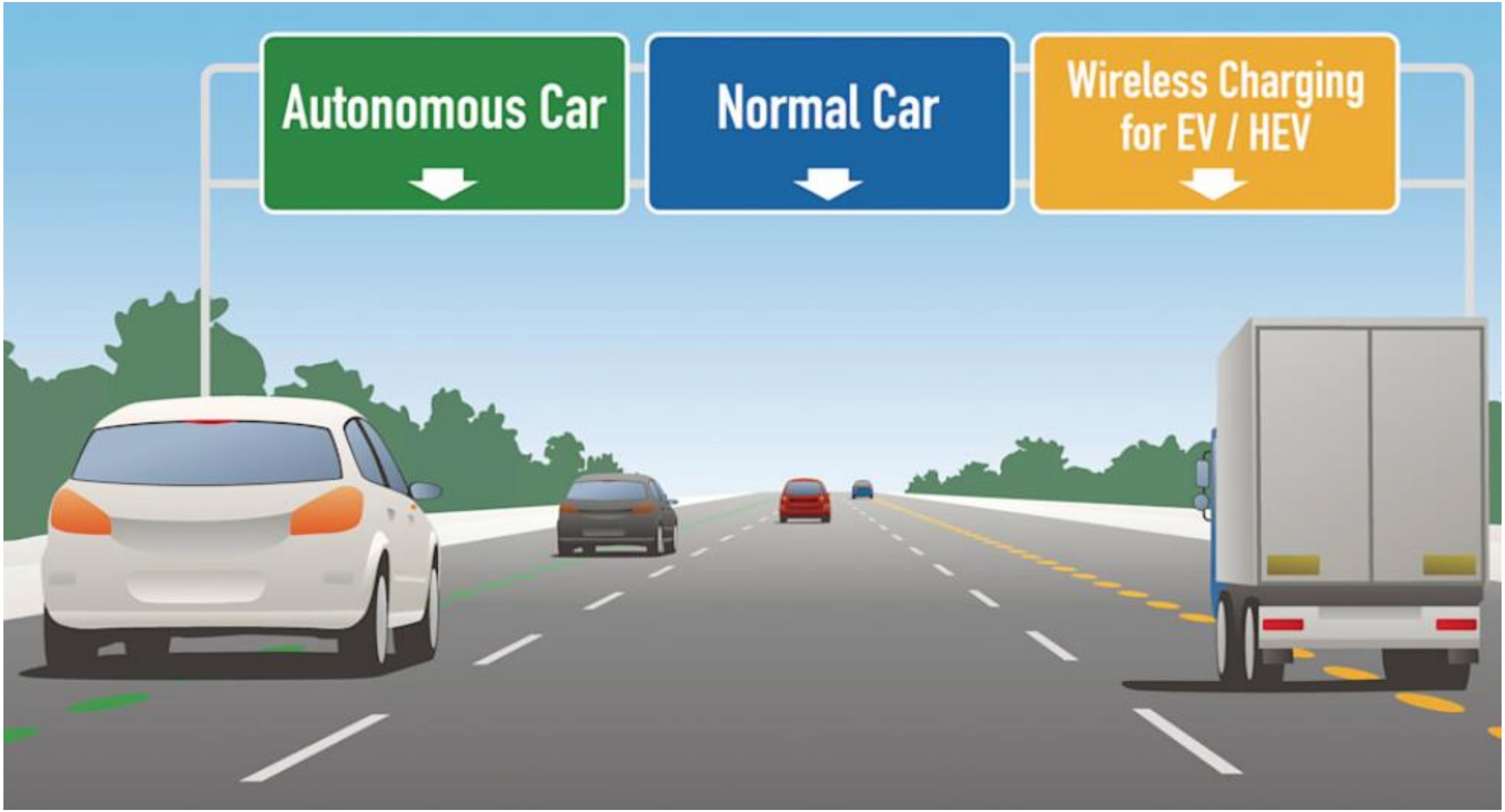

https://www.drive.com.au/news/wireless-electric-car-charging/

Michigan Expects to Have First Mile by 2023 (at $1.9 mn)

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https://www.thecentersquare.com/michigan/one-mile-of-detroits-wireless-ev-charging-road-to-cost-at-least-1-9-million/article_032032ac-838c-11ec-8ad8-97fa45aa9c9d.html

Managed Fleet Charging

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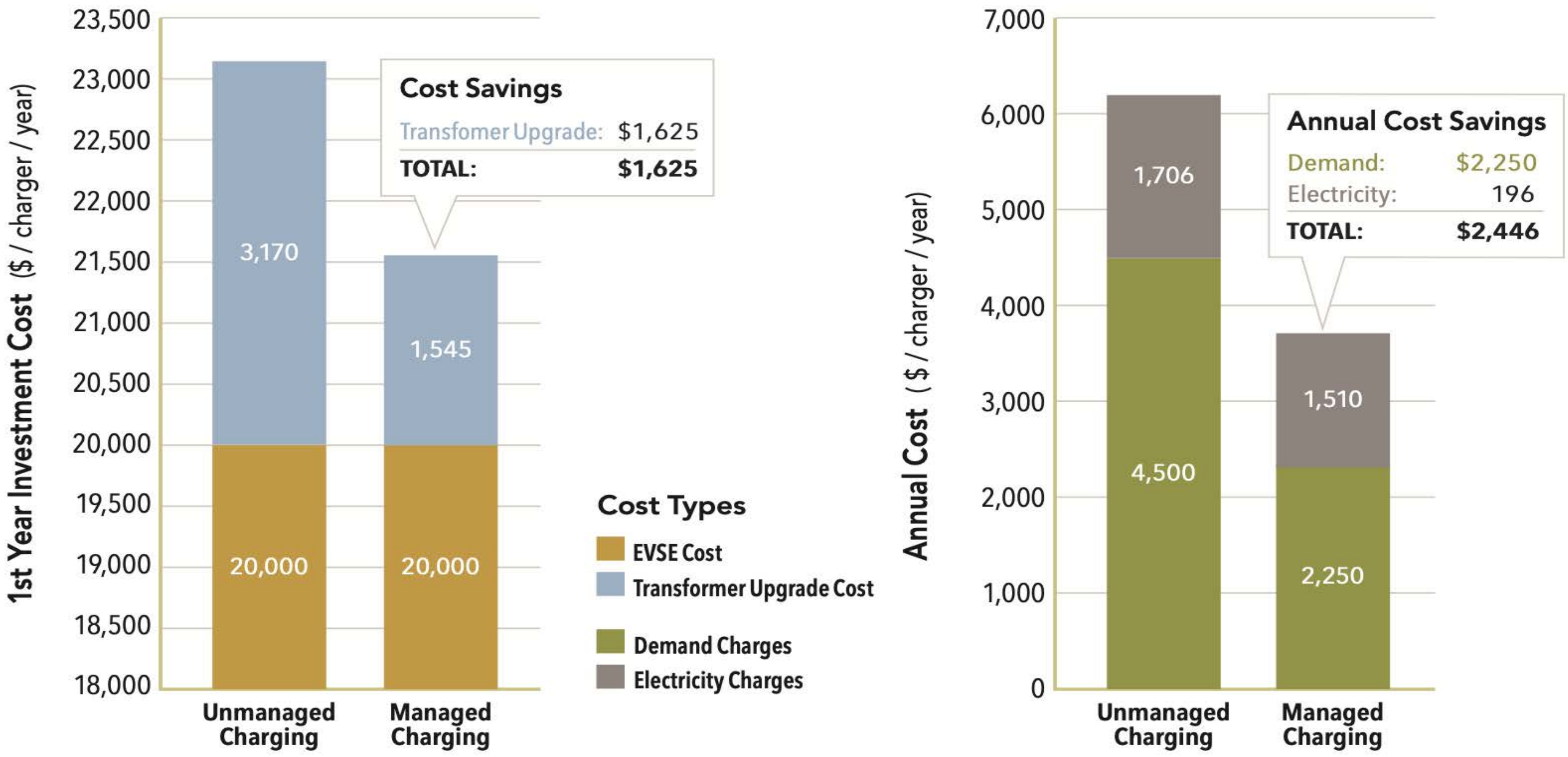
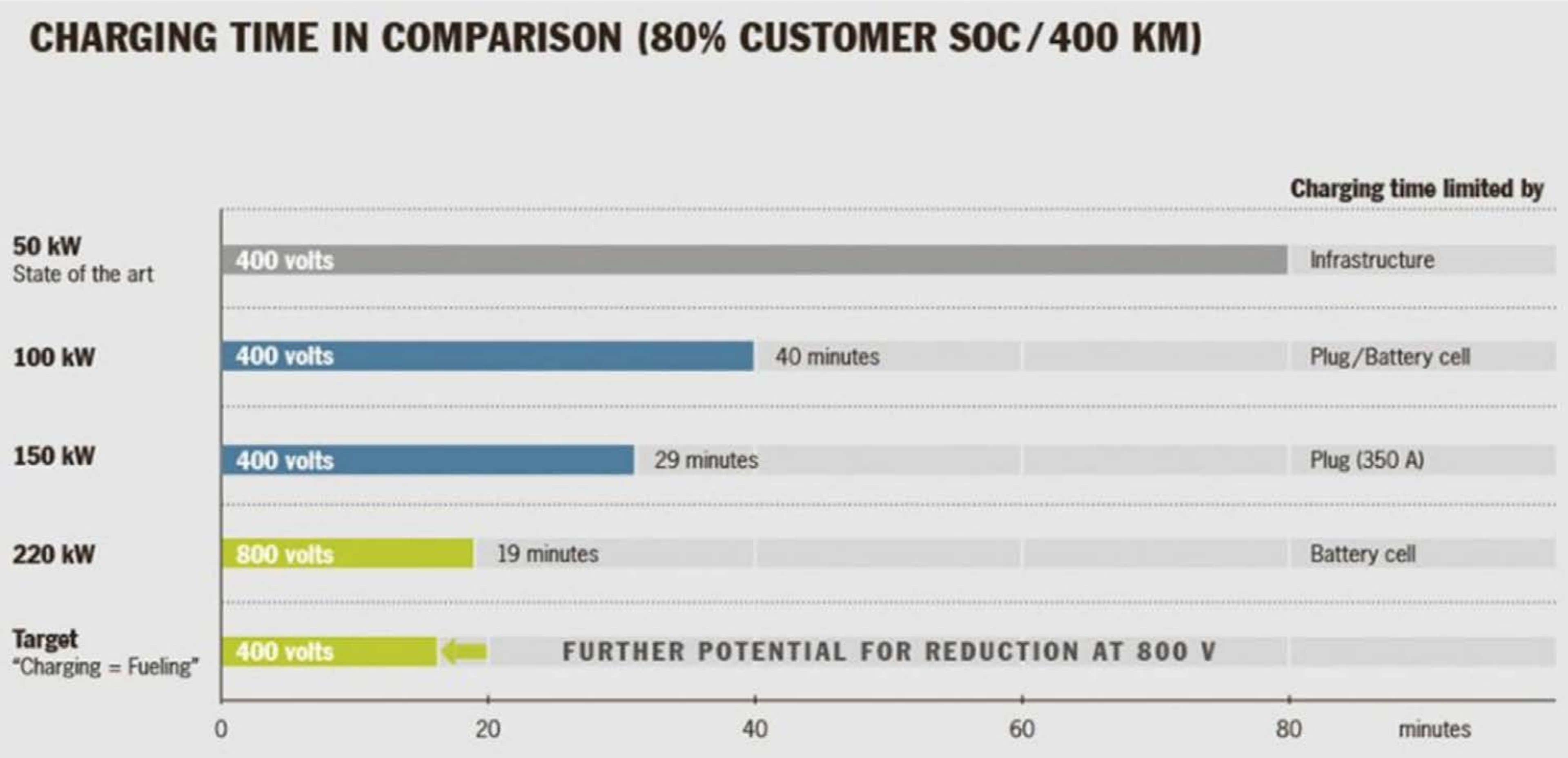


Figure 2. Managed EV charging saves the fleet owner over $244,000 annually and minimizes up-front costs. Itron's projection shows that smaller equipment, less maintenance and off-peak pricing combine for an impressive 38% benefit over the lifespan of a 100-bus fleet and its 100 chargers.

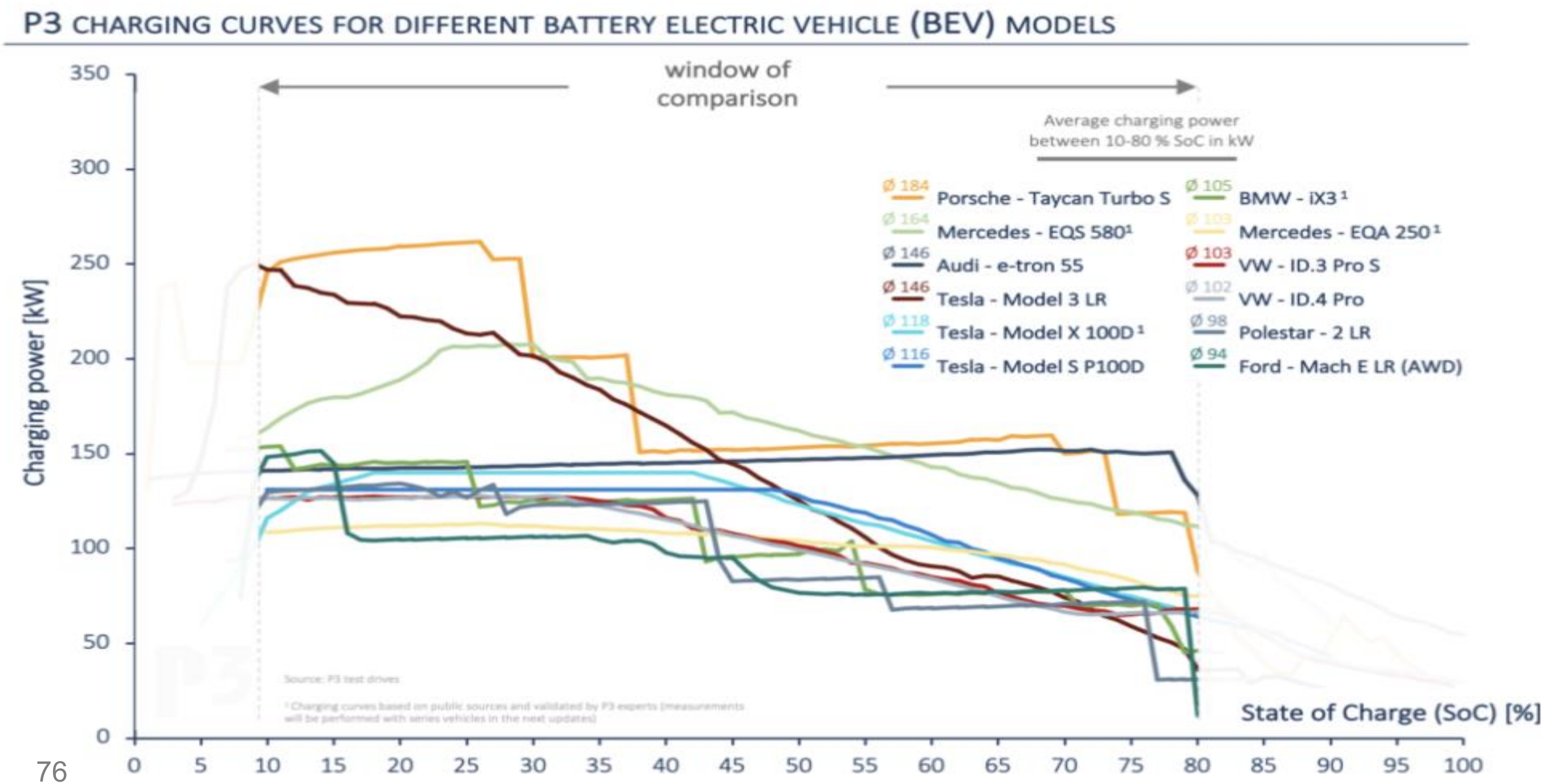
https://uploads-ssl.webflow.com/58ec05db3007283413b38d70/6202a909ec77d67ed12e7c71_EPIcenter%20Itron%20white%20paper-issue%201-2022-020122-web.pdf

Factors Affecting Charging Times (More Volts = More Current)



http://insideevs.com/falling-gas-prices-vs-falling-battery-prices-wins/

Battery Limitations and How Vehicles Actually Charge



https://www.p3-group.com/en/p3-charging-index-comparison-of-the-fast-charging-capability-of-various-electric-vehicles-from-a-users-perspective-update-2021/

Cycle Life Becoming Less of an Issue (Latest LIFP Even Better)

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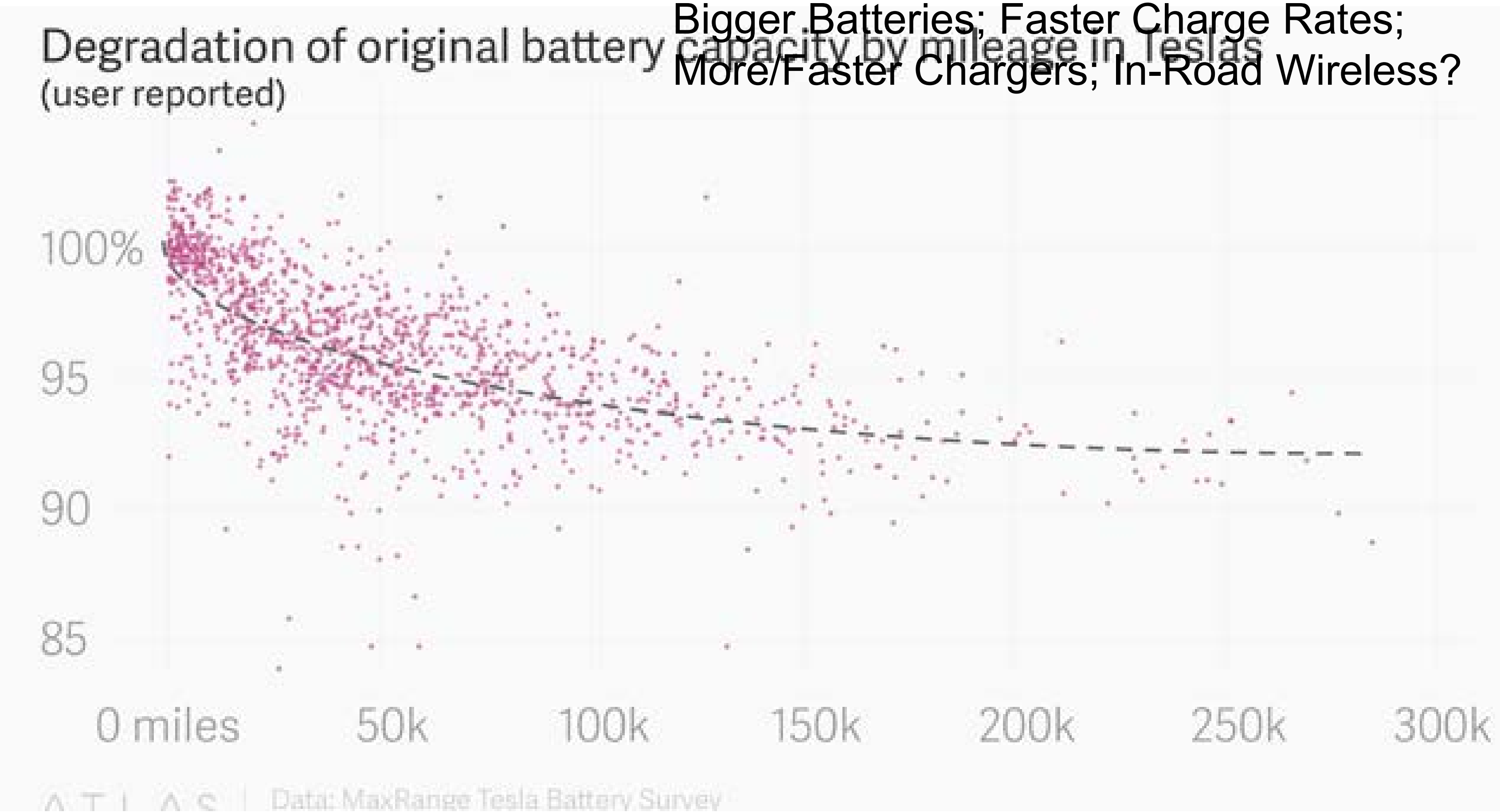
Bigger Batteries; Faster Charge Rates; More/Faster Chargers; In-Road Wireless?



https://qz.com/1325206/tesla-owners-battery-data-show-it-wont-win-through-chemistry-only-a-better-factory/

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Day 2: Implications of Electromobility for Power Grids

Peter Kelly-Detwiler, Principal – NorthBridge Energy Partners, LLC

October 2022

Clean + Modern Grid

Regulatory and Business Innovation | Grid Integration | Electrification

The Coordination Challenge w/ Competitive Markets

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Lack of Visibility, Situational Awareness and Control

GRIDWORKS

Profound Implications for high-voltage AND low-voltage networks

- DO and the ISO do not have visibility and situational awareness about location, status and output of DERs
- DER Operator does not have visibility into distribution system to ensure exported energy is feasible and deliverable
- DO need better visibility into own distribution systems
  - Predict DER behavior
  - Real time DER response
  - Forecast DERs' impacts on grid

https://pubs.naruc.org/pub/67F0F5A8-F49D-9E86-FD4D-EDDE825B007E

Different Objectives…

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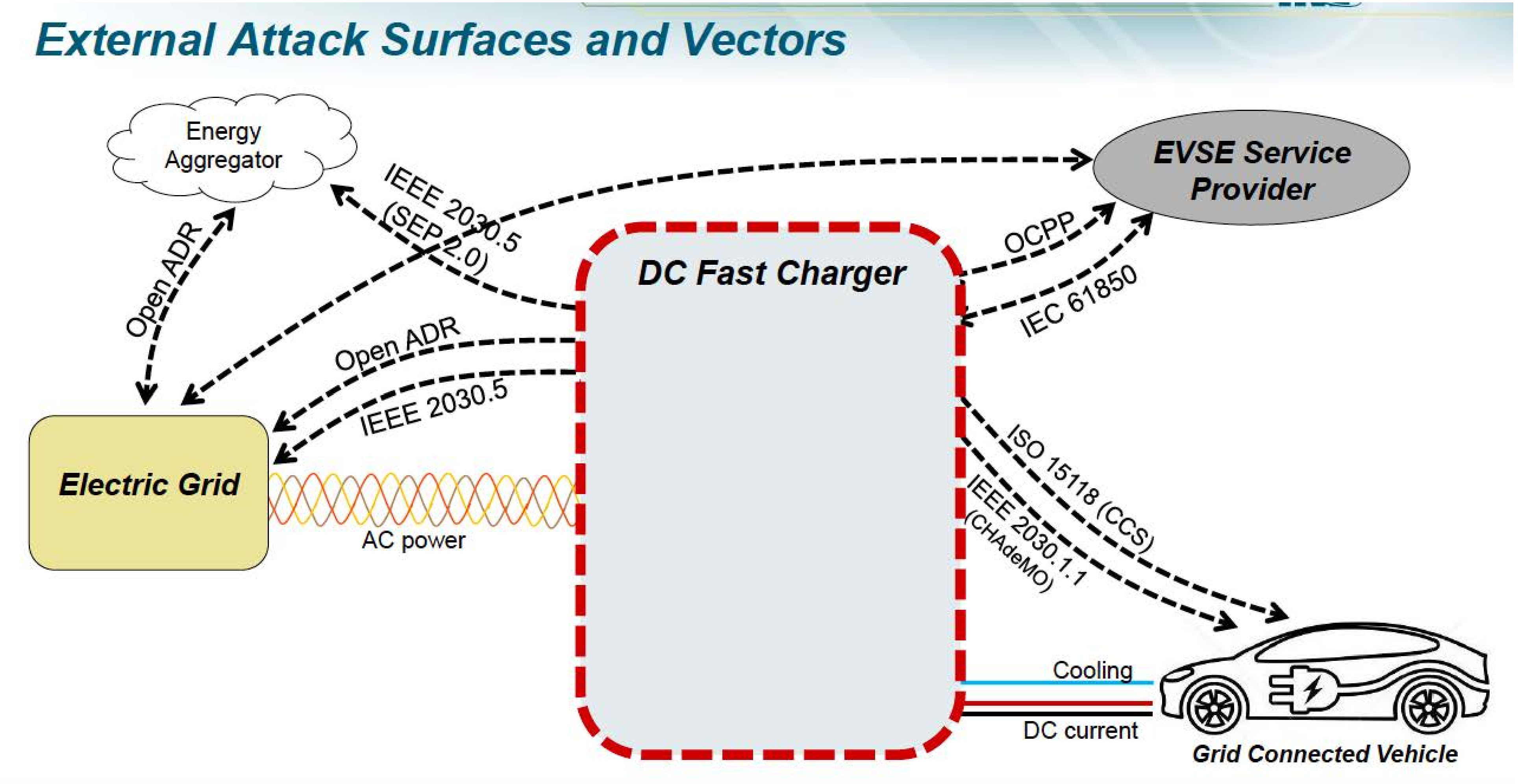
GRIDWORKS

Each entity's objectives and responsibilities drive needed tools, information flows and procedures

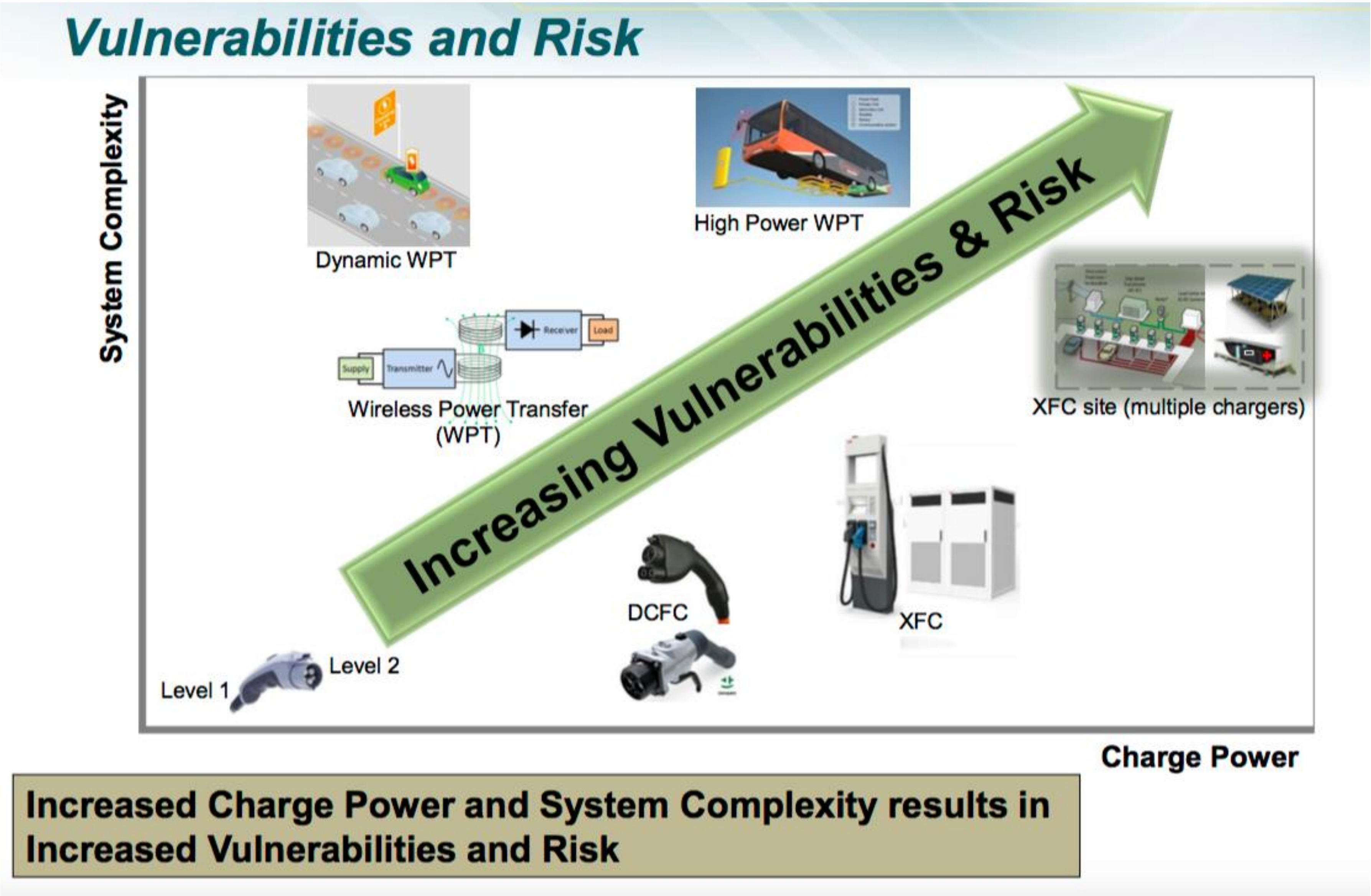
- ISO's primary DER concern is at the T-D interface or p-node
  - Predictability/confidence re DER responses to ISO dispatch instructions
  - Short-term forecasts of net interchange at each T-D interface
  - Long-term DER growth scenarios for transmission planning
- DO's concern starts with reliable distribution system operation
  - Visibility/predictability to current behavior of DER
  - Ability to modify behavior of DER via instructions or controls as needed to maintain reliable operation
  - Long-term DER growth scenarios for distribution planning
- DER provider/aggregator is concerned with business viability
  - Ability to participate, in a non-discriminatory manner, in all markets for which it has the required performance capabilities
  - Ability to optimize its choice of market opportunities and manage its risks of being curtailed for reasons beyond its control

https://pubs.naruc.org/pub/67F0F5A8-F49D-9E86-FD4D-EDDE825B007E

Cyber An Issue: EV Linkages & Vulnerabilities



More kW = Greater Risk



https://itd.idaho.gov/wp-content/autonomous/AV_Aug_2018_Presentation.pdf

Forecasting From A Bulk Power Perspective

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ONLINE LEARNING

The challenge of forecasting off such a low base

Light-Duty Personal EVs							
	CT	MA	ME	NH	RI	VT	NE
2022	17,001	6,201	3,262	3,269	2,332	3,370	35,435
2023	18,843	14,376	4,866	3,461	3,308	4,982	49,837
2024	20,961	38,430	8,259	3,685	4,331	8,776	84,442
2025	22,987	52,242	13,325	3,875	5,549	15,775	113,754
2026	29,365	59,101	18,299	5,165	7,559	21,465	140,954
2027	37,125	64,410	24,611	6,173	9,662	25,886	167,868
2028	44,636	69,735	32,571	7,115	11,895	27,189	193,140
2029	51,281	73,452	41,336	7,796	14,546	32,541	220,953
2030	62,014	75,403	51,368	8,964	17,246	33,285	248,280
2031	65,706	77,405	60,376	9,020	20,223	34,404	267,134
Total	**369,920**	**530,755**	**258,273**	**58,524**	**96,652**	**207,673**	**1,521,796**

https://www.iso-ne.com/static-assets/documents/2022/02/evf2022_forecast.pdf

With New Data, Significant YOY Forecast Variances

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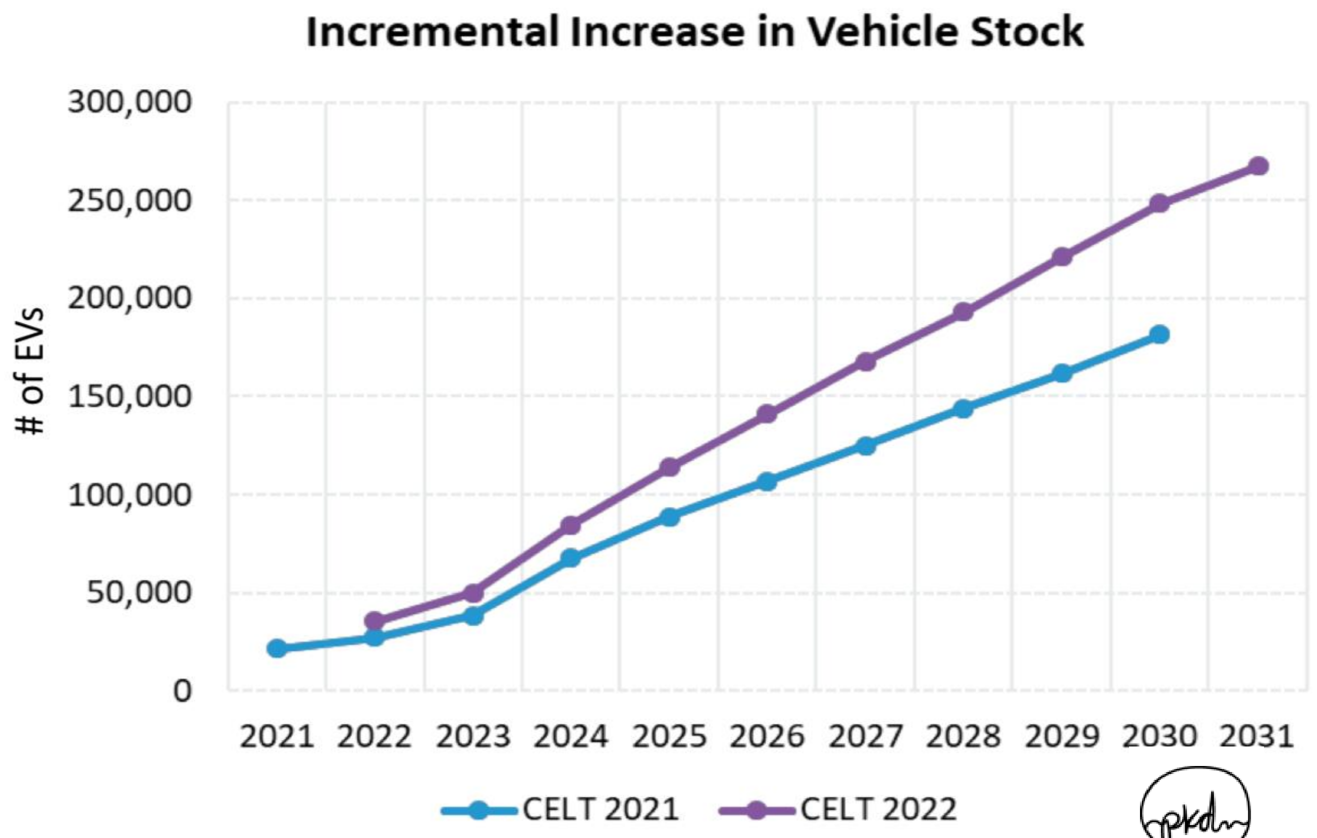
New England Light-Duty Personal EV Adoption Forecast

Comparison Between CELT 2021 and CELT 2022

Year	CELT 2021*	CELT 2022
2021	21,708	
2022	27,249	35,435
2023	38,594	49,837
2024	67,948	84,442
2025	88,797	113,754
2026	107,095	140,954
2027	124,891	167,868
2028	144,168	193,140
2029	161,861	220,953
2030	181,580	248,280
2031		267,134
10-year total	**963,891**	**1,521,796**



https://www.iso-ne.com/static-assets/documents/2022/02/evf2022_forecast.pdf

Hardly Enough Data to Go By

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Current Fleet Vehicle Stock in New England

As of March 31, 2021

	Light-duty Fleet Vehicles		Medium-duty Delivery Vehicles		School Buses		Transit Buses	
	All	Electric	All	Electric	All	Electric	All	Electric
CT	142,921	623	4,581	0	5,265	2	771	2
MA	337,296	1,915	9,476	8	9,668	7	1,763	25
ME	66,180	210	1,869	0	3,777	1	194	0
NH	98,716	379	2,047	0	3,571	0	143	0
RI	48,552	199	1,389	0	2,404	0	252	3
VT	30,020	219	833	0	1,780	6	118	2
Total	723,685	3,545	20,195	8	26,465	16	3,241	32

https://www.iso-ne.com/static-assets/documents/2022/02/evf2022_forecast.pdf

The Forecasts Will Likely Be Way Off

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Fleet EV Adoption Forecast					
Year	**LD Fleet**	**MD Delivery**	**School Buses**	**Transit Buses**	**Fleet Total**
2022	713	48	51	15	827
2023	1,071	69	84	22	1,246
2024	1,897	94	130	28	2,149
2025	2,549	133	186	34	2,902
2026	3,784	174	259	41	4,258
2027	5,162	231	374	54	5,821
2028	6,411	301	515	71	7,298
2029	7,885	368	674	85	9,012
2030	9,520	439	864	102	10,925
2031	11,214	499	1,012	115	12,840
Total	**50,206**	**2,356**	**4,149**	**567**	**57,278**

https://www.iso-ne.com/static-assets/documents/2022/02/evf2022_forecast.pdf

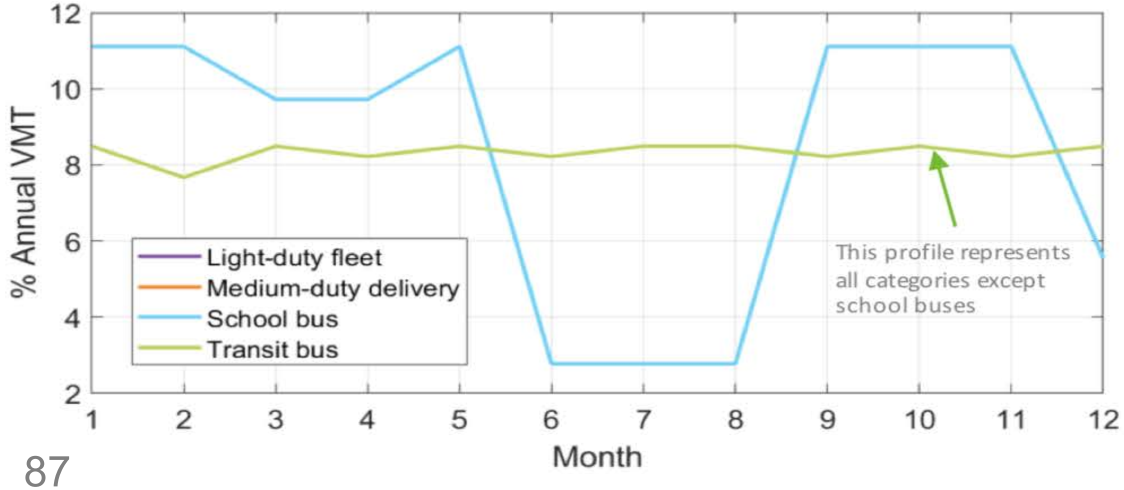
Other Variables to Consider

Vehicle Miles Traveled (VMT)

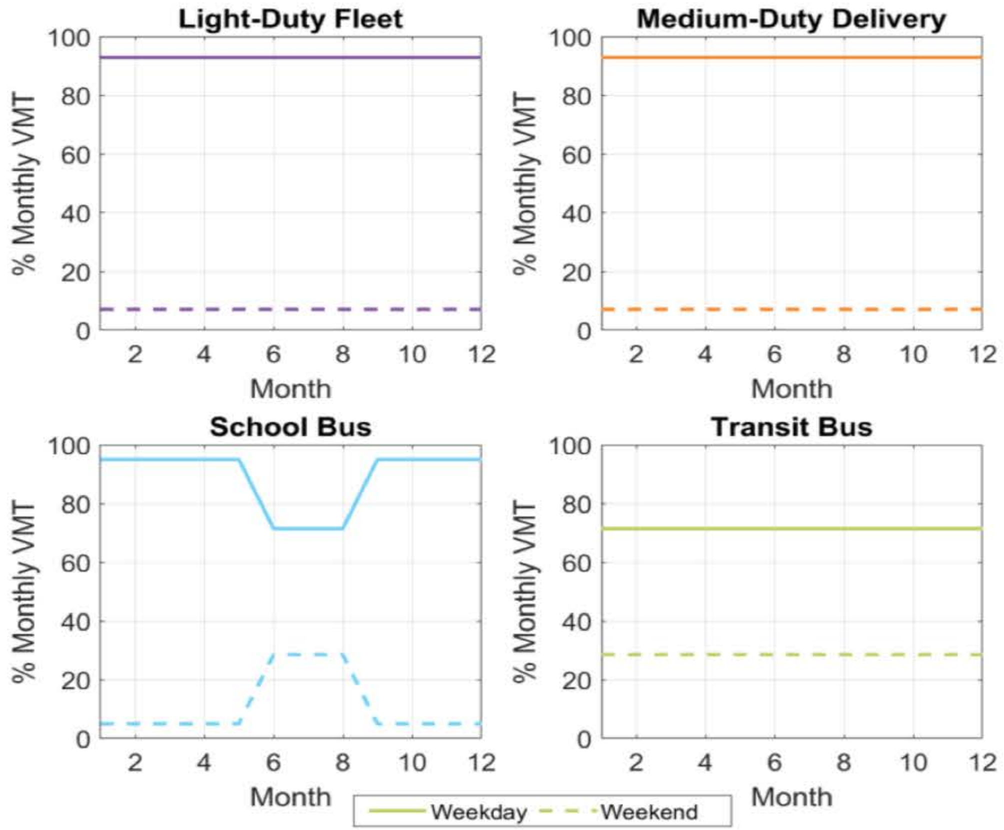
Annual VMT

Vehicle Category	Average Annual VMT
School bus	11,483
Transit bus	38,488
Medium-duty delivery	13,655
Light-duty fleet	21,258

Monthly VMT Allocation



Day-type VMT Allocation



https://www.iso-ne.com/static-assets/documents/2022/02/evf2022_forecast.pdf

Weather (Cabin Heating) Plays a Role in Affecting Efficiencies

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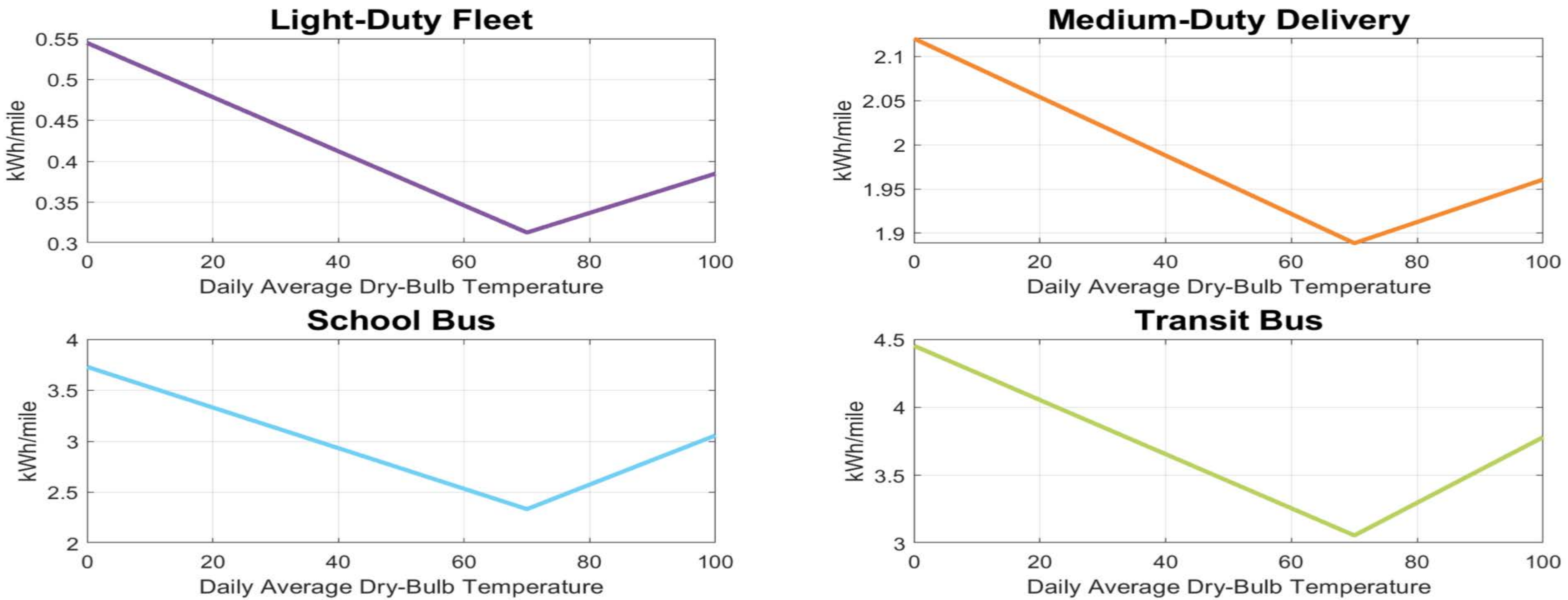
Electric Vehicle Efficiency

Energy Consumption as a Function of Daily Temperature



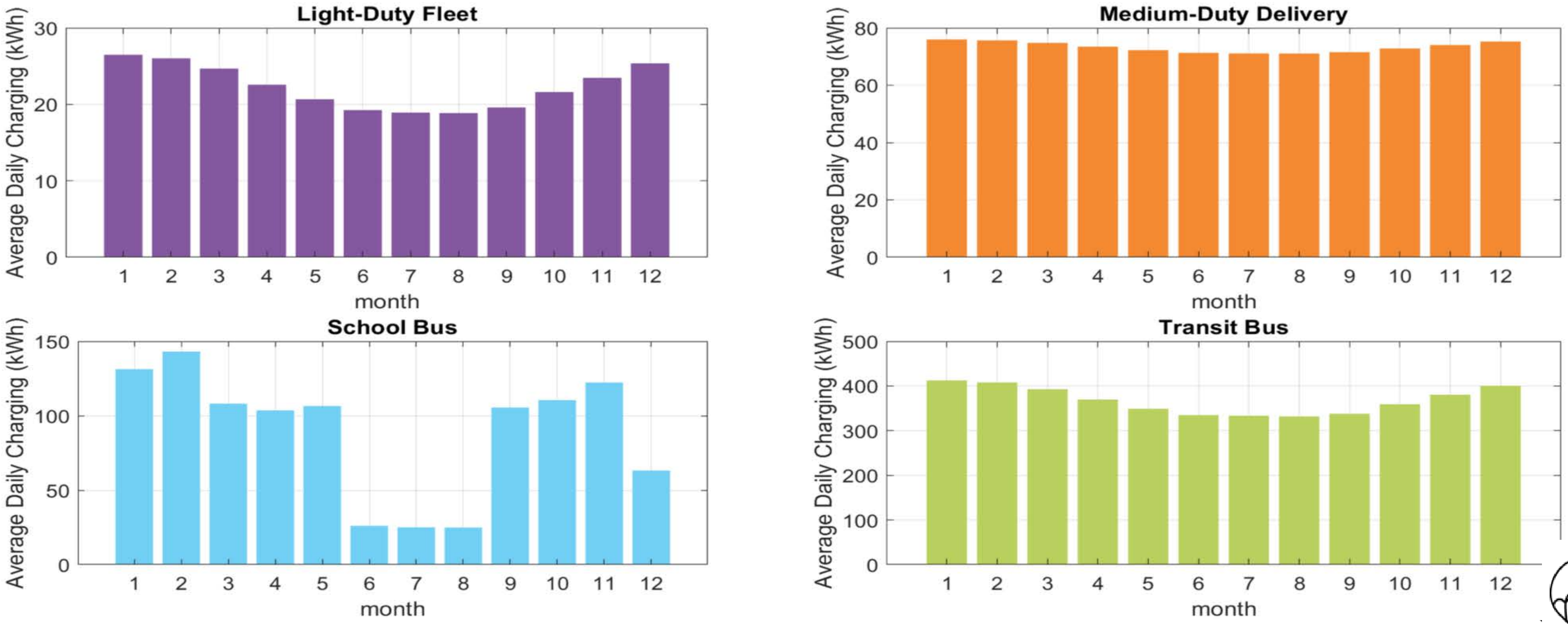
** School bus and transit bus efficiencies reflect an adjustment for the partial use of auxiliary cabin heating systems*

https://www.iso-ne.com/static-assets/documents/2022/02/evf2022_forecast.pdf

Estimated Energy Use May Be Highly Seasonal

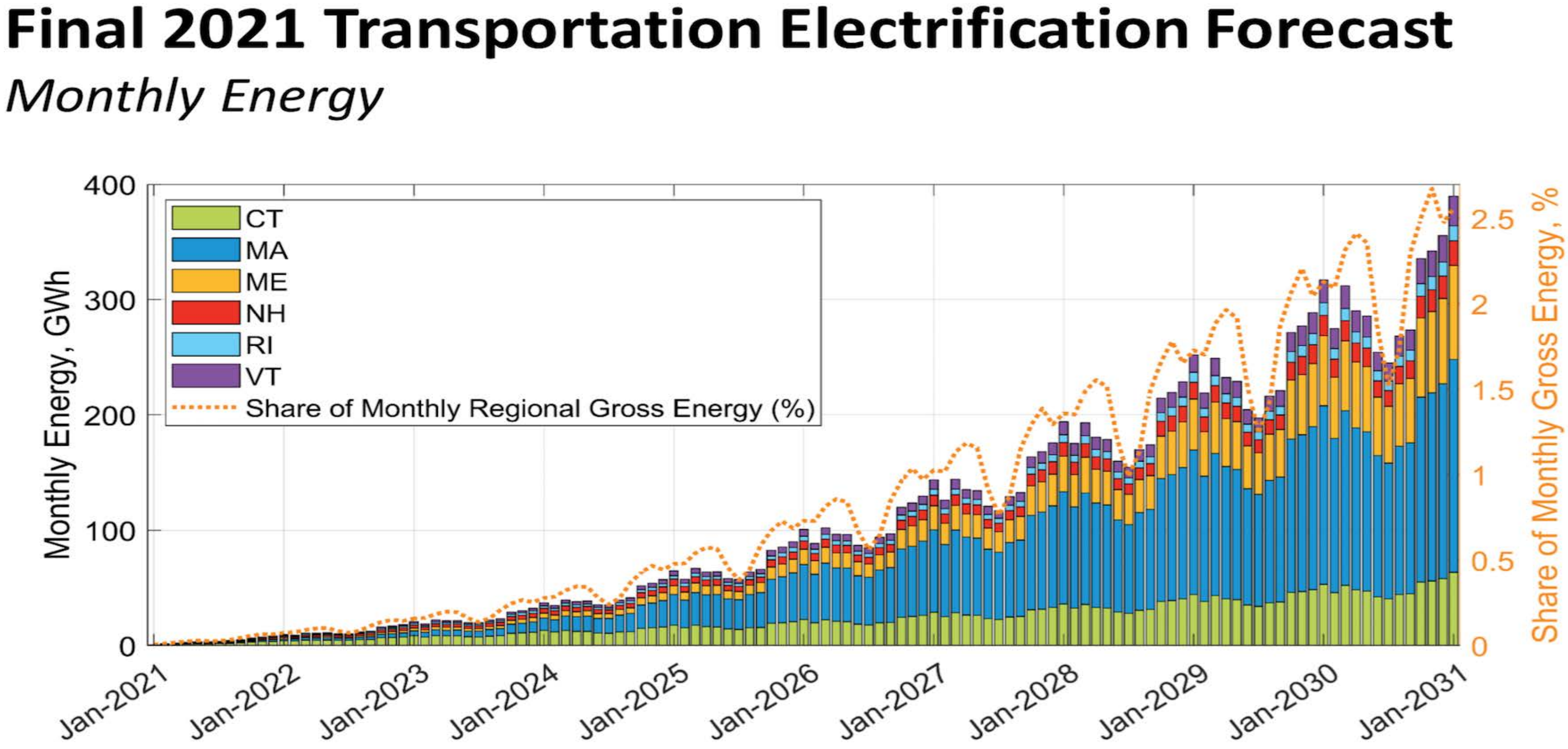
Estimating Energy Impacts of EV Adoption

Fleet EV Average Daily Energy – New England



https://www.iso-ne.com/static-assets/documents/2022/02/evf2022_forecast.pdf

The 2021 ISO-NE Forecast Was Fairly Significant…



https://www.iso-ne.com/static-assets/documents/2021/02/evf2021_forecast.pdf

And Then the 2022 Forecast Came Along

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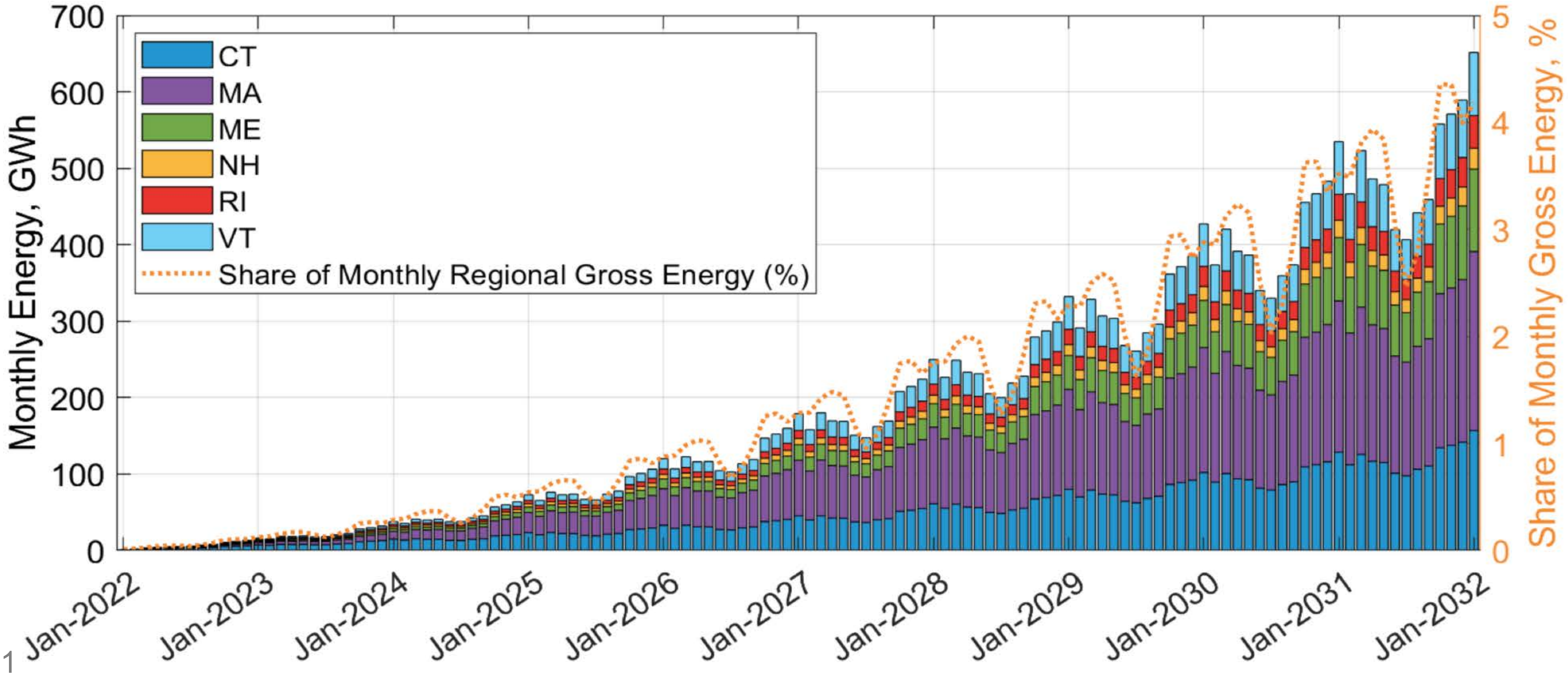
2022 Transportation Electrification Forecast

Monthly Energy



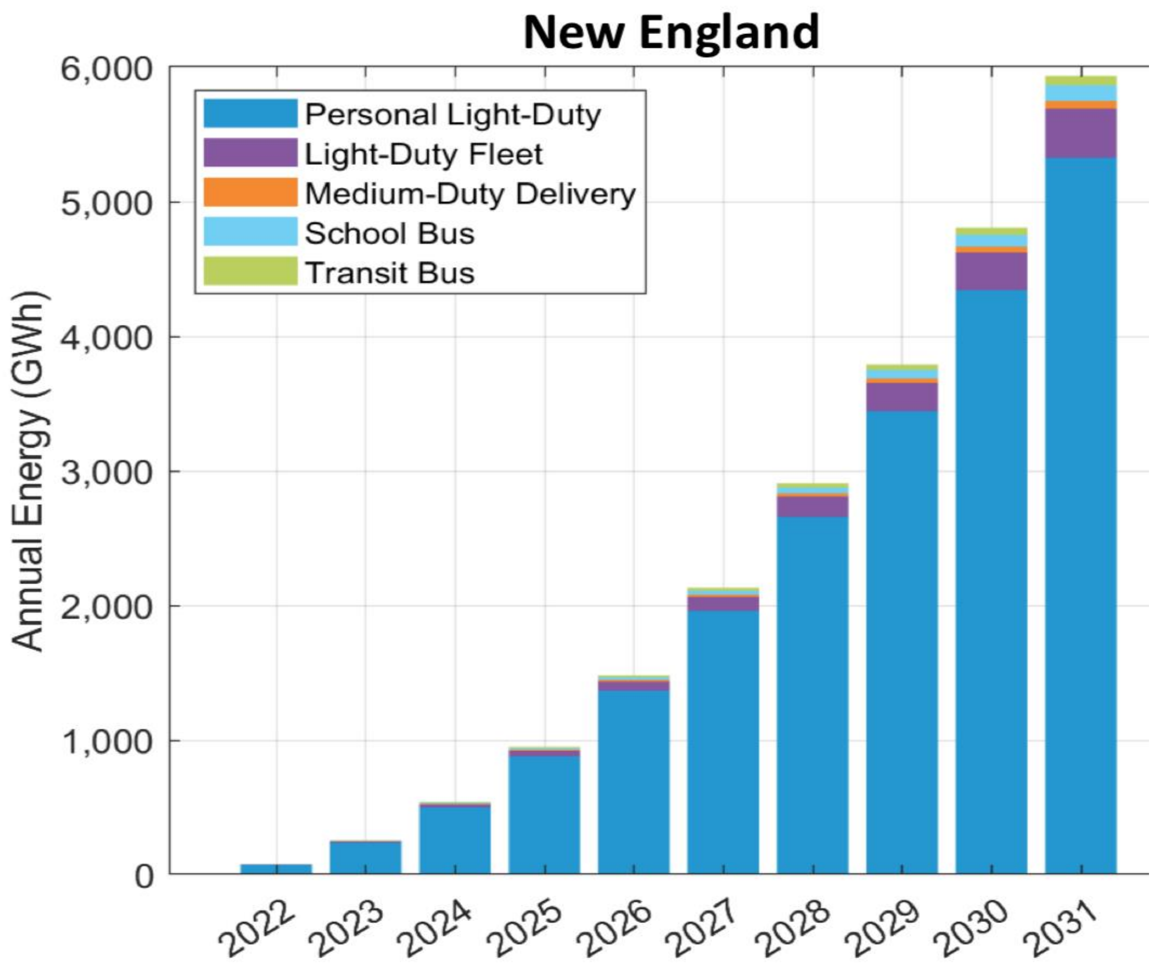
https://www.iso-ne.com/static-assets/documents/2022/02/evf2022_forecast.pdf

6,000 GWh by 2031

2022 Transportation Electrification Forecast

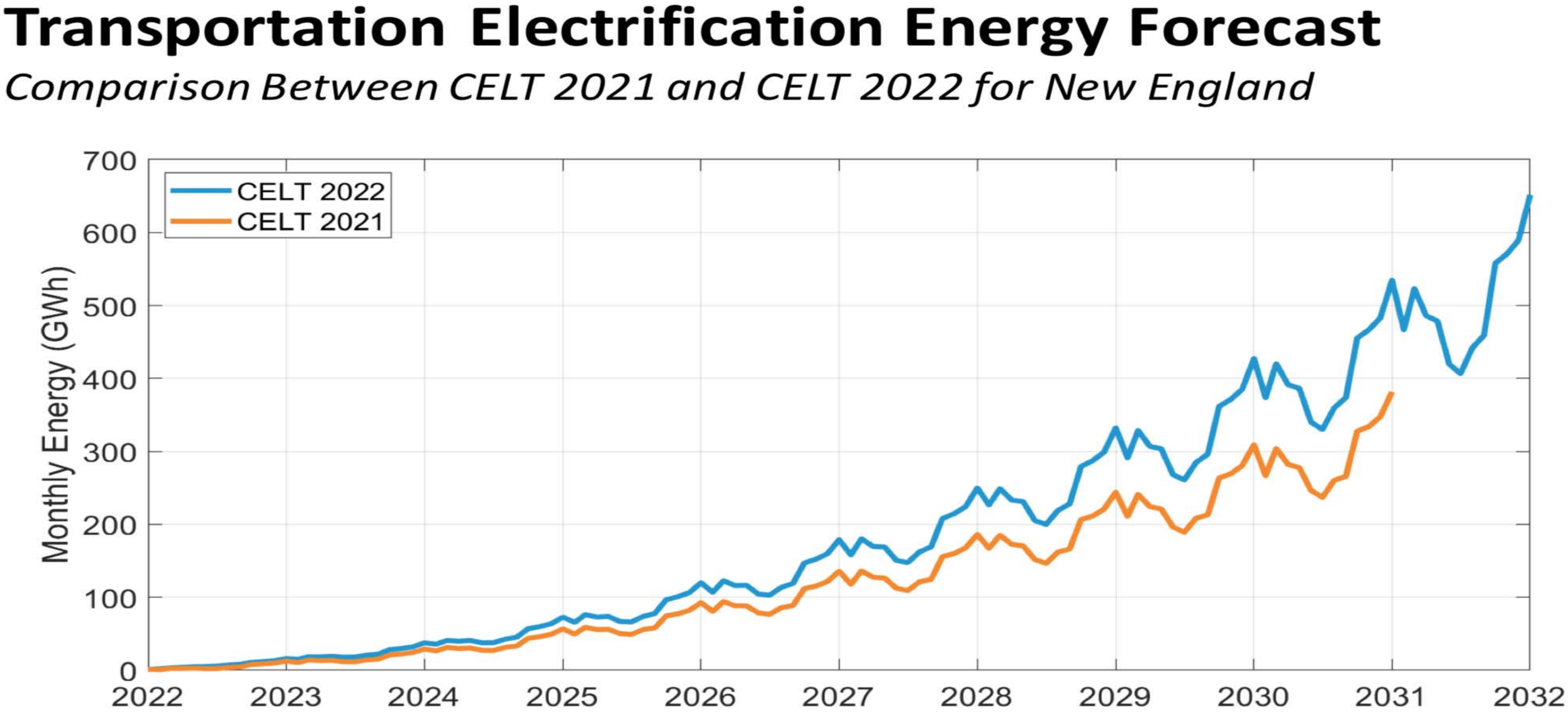
Annual Energy

Annual Energy (GWh)							
Year	CT	MA	ME	NH	RI	VT	NE
2022	36	15	7	7	6	7	78
2023	108	62	24	20	18	24	256
2024	189	176	51	35	35	52	539
2025	279	365	96	51	57	101	950
2026	389	598	161	71	87	175	1,481
2027	530	861	251	96	125	269	2,132
2028	706	1,156	372	127	173	375	2,908
2029	909	1,471	525	162	231	493	3,790
2030	1,152	1,810	718	203	300	624	4,807
2031	1,428	2,166	949	249	383	761	5,934



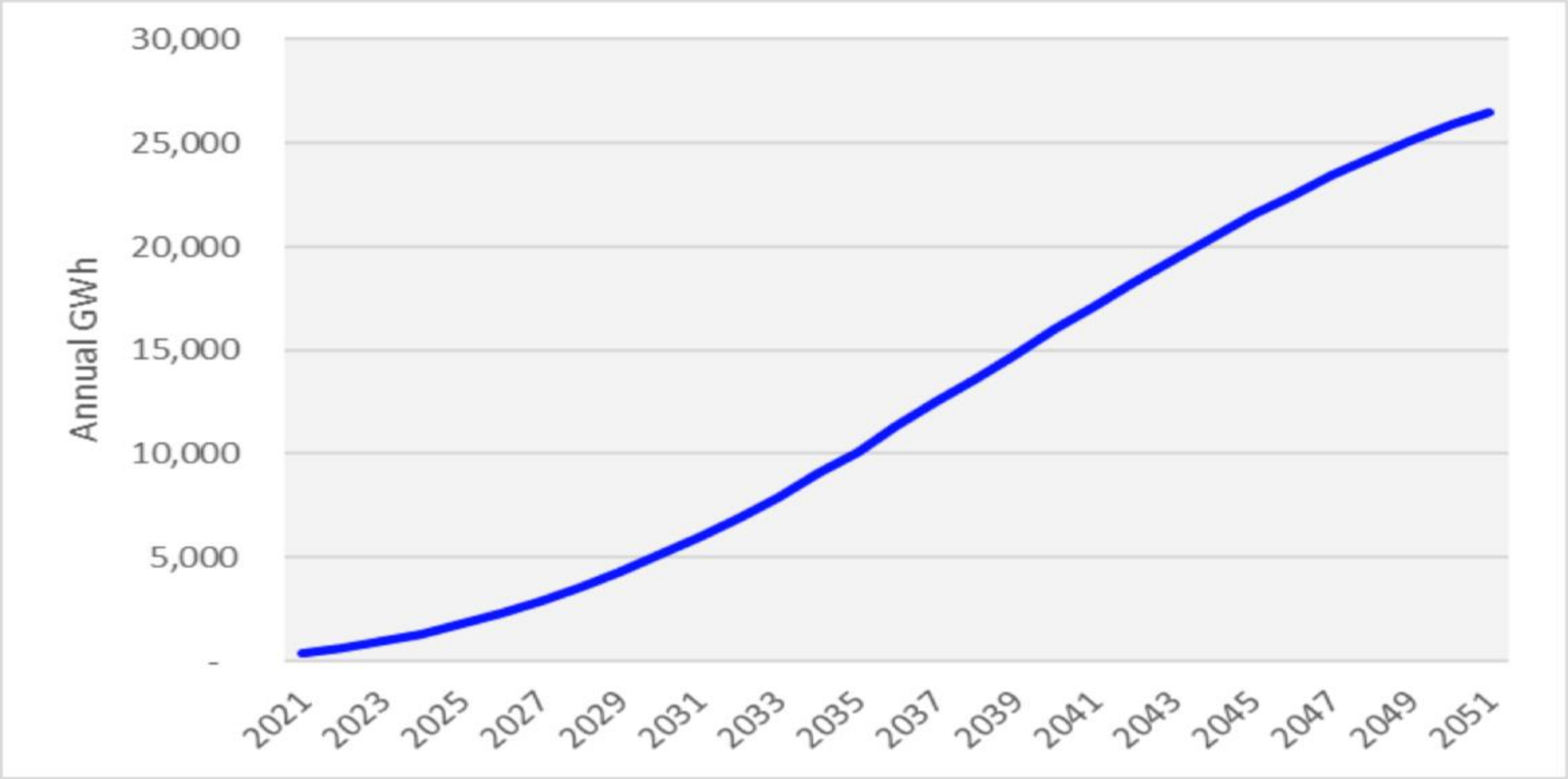
https://www.iso-ne.com/static-assets/documents/2022/02/evf2022_forecast.pdf

The Annual Forecast Delta is Unsettling



https://www.iso-ne.com/static-assets/documents/2022/02/evf2022_forecast.pdf

New York's Curve Looks Familiar



https://www.nyiso.com/documents/20142/19415353/04%202021%20GoldBook%20EVForecast.pdf/bc823f27-cbbd-669f-8d76-e695d59b9bed

As Does California’s

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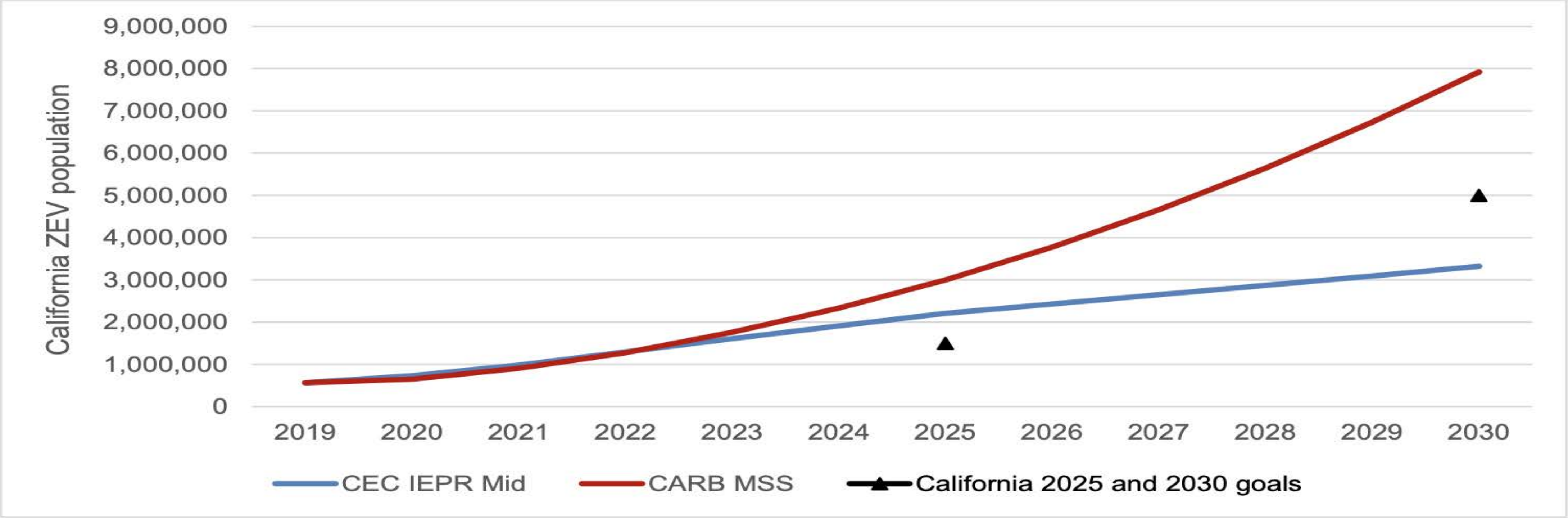
Figure 11: ZEV Adoption Trajectories



The CEC’s 2020 Transportation Energy Demand Forecast mid case forecast offers a scenario of ZEV adoption through 2030, with 2.2 million ZEVs in 2025 and 3.3 million in 2030. CARB’s *Draft 2020 Mobile Source Strategy* scenario shows the rate of ZEV adoption needed through 2030 to meet California’s climate and air quality goals. The black triangles show California’s 2025 and 2030 ZEV adoption goals, for reference.

Source: CEC and CARB staff

https://www.energy.ca.gov/programs-and-topics/programs/electric-vehicle-charging-infrastructure-assessment-ab-2127

By One Estimate, We'll Need $39 Bn for Public Charging By 2030

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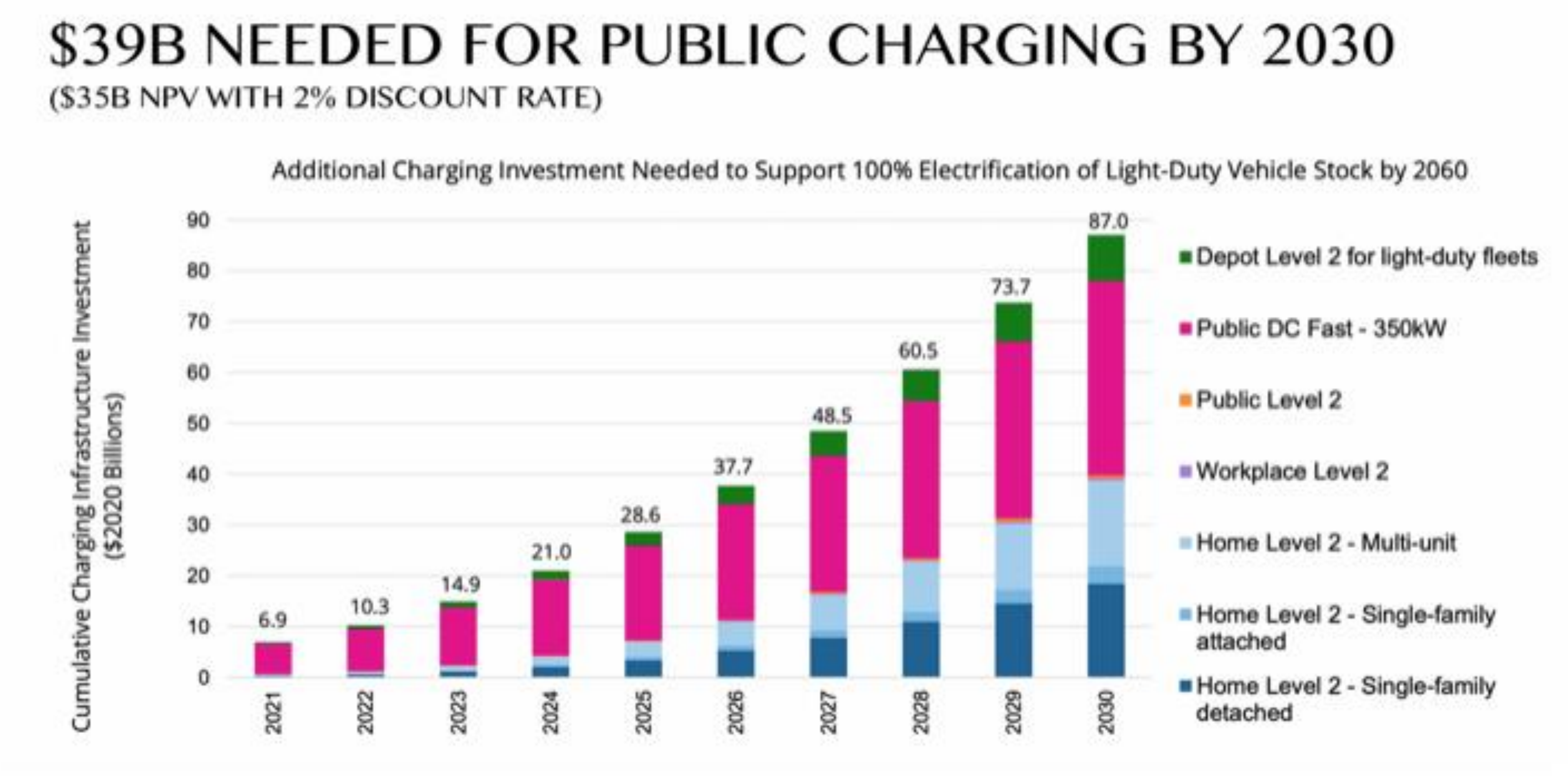

Image credit: Atlas Public Policy

https://www.canarymedia.com/articles/ev-charging/we-need-gargantuan-investment-in-ev-charging-stations

The Charging Infrastructure Challenge - Example of LADWP

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The city of Los Angeles, with 4 million people, has a plan calling for 80% of all light-duty passenger vehicle sales to be EVs by 2028.

In the past three years, LADWP has helped to increase the number of commercial charging stations in the city by over 7X, from 2,000 to 14,000 commercial charging stations, with about 2,700 of those publicly accessible.

In May, the California Energy Commission completed an assessment at the direction of state lawmakers to determine how the state is going to meet EV adoption targets. Los Angeles has about 10% of the state's vehicles, meaning the city needs about 120,000 commercial chargers by 2030.

As Many as 4 Million Public Chargers May Be Needed

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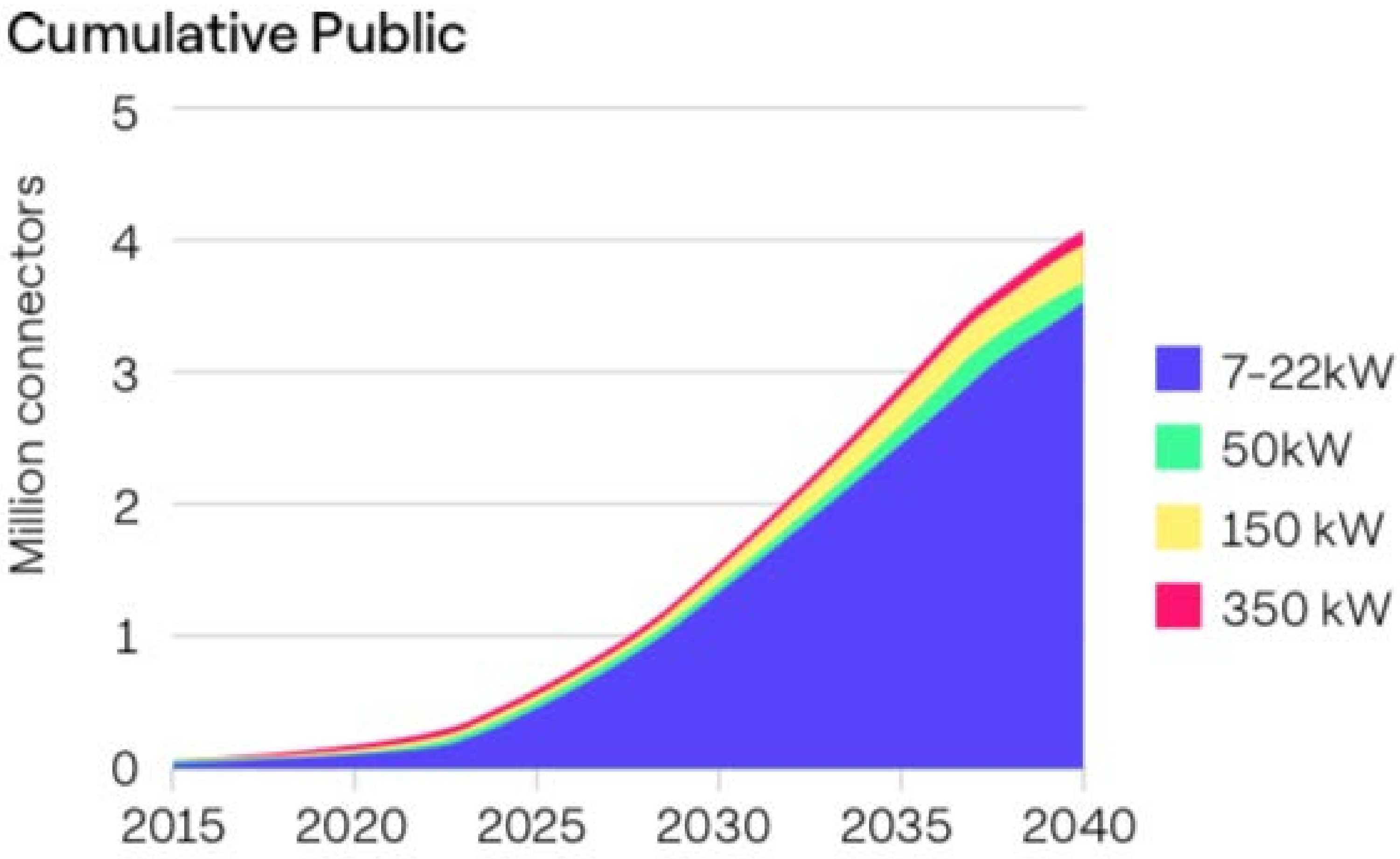

https://www.enelx.com/n-a/en/resources/ebooks-white-papers/fulfill/2022-energy-market-outlook

Challenges - Potential Stress on Low-Voltage Distribution Infrastructure

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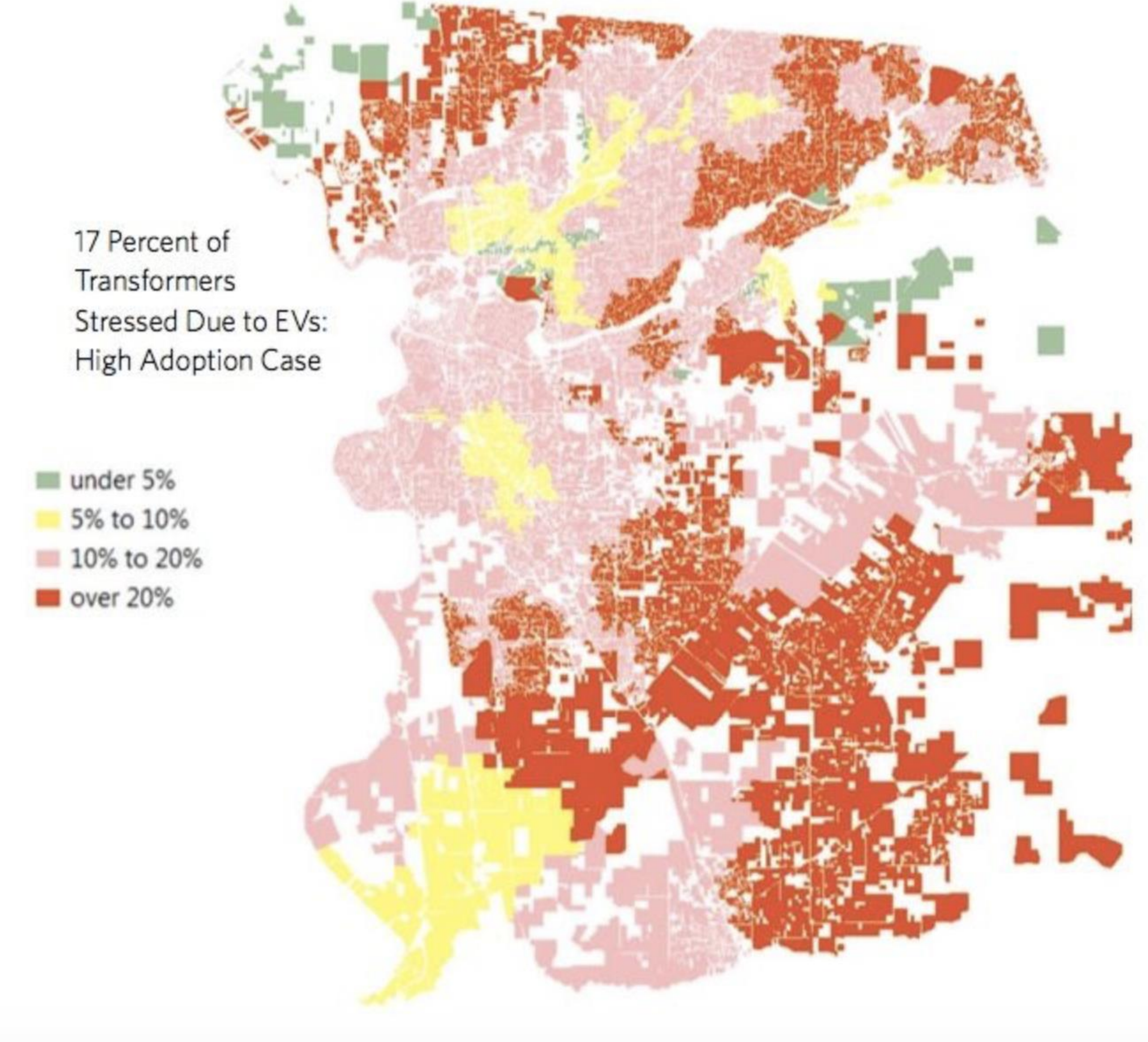

https://www.greentechmedia.com/articles/read/sacramentos-use-of-distributed-energy-and-customer-data-is-groundbreaking

There Are Also Increasing Equity Issues

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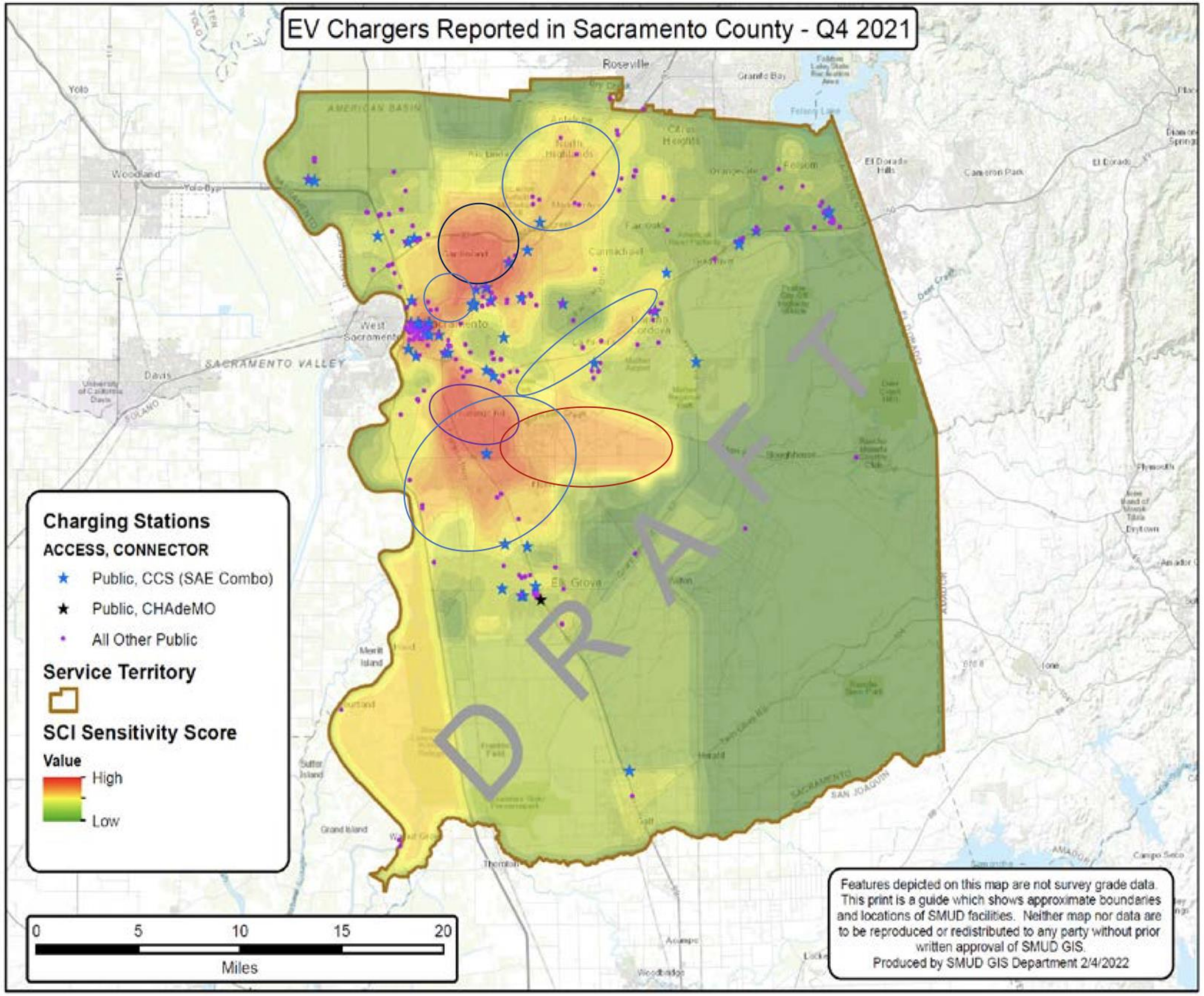

https://www.valleyvision.org/wp-content/uploads/4-Agency-Basic-Deck.pdf

Example of Hosting Capacity Map

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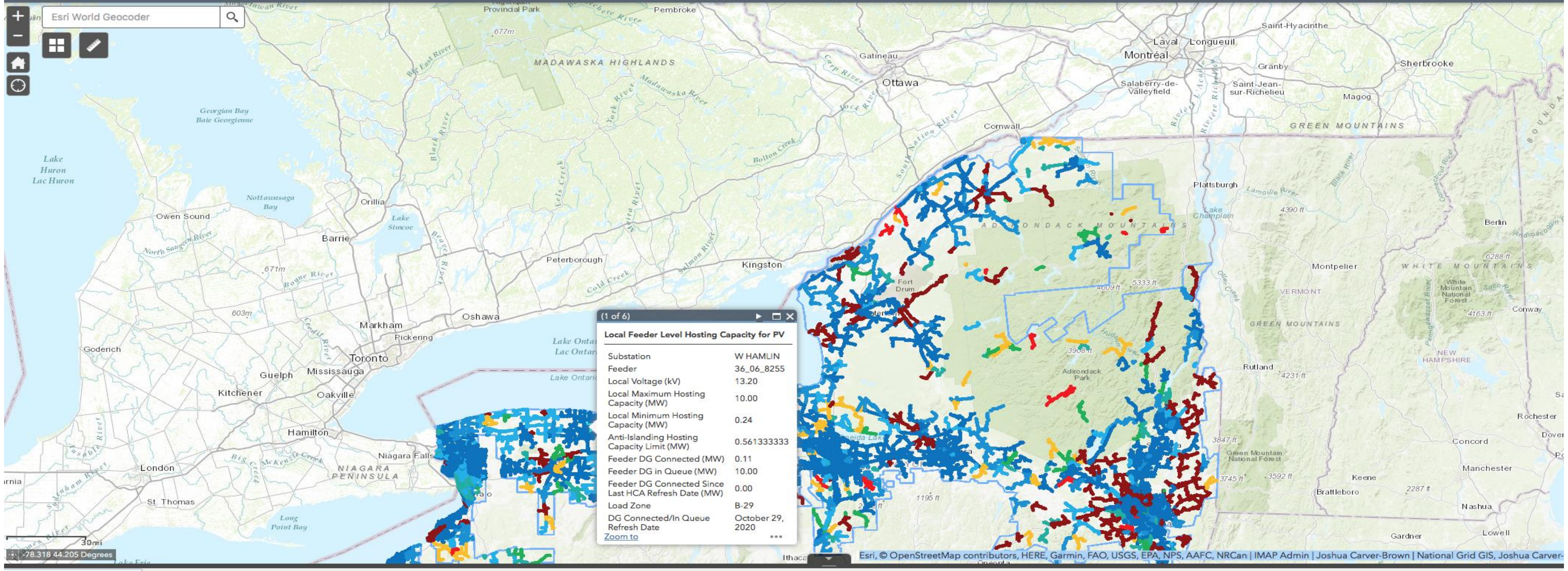
National Grid New York System Data Portal

A story map

Introduction | Company Reports | Distribution Assets Overview | Hosting Capacity | EV Load-Serving Capacity | NWA | LSRV/VDER

Hosting Capacity



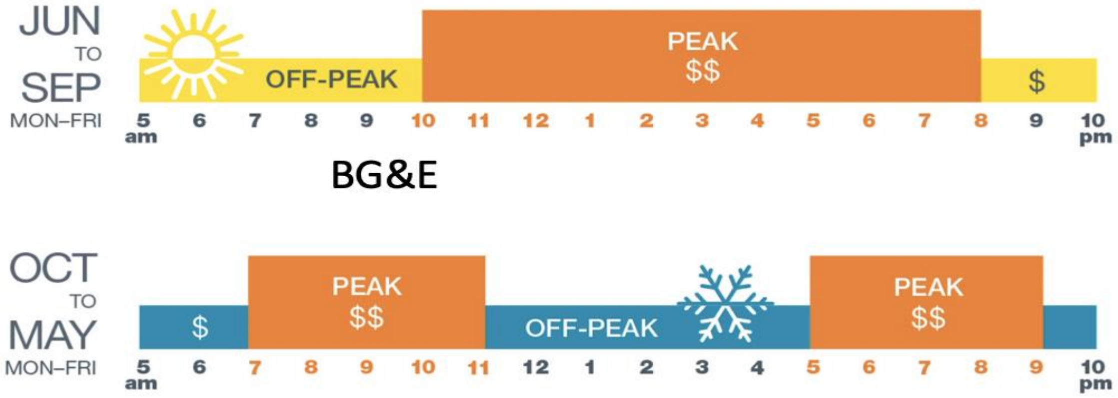
Feeder Level Data 3 Phase (MW) | Substation Level Data 3 Phase (MW)

Options | Filter by Map Extent | Zoom to | Clear Selection | Refresh

Feeder	Local Voltage (kV)	Local Maximum Hosting Capacity (MW)	Local Minimum Hosting Capacity (MW)	Anti-Islanding Hosting Capacity Limit (MW)	Feeder DG Connected (MW)	Feeder DG in Queue (MW)	Feeder DG Connected Since Last HCA Refresh Date (MW	Load Zone	DG Connected/In Queue Refresh Date	HCA Refresh Date	Notes:
36_01_4171	4.16	0.80	0.70	0.208133333	0.00	0.00	0.00	A-1	October 29, 2020	September 30, 2020	None
36_01_4171	4.16	1.40	1.40	0.208133333	0.00	0.00	0.00	A-1	October 29, 2020	September 30, 2020	None
36_01_4171	4.16	1.80	1.50	0.208133333	0.00	0.00	0.00	A-1	October 29, 2020	September 30, 2020	None
36_01_4171	4.16	1.40	1.30	0.208133333	0.00	0.00	0.00	A-1	October 29, 2020	September 30, 2020	None
36_01_4171	4.16	1.30	1.30	0.208133333	0.00	0.00	0.00	A-1	October 29, 2020	September 30, 2020	None
36_01_4172	4.16	1.30	1.30	0.144106667	0.00	0.00	0.00	A-1	October 29, 2020	September 30, 2020	None
36_01_4172	4.16	0.40	0.40	0.144106667	0.00	0.00	0.00	A-1	October 29, 2020	September 30, 2020	None
36_01_4172	4.16	1.20	1.00	0.144106667	0.00	0.00	0.00	A-1	October 29, 2020	September 30, 2020	None
36_01_4172	4.16	1.30	1.20	0.144106667	0.00	0.00	0.00	A-1	October 29, 2020	September 30, 2020	None
36_01_4172	4.16	1.75	1.50	0.144106667	0.00	0.00	0.00	A-1	October 29, 2020	September 30, 2020	None

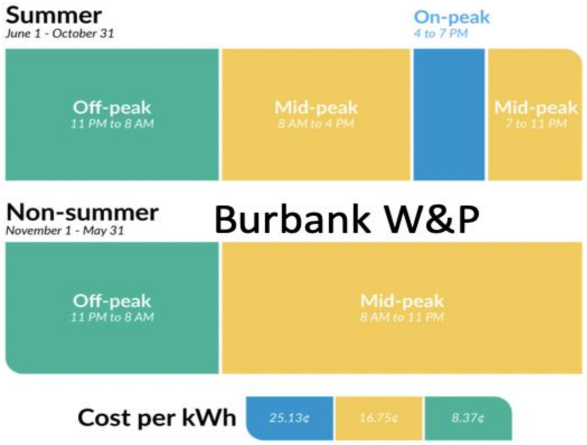
https://ngrid.portal.esri.com/SystemDataPortal/NY/index.html

Getting the Rates Right Will Matter a Great Deal



TIME OF USE (TOU) RATE FOR ELECTRIC VEHICLE (EV) OWNERS

With TOU, your usage is billed at a rate that varies based on the time of day and the season. This rate promotes shifting usage when renewables (sun, wind) are plentiful or when the overall demand for energy is lower.



Timing Will Be Important (and Different by Region)

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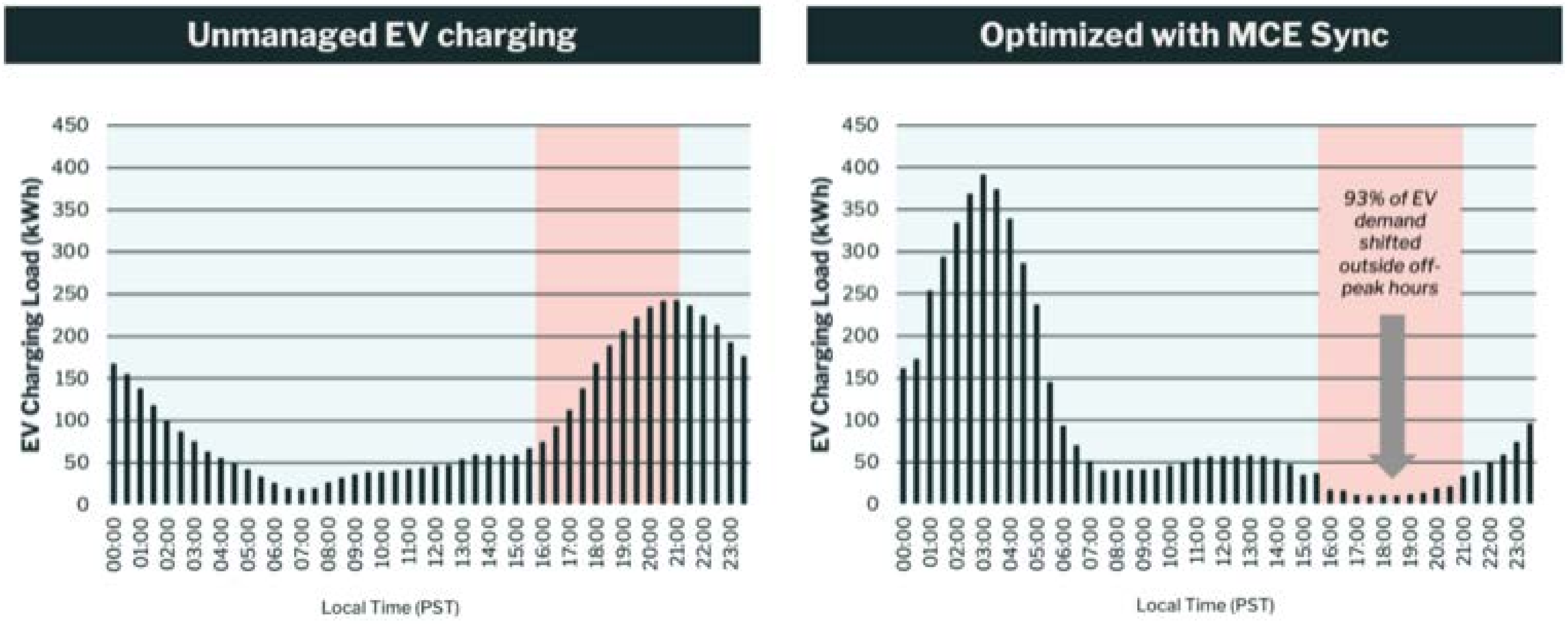

https://cacurrent.com/marin-clean-energy-expands-ev-charging-pilot-to-curb-peak-demand/

It’s Critical to Get This Right

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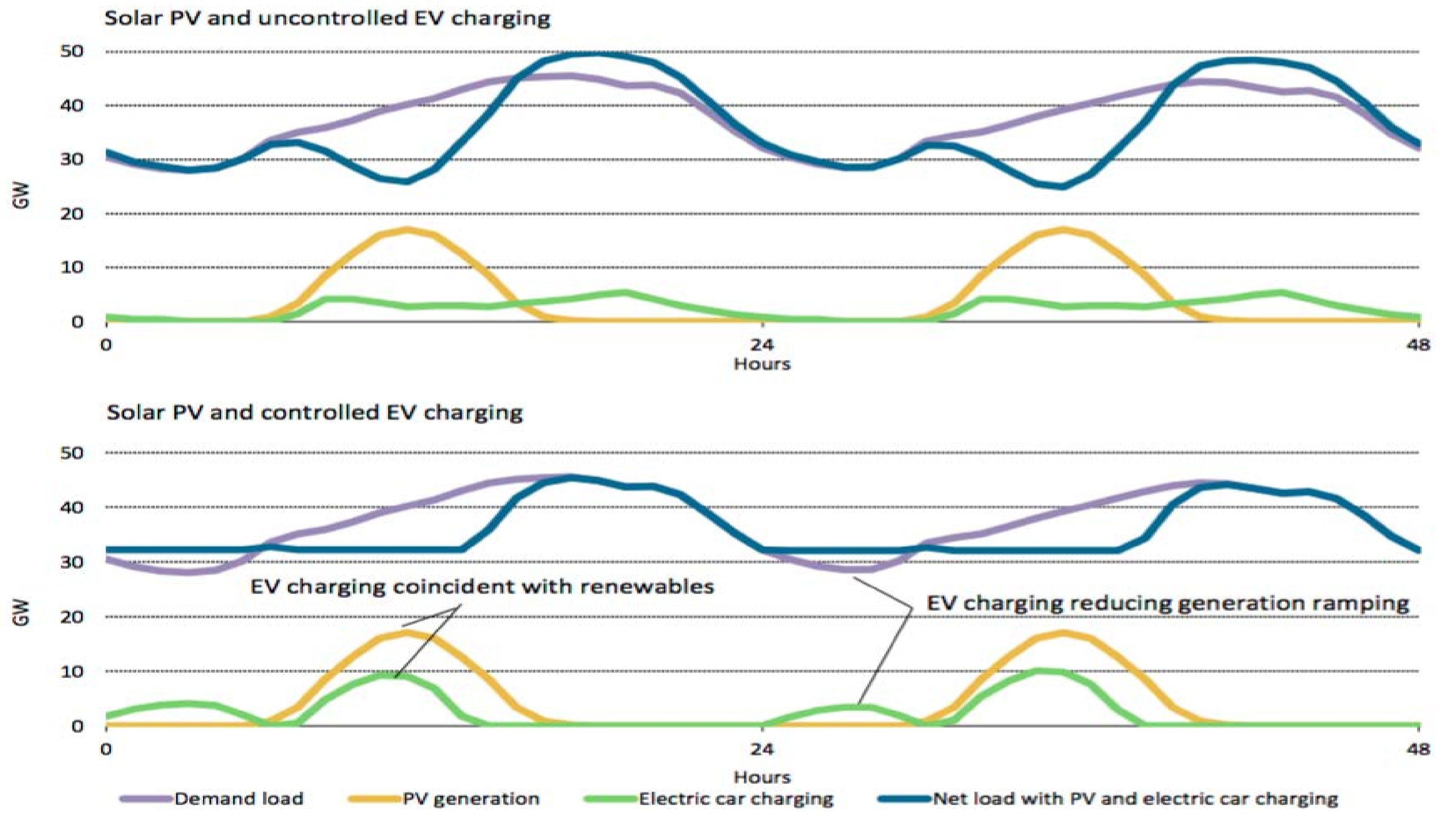
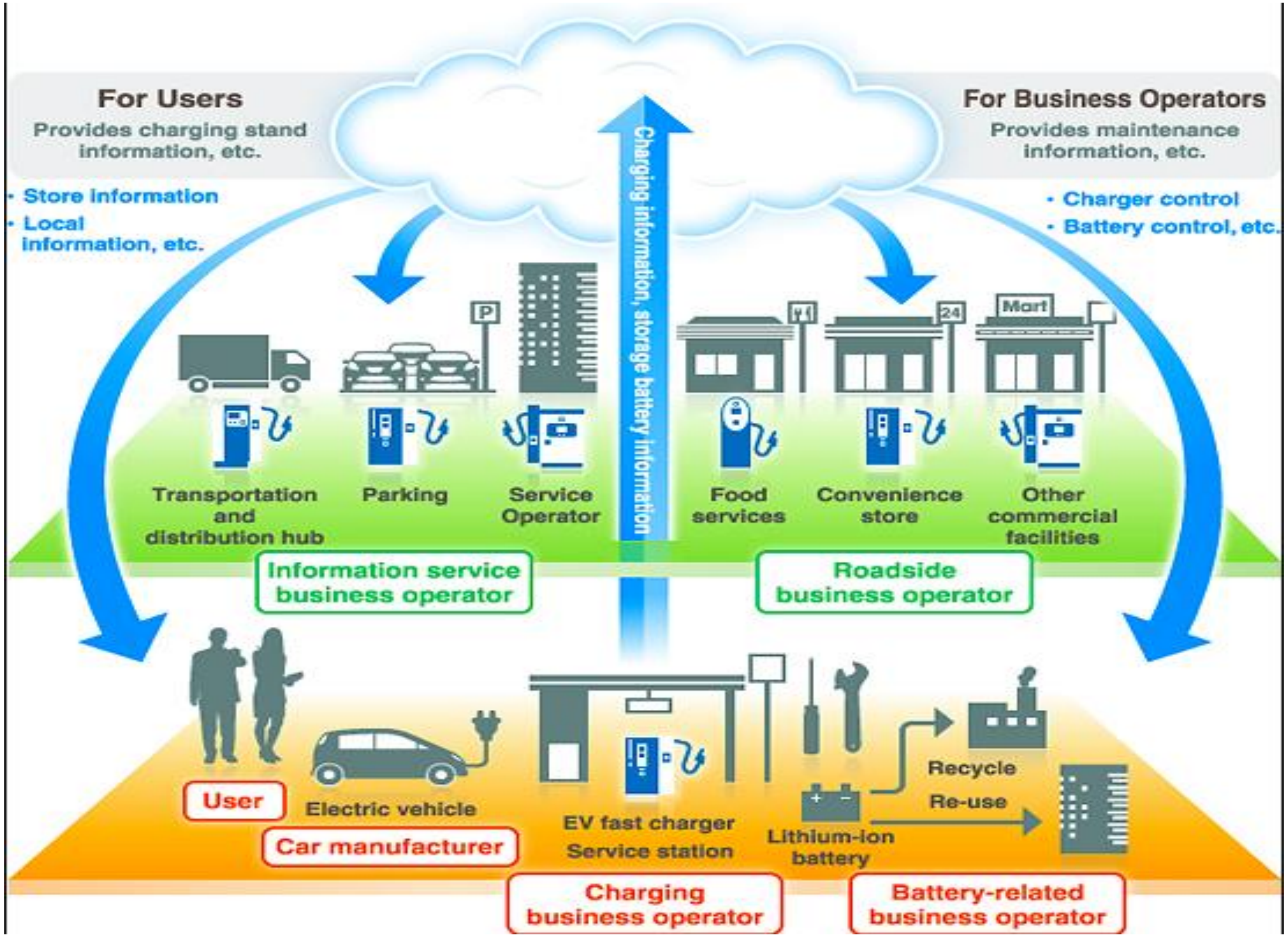


Sources: IEA (2017b).

Key point: In a scenario with high electric car market penetration, unmanaged charging could result in a sizeable increase (over 30%) in peak power draw.

https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf

Smart Charging: Early Stage and Mostly Uni-Directional



Managed Charging As a DR Resource

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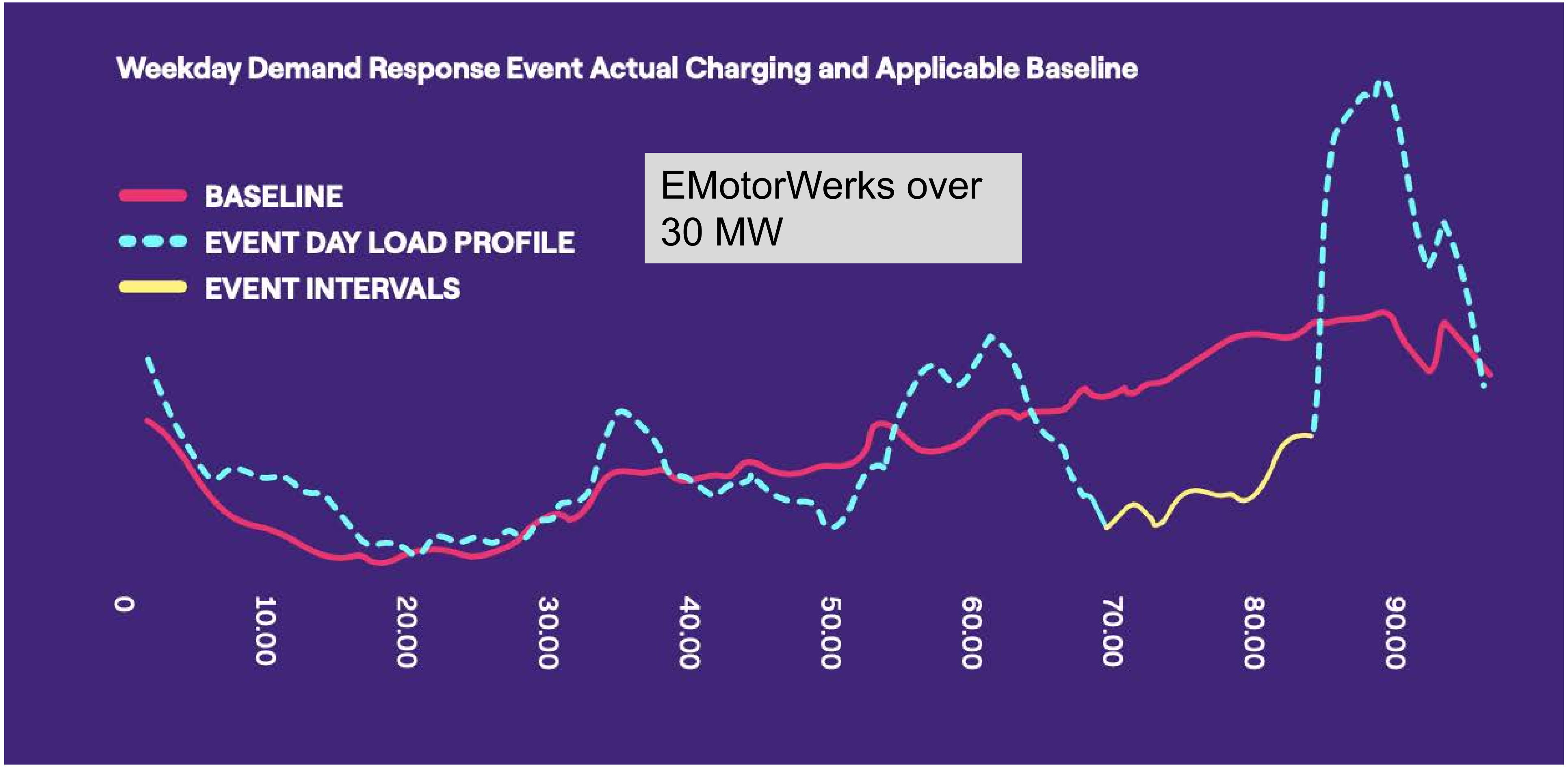

EMotorWerks over 30 MW

Enel X 2022 Smart-EV-Load-Management-eBook.pdf

Vehicles Can Do This Already

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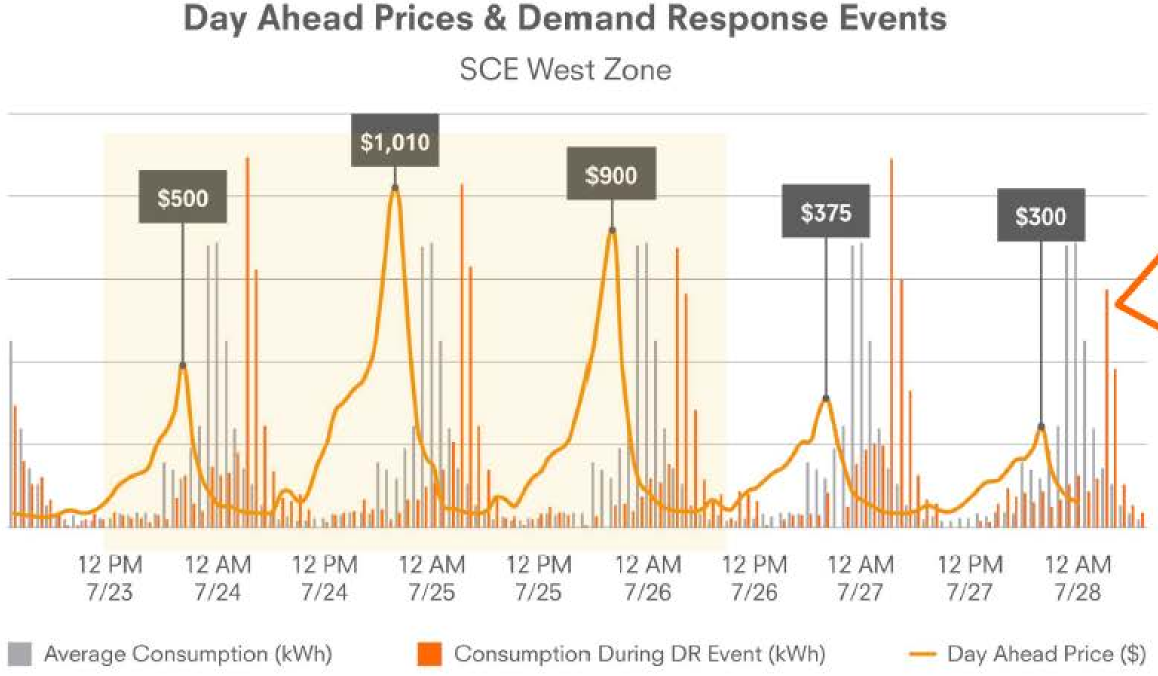
Day Ahead Prices & Demand Response Events

eMotorWerks
An Enel Group Company



Data based on five-day period, July 2018

- 3 CAISO Flex Alert Days, plus No Maintenance Days
- Day Ahead prices @ Price Cap
- All eMotorWerks' CAISO Resources dispatched for multiple hours
- Dispatched EVSE network to shift demand to lowest cost intervals

https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=18-MISC-04 - David Scholsberg comments

Migrate from Open ADR…

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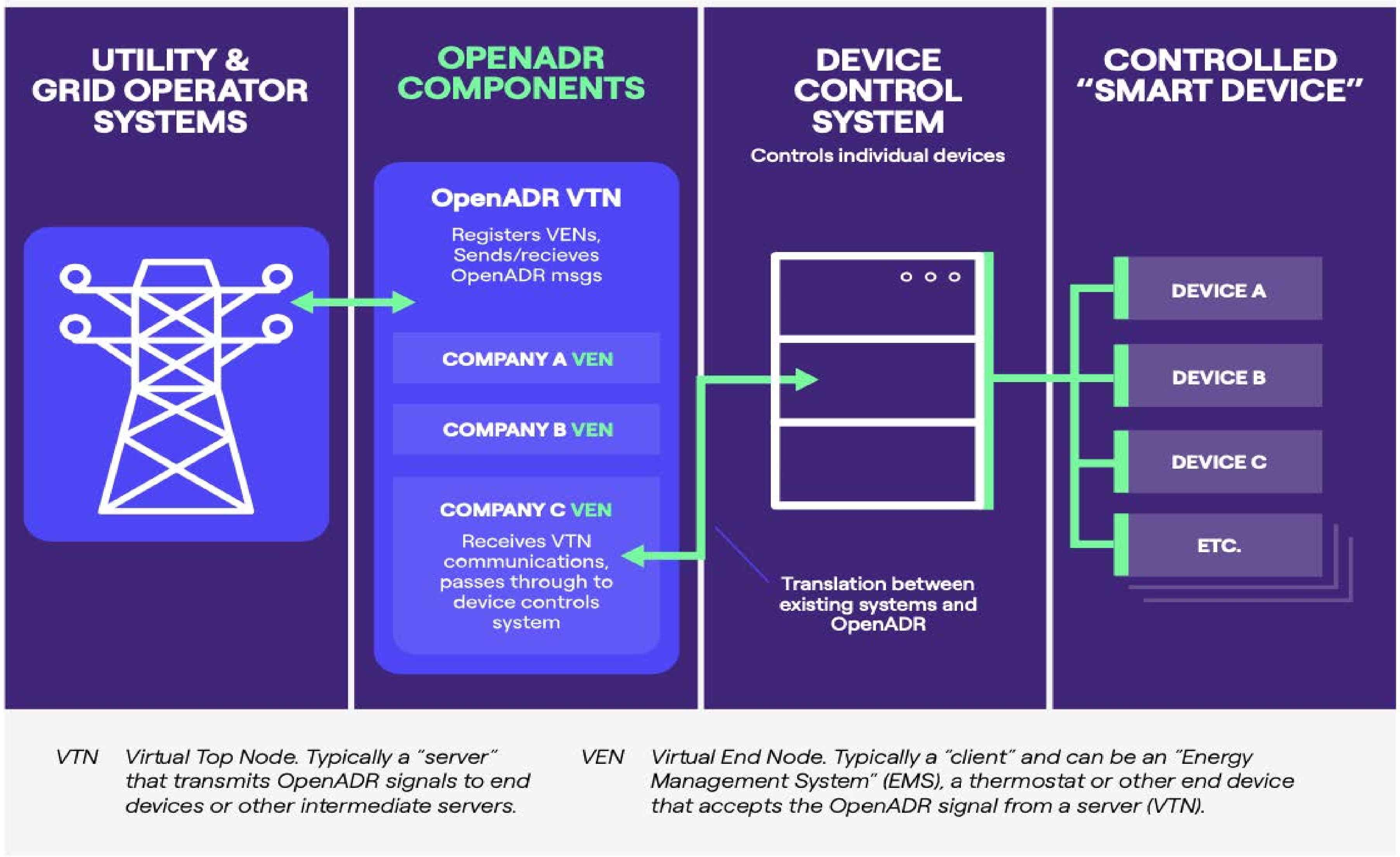
Components of a Typical OpenADR Load Shifting Program



[Enel X 2022 Smart-EV-Load-Management-eBook.pdf](#)

…To Open VGI

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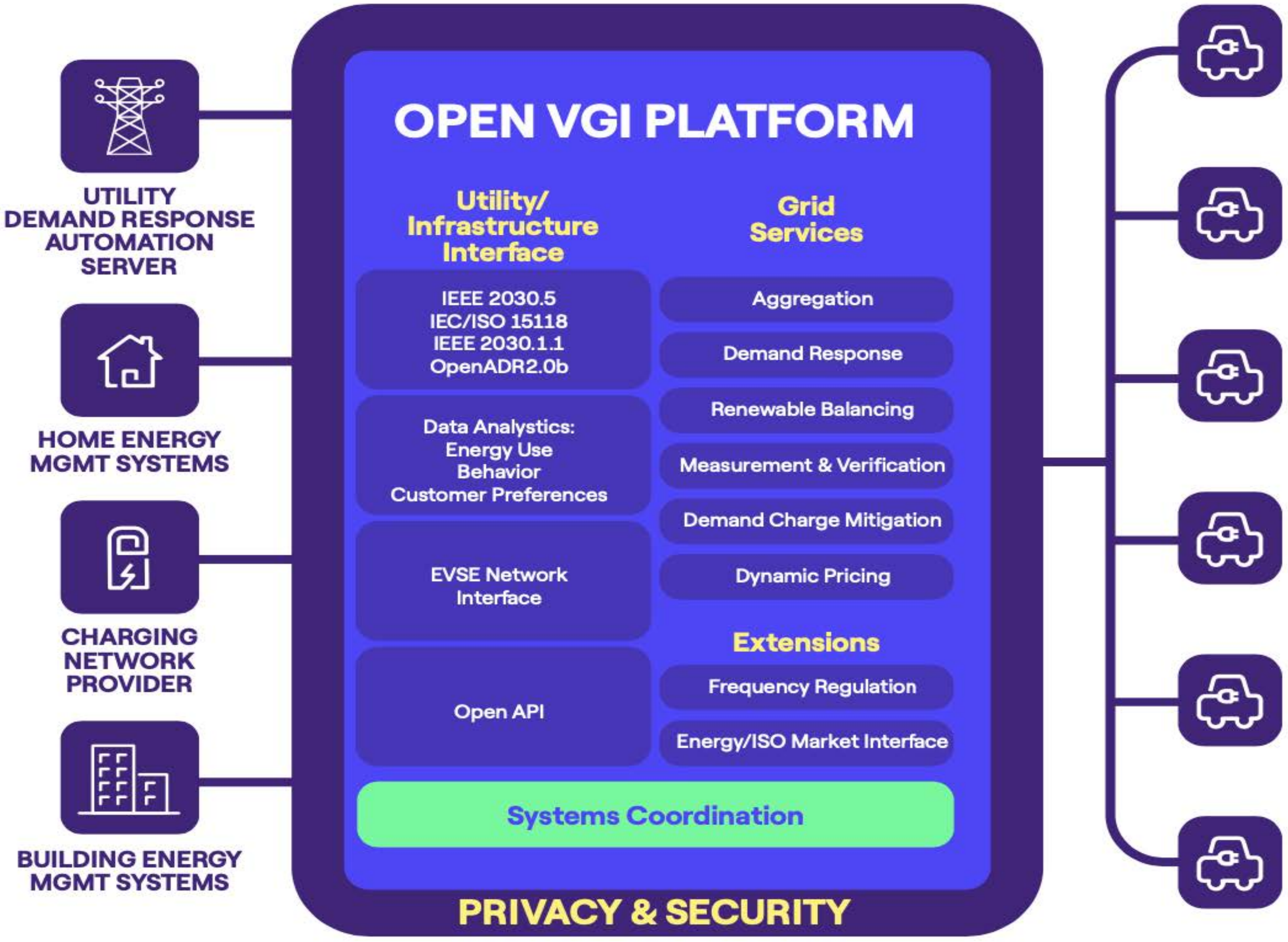
Open VGI Platform (OVGIP)



Enel X 2022 Smart-EV-Load-Management-eBook.pdf

The Vehicle Resource Potential Dwarfs Other Assets

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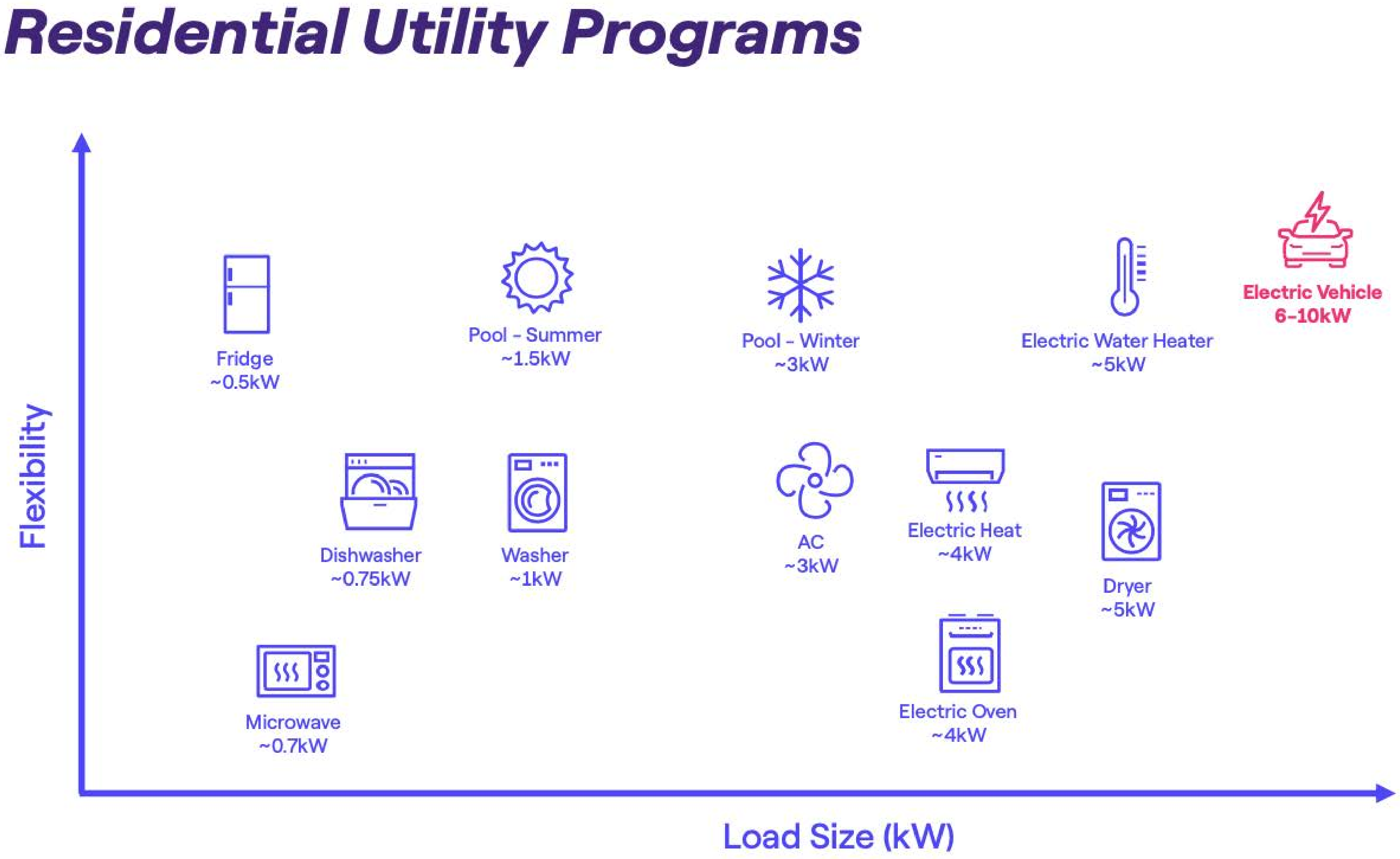

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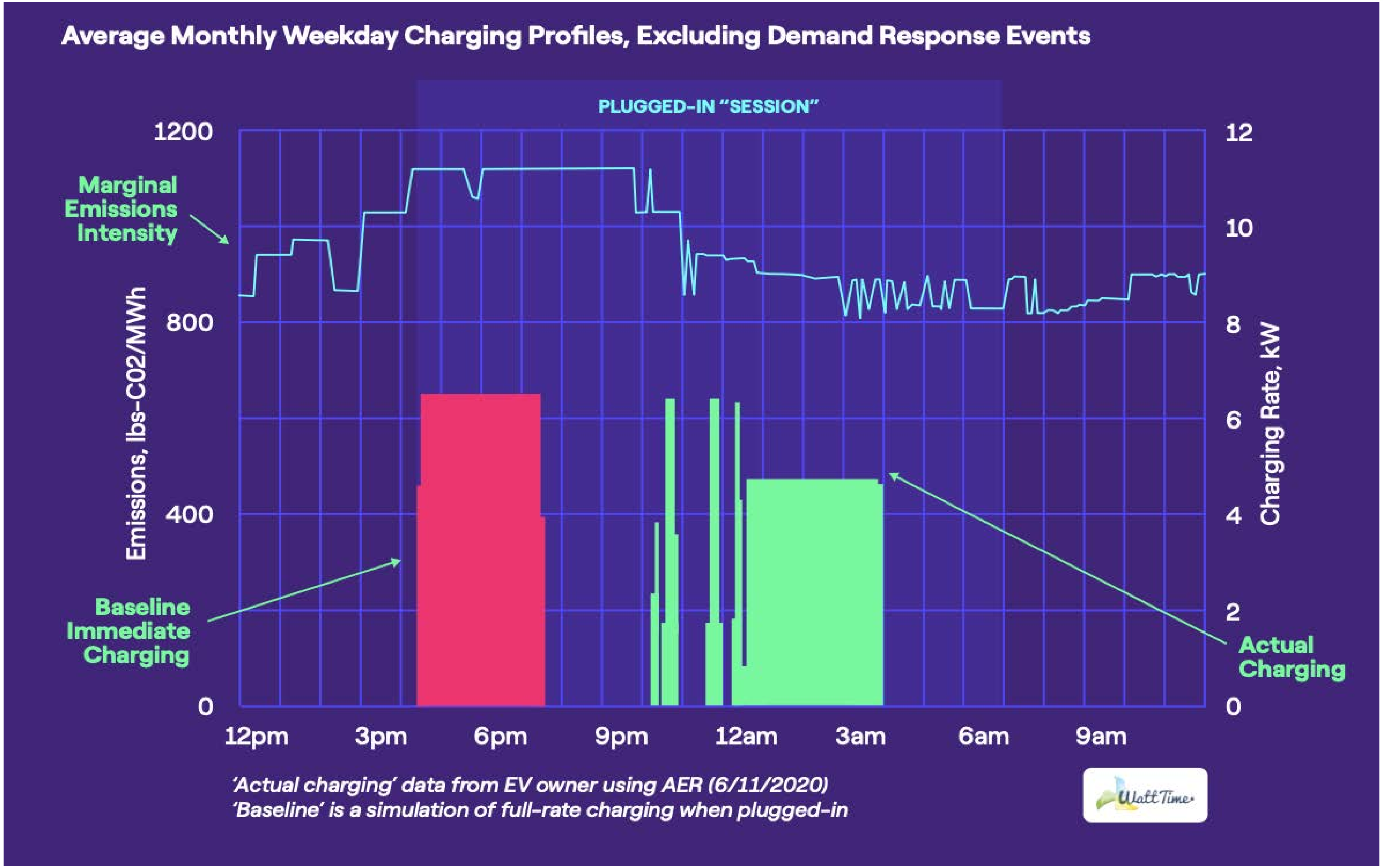
In Theory, Charging Could Also Be Managed For Carbon-Intensity



Enel X 2022 Smart-EV-Load-Management-eBook.pdf

Utilizing Batteries as Intermediaries Between Chargers and Grid

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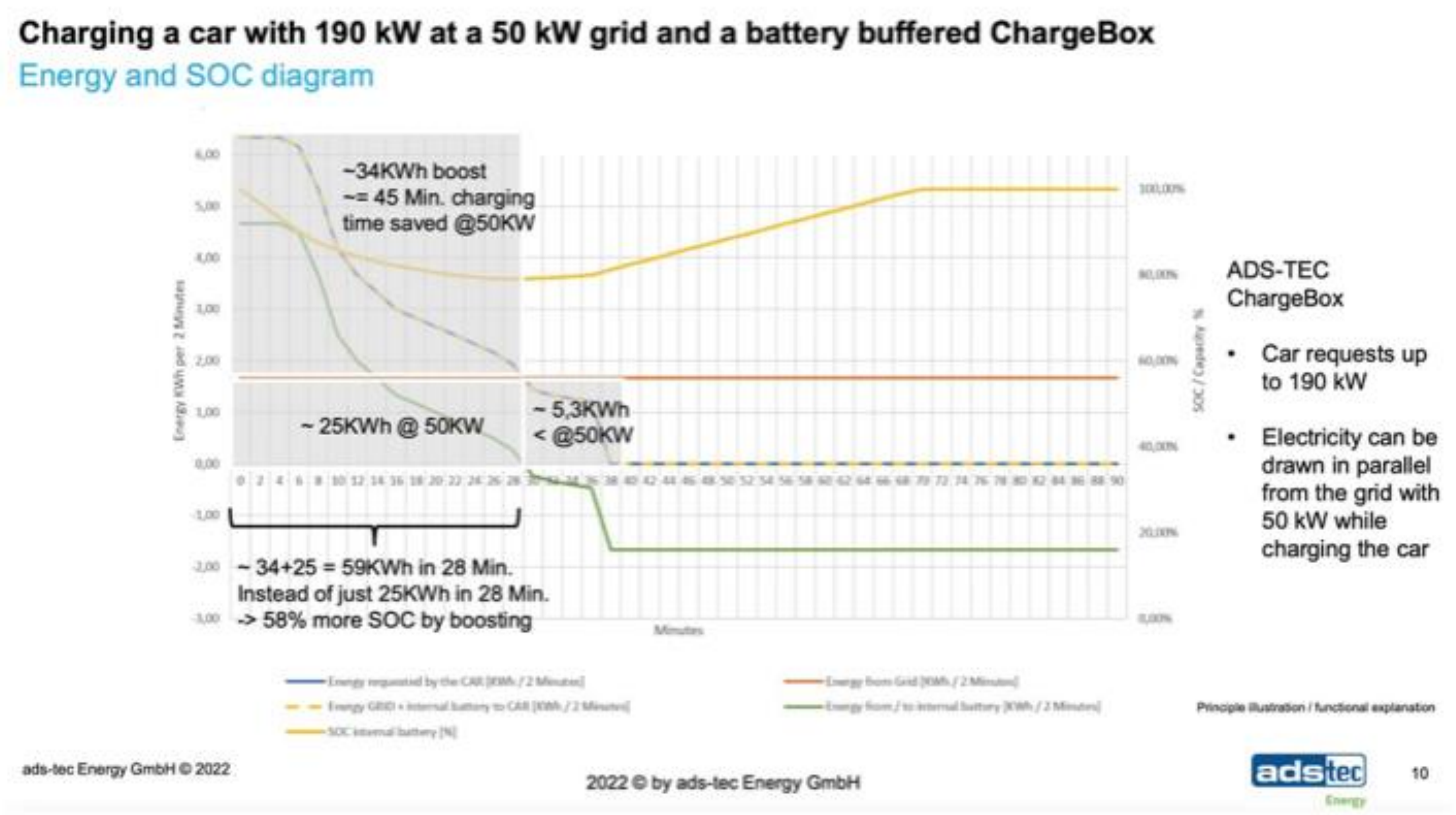

An ADS-TEC ChargeBox can charge an EV at 190 kW from a 50 kW grid connection by using its battery to reduce grid demand. (ADS-TEC)

Capacity Implications: 100-Stall SuperCharger, at 250 kW?

Pasadena Power & Light w/Tesla

Twenty 50kW stalls w/both Chademo and CCS/SAE ports; another 24 parking stalls w/72kW Tesla urban Superchargers. Tesla paid for wiring, saving city $140K

https://electrek.co/2020/02/18/largest-public-fast-charging-station-in-us-help-from-tesla/

Load Balancing Also Potentially Part of the Solution

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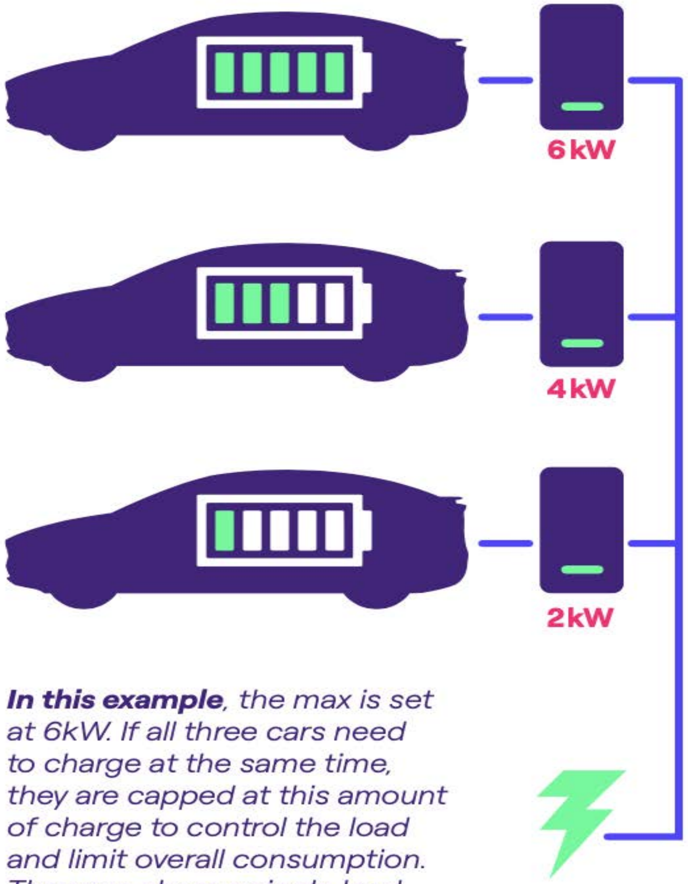
How Load Balancing Works

With load balancing, a maximum load cap can be set to manage energy usage, enabling load sharing and demand charge management.



***In this example**, the max is set at 6kW. If all three cars need to charge at the same time, they are capped at this amount of charge to control the load and limit overall consumption. They can share a single load circuit and reduce the electrical infrastructure upgrades needed.*

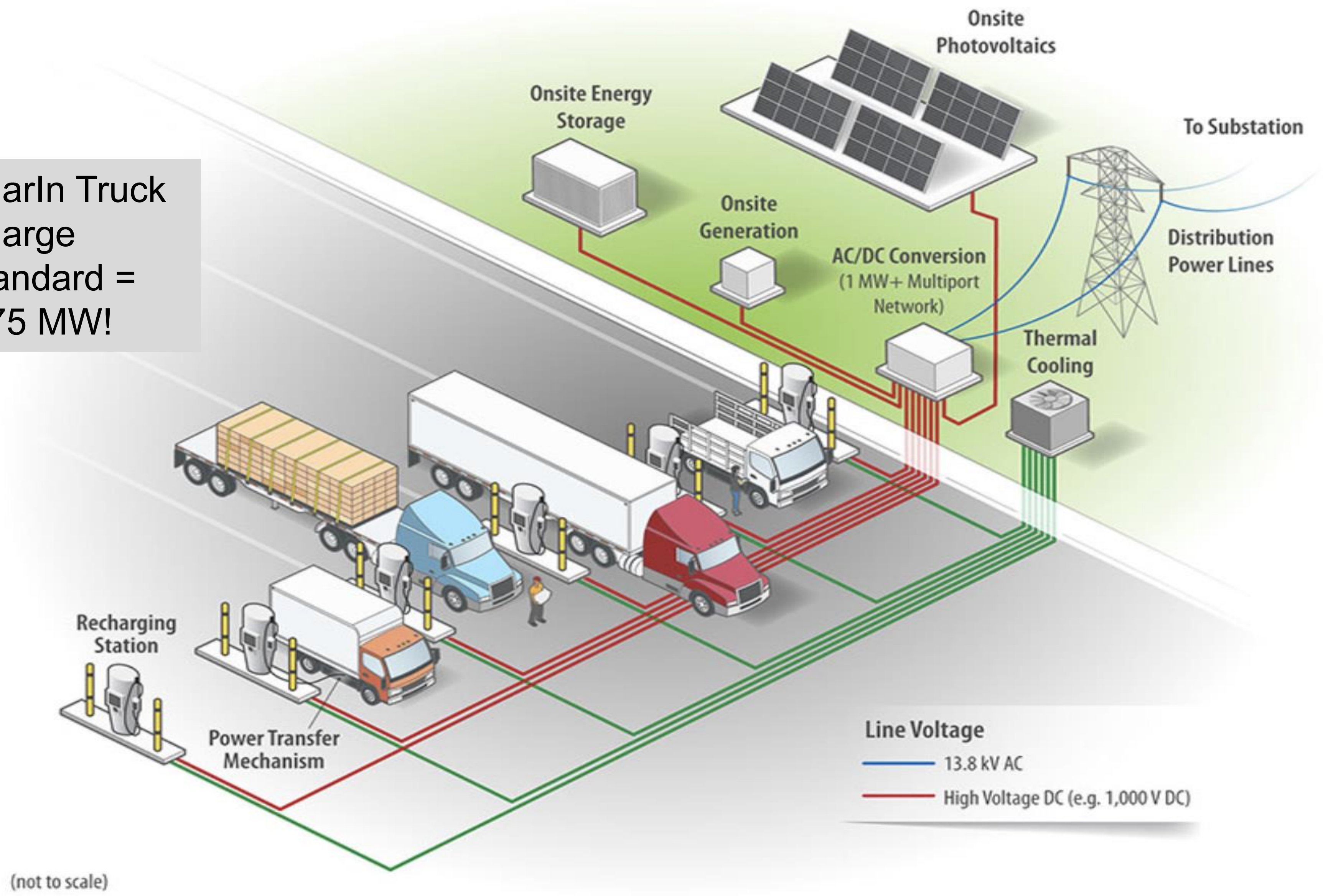
Key Smart Charging Features

- ***Load balancing** Enabled by charging caps, load balancing allows providers to use less electricity, lower demand strain, and prevent demand spikes, by proportionally reducing charging across an installation to stay within a site's capacity constraints.*
- ***Charging Scheduling** Enables charging to be scheduled to prevent demand spikes, reduce costs, simplify grid planning requirements and yield predictable, location specific response from managed charging.*
- ***Charging cap** Enables load balancing and energy management by placing a cap on the amount of power that an overall charging station installation will deliver.*
- ***Tariff optimization** Takes advantage of the lowest "costs of fuel" available through dynamic rate structures.*
- ***Charging prioritization** Prioritizes the order and level to which vehicles are charged when multiple vehicles are plugged in. Gives drivers the added touchpoint of a mobile application that provides visibility into the charging process.*
- ***Data access** A dashboard provides access to charging and energy data to bolster sustainability reporting and make compliance reporting easier.*

Enel X 2022 Smart-EV-Load-Management-eBook.pdf

Truck Charging Likely to Require Intermediary Storage Installations

CharIn Truck Charge Standard = 3.75 MW!

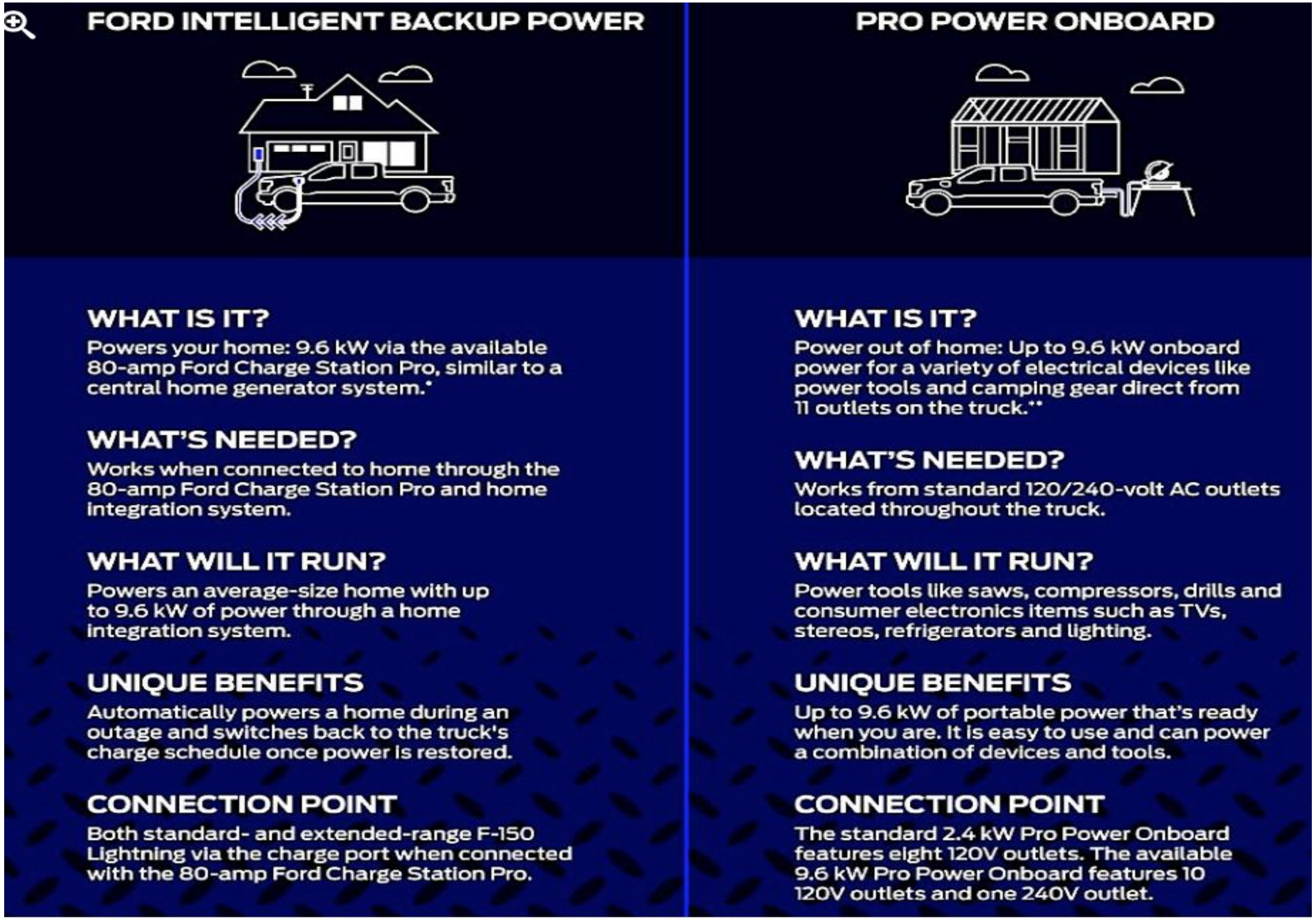


https://www.nrel.gov/transportation/medium-heavy-duty-vehicle-charging.html

V2X Showing Value (Municipal Treatment Plant)

https://chargedevs.com/newswire/nissan-leaf-earns-4200-in-fermata-energy-v2x-pilot/

Vehicle-to-Home Already Here



Ford Intelligent Backup Power - F-150 Lightning

https://www.greencarreports.com/news/1134943_ford-f-150-lightning-will-team-with-home-solar-bypass-brownouts-here-s-how

Integrating Charging Into Facilities

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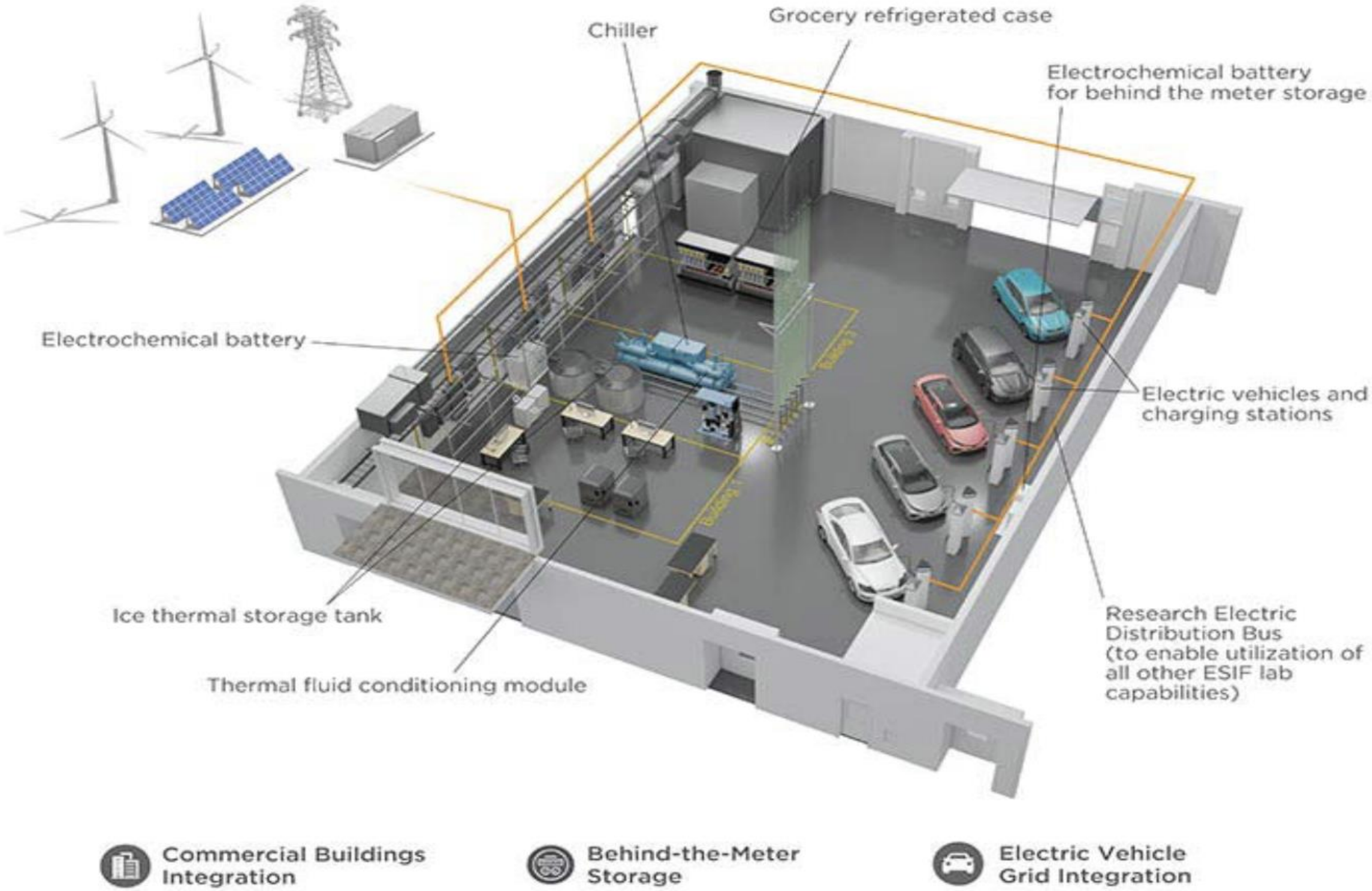

At NREL's Optimization and Control Laboratory, researchers develop optimal strategies for coordinating EVs with buildings, the grid, and other energy systems.

https://www.nrel.gov/transportation/electric-vehicle-grid-impacts.html

Hyundai, Ford, VW & Others Gearing up for V2G Play

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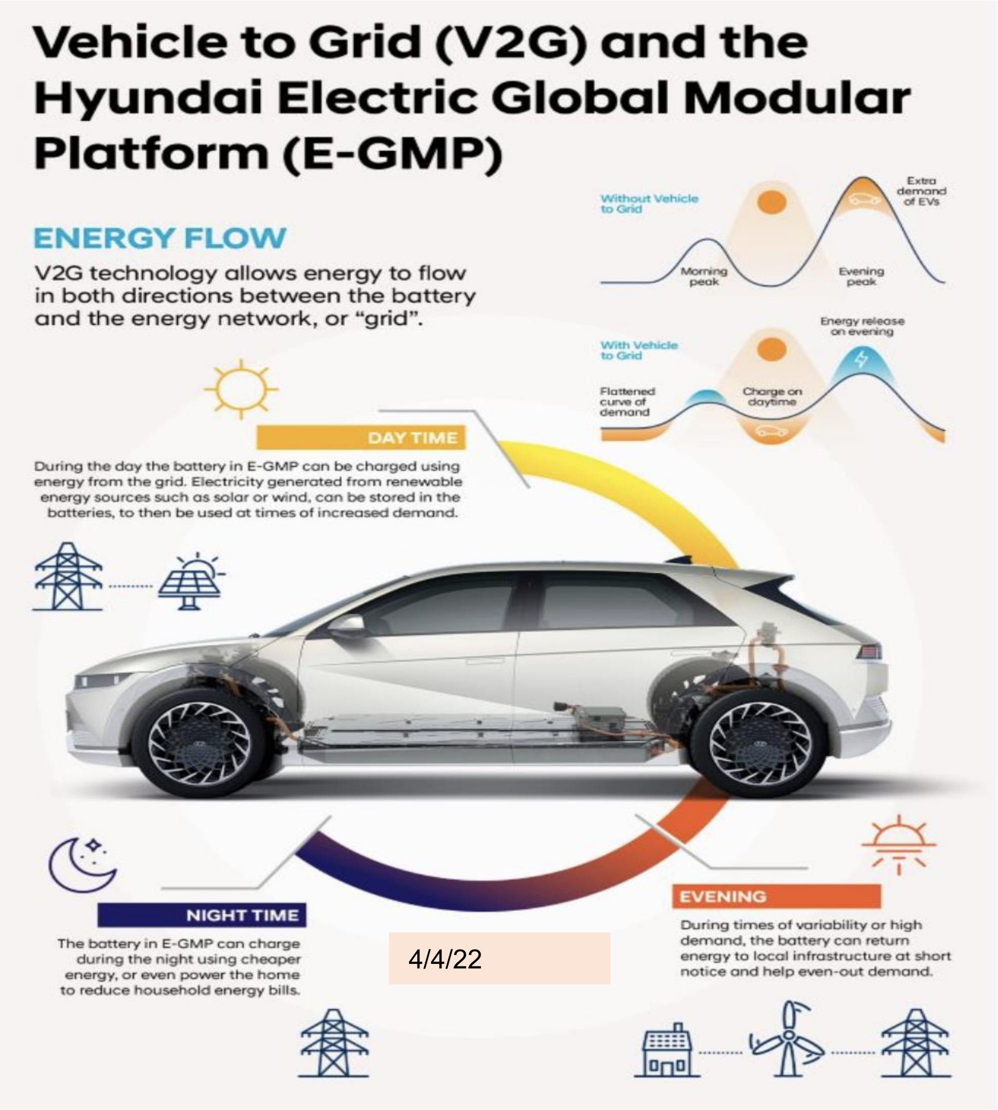
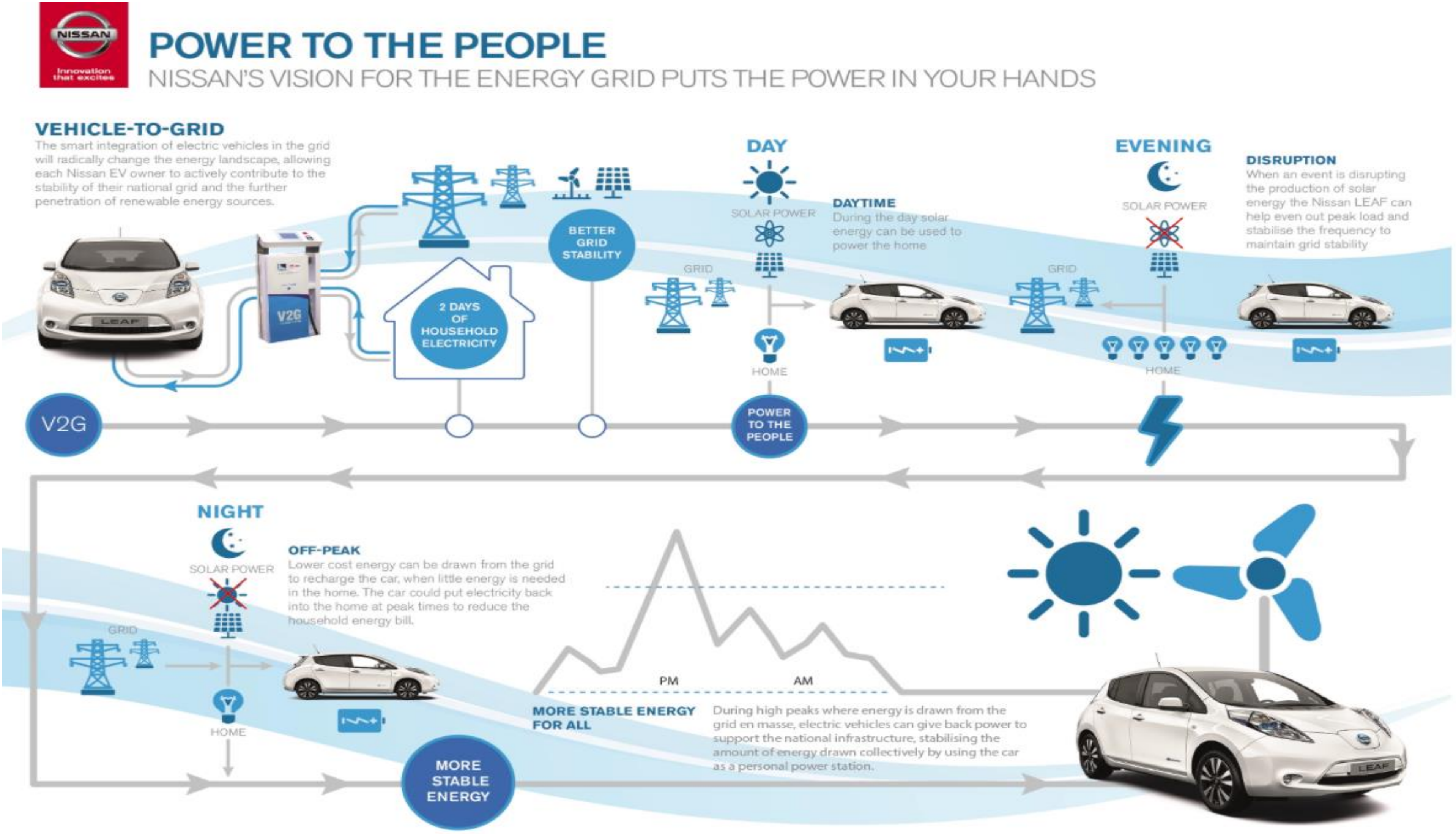


4/4/22

HYUNDAI

https://www.hyundai.news/eu/articles/press-releases/hyundai-broadens-its-energy-solutions-to-include-vehicle-to-everything-technology.html

V2G – the Next Big DR Asset?



http://blogmedia.dealerfire.com/wp-content/uploads/sites/252/2015/12/Cardinale-Nissan-1_V2G.jpg

Nissan Shows Off: Vehicle Battery Can Pay for Parking

https://www.autoblog.com/2020/08/08/ev-electricity-pay-parking-nissan-pavilion/

Bi-Directional Fleet Management

School Buses (150 kWh + Schedule) a Logical Place to Start

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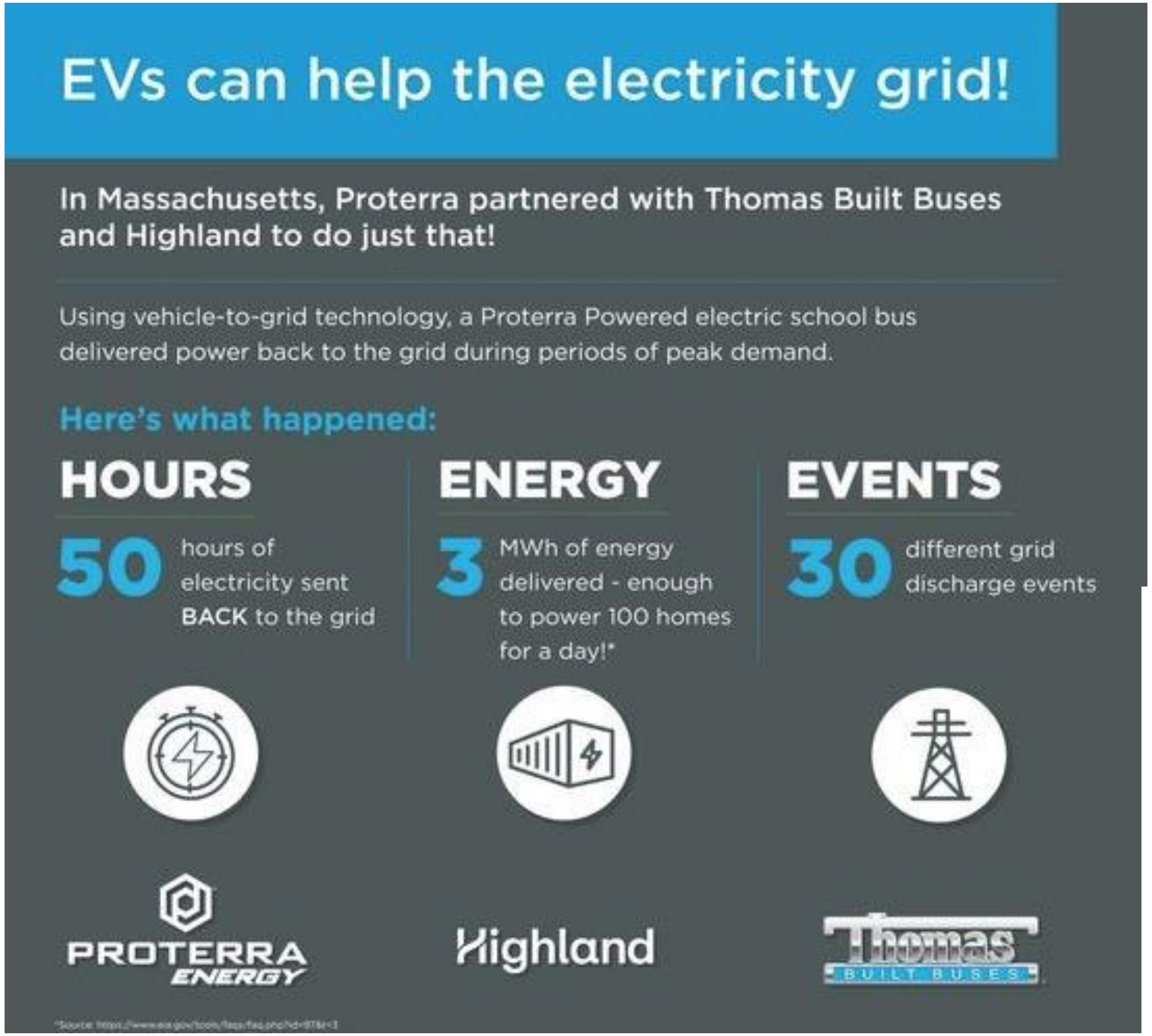

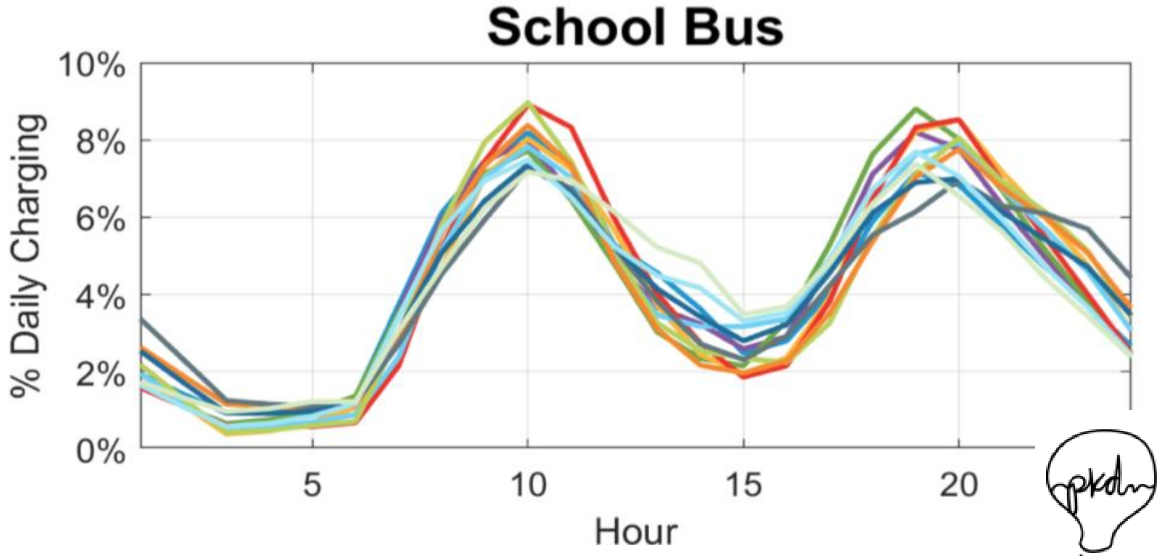

https://thomasbuiltbuses.com/resources/articles/beverly-massachusetts-electric-school-buses-make-v2g-energy-transfer-history/
https://www.iso-ne.com/static-assets/documents/2022/02/evf2022_forecast.pdf

V2G Interoperability Standards Are Arriving Soon

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Grid Integration Levels

2020-06-26 V5.2

- There are many levels of Grid Integration that can generate value
- CCS with ISO/ISO 15118-20 is the key enabler of Grid Integration and is ready for V2G
- This technology is prepared for a wide range of use cases.

	Grid-compliant Charging	Level 1 - V1G Controlled Charging	Level 2 - V1G/H Cooperative Charging	Level 3 – V2H Bidirectional Charging	Level 4 – V2G Aggregated (bidirectional) charging
Description	• EV and EVSE are compliant with the local requirements, guidelines and regulations. • This level only considers charging events from grid to EV. • The charging power is below thresholds, requiring controllability / load management by the DSO.	• The charging event can be influenced regarding the charging power and can be shifted in time remotely by DSO (with highest priority), CPO, EV user, EV or home energy management (HEM). • The EV is capable to wake up for defined start/stops. • Reaction timings are defined. • EV/EVSE, HEM consider variable power settings.	• EV and EVSE negotiate a charging profile based on various drivers (monetary incentives or grid constraints) mainly w/o user interaction (also aggregation); tariff tables etc; mobility need taken into account • Aggregation(local, per charging spot)	• Energy transfers between EVs battery and the home / customer system. • Energy transfers are motivated by sustainability or economical reasons (storage and usage of power, generated by local PV panels or similar). • Supports behind the meter (BTM) use cases	• The EV and the EVSE fulfil functions that go beyond the customer's own energy system (bidirectional energy transfers, aggregators qualification, full balancing market services, economic interests of the EV owner). • Supports in front of the meter (FTM) use cases • Swarm qualification/ aggregation across larger area (entire state or country)
Technical requirements:	• Various local regulations per country (e.g. grid codes, IEC61851-1, IEC 60364 series, …)	Local regulations EV and EVSE • PWM signal, IEC 61851 • DIN-SPEC 70121 (for DC) EVSE and grid (Utility, CPO, …) • OCPP 1.6 • Demand-response • Opt-out possibilities	Local regulations EV and EVSE • ISO/IEC15118 Ed1 • Telematics EVSE and grid • OCPP 1.6f • See level 1 • ToU	Local regulations EV and EVSE • See level 2 • ISO/IEC15118-20 EVSE and grid • See level 2 • EEBus • Many requirements still missing	Local regulations EV and EVSE • See level 2 EVSE and grid • See level 3 • Many requirements still missing
	Grid connection	Grid integration			

EV – electric vehicle, EVSE – electric vehicle supply equipment, DSO- distributed system operator ,CPO – charge point operator

Coordination Office CharIN
c/o innos GmbH

11/23/2020

https://www.charinev.org/fileadmin/Downloads/Papers_and_Regulations/CharIN_Levels__Grid_Integration_v5.2.pdf

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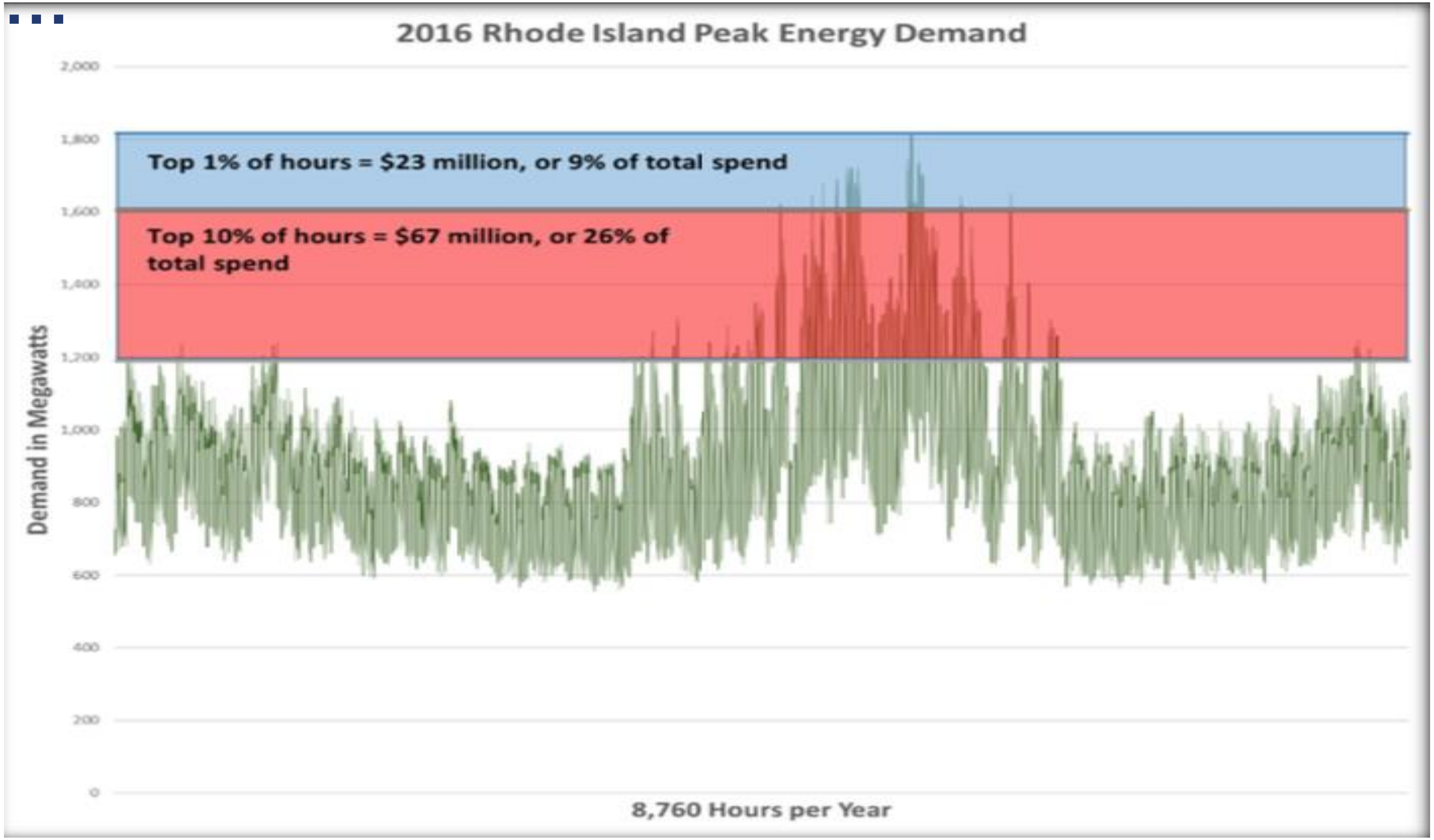
Day 3: Policies And Planning Models for an Optimized Future

Peter Kelly-Detwiler, Principal – NorthBridge Energy Partners, LLC
October 2022

Clean + Modern Grid

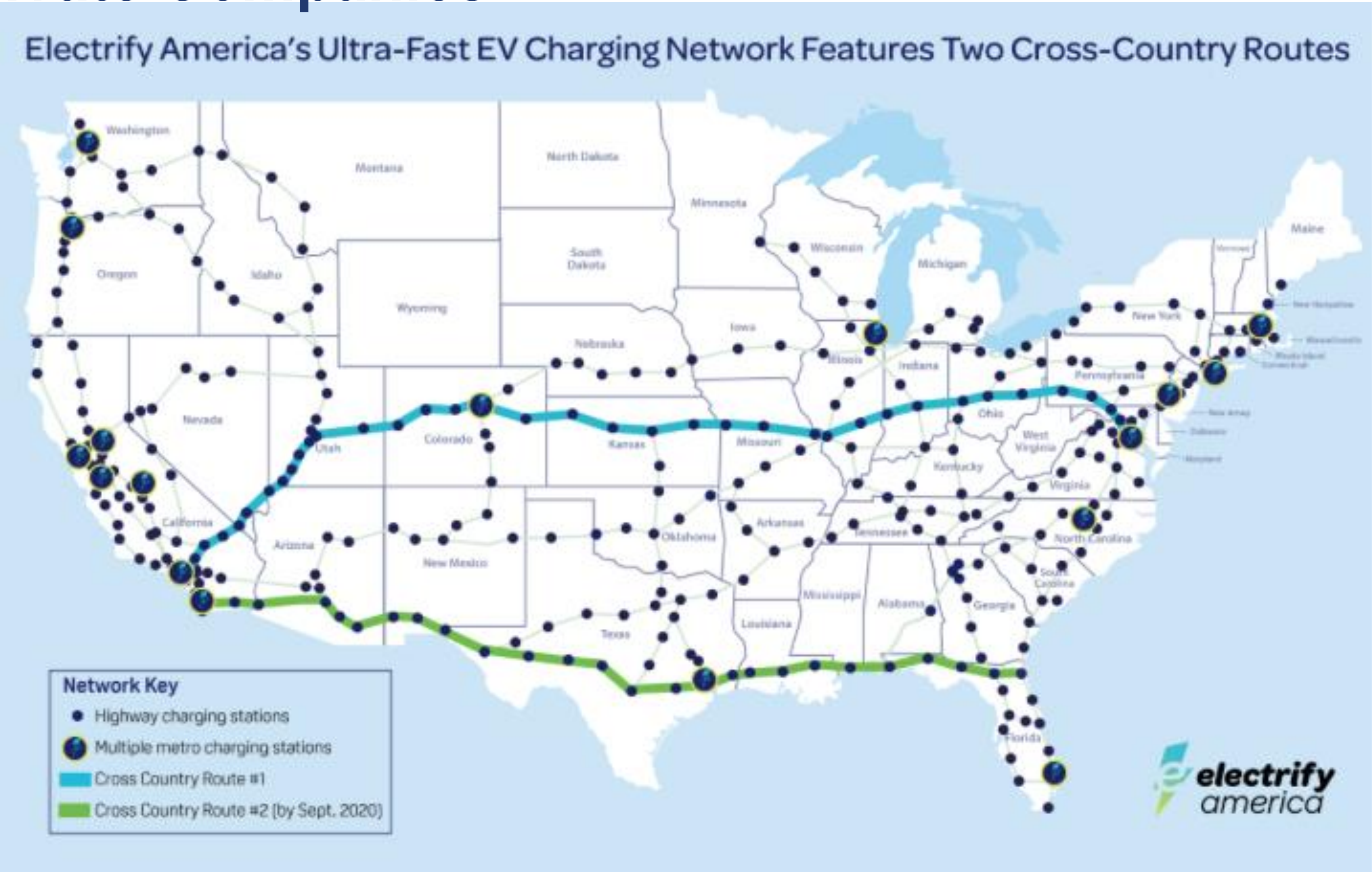
Regulatory and Business Innovation | Grid Integration | Electrification

Done Right, We Improve Grid Efficiencies; Done Wrong…



How Do Utilities Deal with Mobile Loads?

Private Companies



https://media.electrifyamerica.com/en-us/releases/100#images

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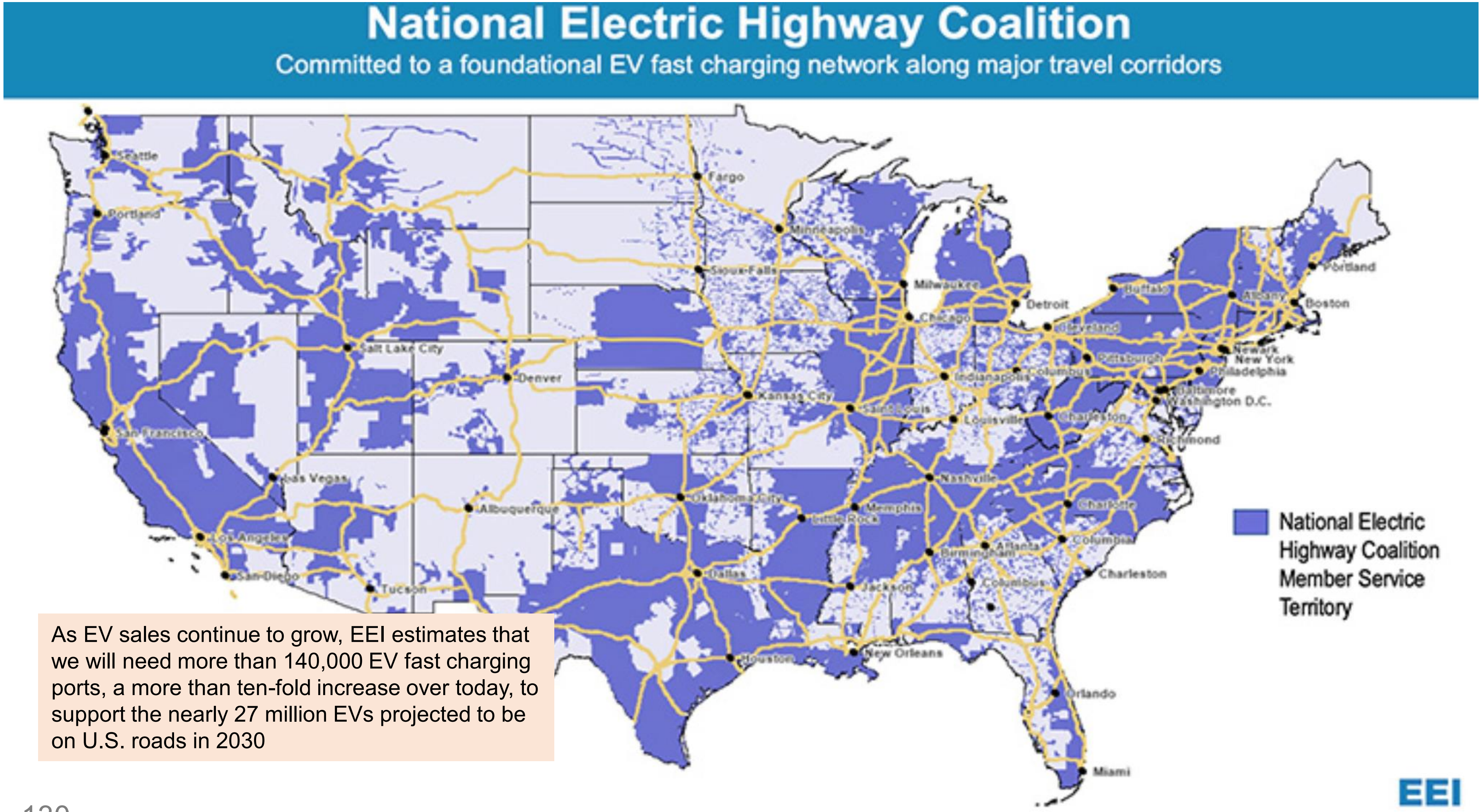
Utilities Themselves



As EV sales continue to grow, EEI estimates that we will need more than 140,000 EV fast charging ports, a more than ten-fold increase over today, to support the nearly 27 million EVs projected to be on U.S. roads in 2030

https://www.eei.org/en/issues-and-policy/national-electric-highway-coalition

Western States Charging Initiative

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https://www.teslarati.com/west-electric-highway-develops-ev-charging-in-eight-western-states/

A Growing Population of Assets

Smart Electric Power Alliance ONLINE LEARNING

Electric Vehicles as Grid Assets

By 2030, over 20 million electric vehicles (EVs) are expected to be on U.S. roads, representing 93 TWh of added electric load.[23] Without managed charging functionality, these vehicles could lead to grid constraints and unplanned costs. Managed charging will be a key part of utilities' DR portfolios, and implemented properly, can lower the cost of electricity grid payments for customers and provide benefits to the grid.

Table 7: Examples of Active and Passive Managed Charging

Passive	Active
EV time-varying rates, including time-of-use rates and hourly dynamic rates	Direct load control via the charging device
Communication to customer to voluntarily reduce charging load (e.g., behavioral DR event)	Direct load control via automaker telematics
Incentive programs rewarding off-peak charging	Direct load control via a smart circuit breaker or panel

Source: Smart Electric Power Alliance, A Comprehensive Guide to EV Managed Charging, 2019.

https://sepapower.org/resource/2019-utility-demand-response-market-snapshot/

Not Just More: Bigger & More Powerful

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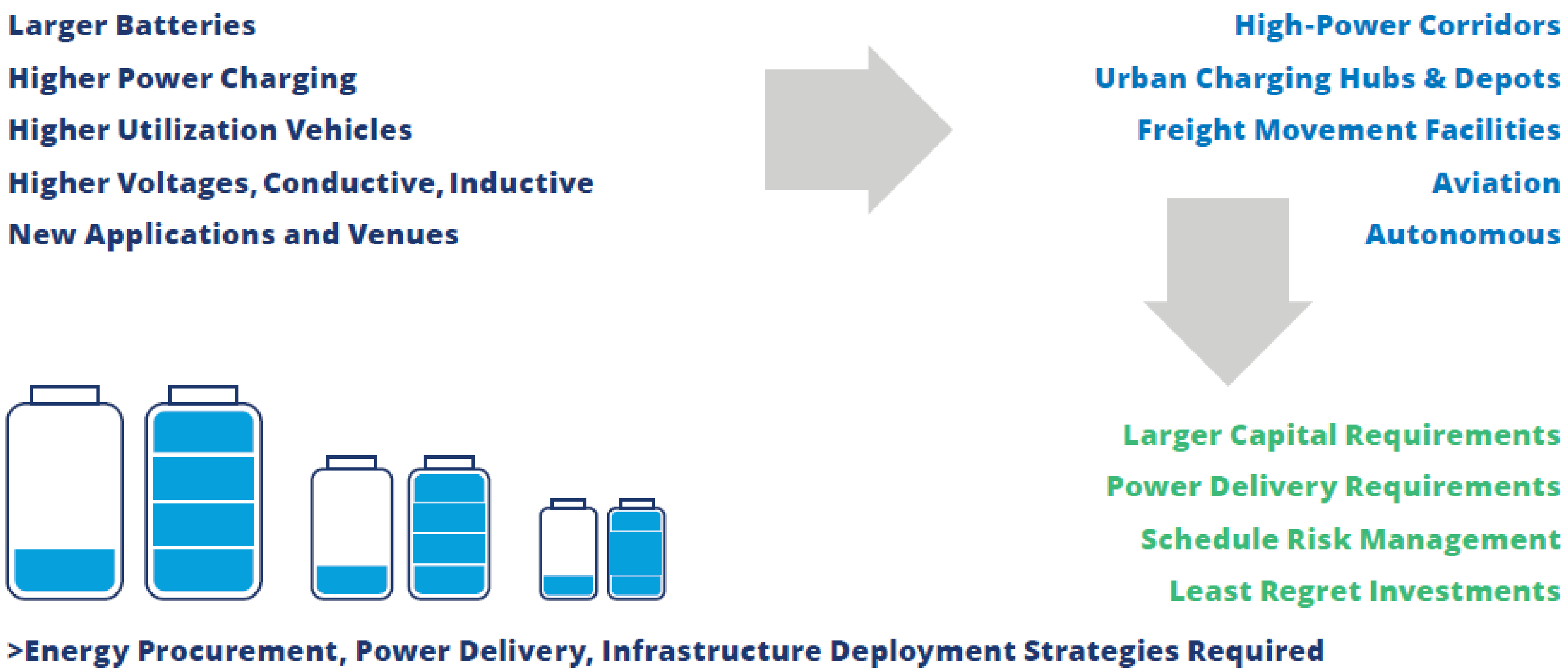
Figure 5: Step Change in Charging Infrastructure Requirements



Source: Black & Veatch, 2019[25]

https://sepapower.org/resource/preparing-for-an-electric-vehicle-future-how-utilities-can-succeed/

Communications Options

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"EVSE" = EV Supply Equipment

Many stakeholders are asking: What's the most effective form of EV load management? Ultimately, combining networked EVSE and EV telematics affords the best view for utility EV load management. Each has benefits and limitations given the technology pathways, use cases and customer behavior.

	EVSE	EV Telematics	Why it matters
Grid Signal Connection	WiFi/Cellular	Cellular	*A cellular connection is more reliable than WiFi.*
Meter Accuracy	Higher	Lower	*Higher meter accuracy provides better quality data.*
Schedule Charging via Timer	Yes (60%)	Yes (25%)	*Consumer behavior: Over 60% of Enel X residential customers use their smart charging station to schedule charging.*
Behavioral Demand Response (BDR)	Yes	Yes	*Example: Off peak charging program (between 9pm and 9am on weekdays, or anytime on weekends and holidays) is popular and cost-effective. At least 25% of US utilities have EV TOU.* *Example: sending a text for the EV driver to respond.*
Automated Load Management (ALM)	Yes	No	*EVSE enables Automated Load Management (ALM) via near-real-time communications between the EVSE and a site Energy Management System (EMS) that talks to the host meter to dynamically balance load.*
State of Charge (SoC) Data	No	Yes	*(+) Electric vehicle telematics provides the EV battery's State of Charge(SoC), which can provide utilities with a real picture of energy demands and how it relates to different electric car models.* *(+) DC Fast Chargers with CCS can also access SoC information* *(–) Level 2 EVSE do have access to an EV's State of Charge (SoC), unless the EVSE provider has integrated with an automaker's telematics system, or unless it utilizes advanced (pre-commercial) communication protocols like ISO 15118 to obtain "required energy" (a proxy for SoC).*

Enel X 2022 Smart-EV-Load-Management-eBook.pdf

Here's How That May Look In Terms of Communications Protocols

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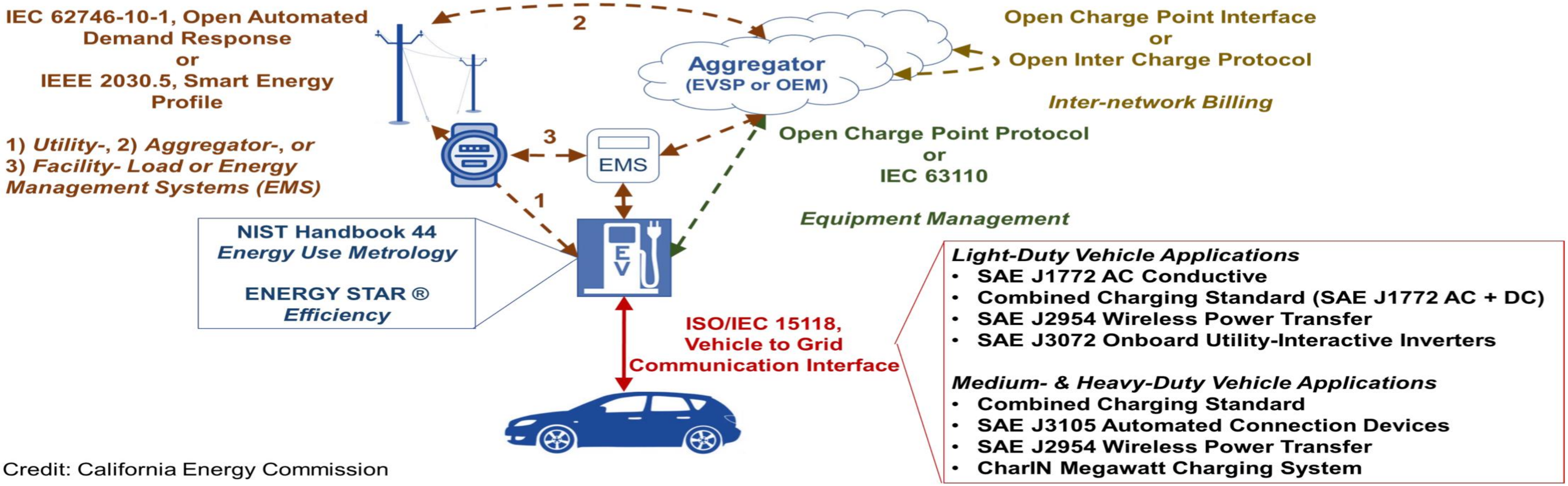
Figure 22: Grid-Integrated Charging Equipment Design Archetype



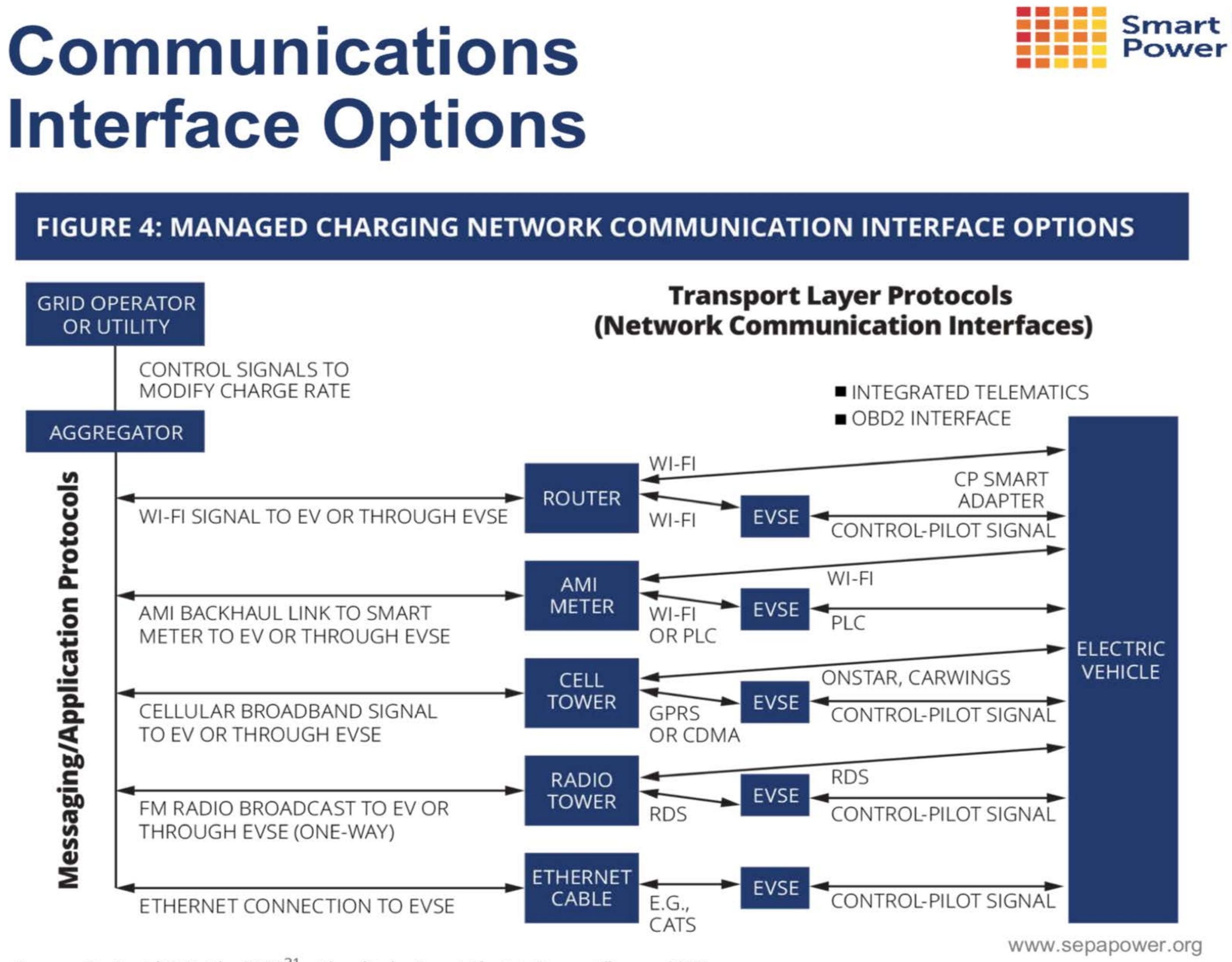
Credit: California Energy Commission

Interoperable charging hardware may enhance and support a user-friendly and grid-responsive charging. ISO 15118 may provide a standard vehicle-charger communication language, and OCPP may provide a standard charger-network language. Widespread deployment of chargers that "speak" these languages can ensure that California is prepared for vehicle-grid integration, as well as future vehicle and charger features.

Source: CEC

https://www.energy.ca.gov/programs-and-topics/programs/electric-vehicle-charging-infrastructure-assessment-ab-2127

The Technical Challenge



Source: Dr. David P. Tuttle, 2016[31] with edits by Smart Electric Power Alliance, 2017

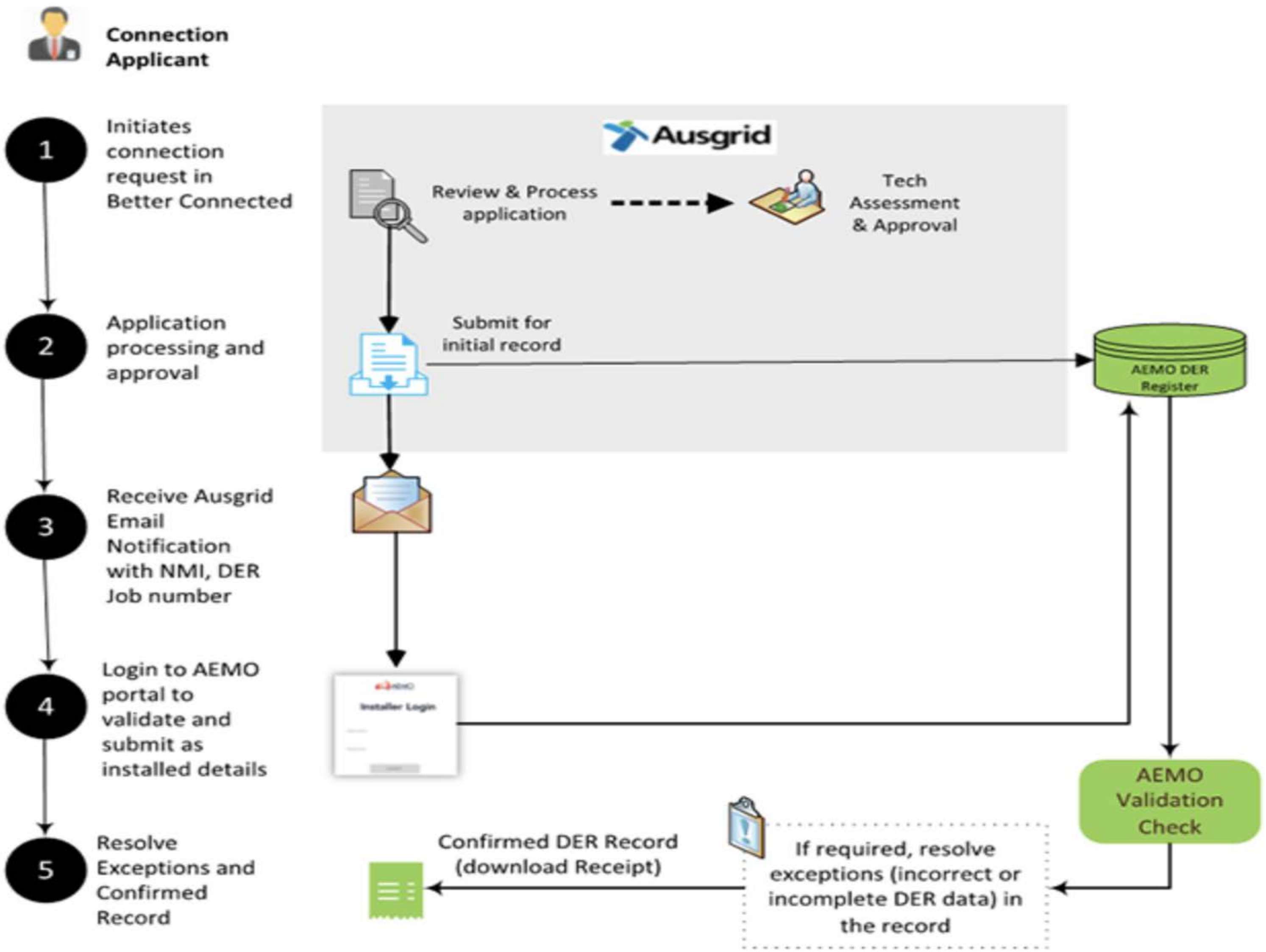
https://www.peakload.org/assets/36thConf/A1.SEPA&NVENERGY-%20Managed%20Electric%20Vehicle%20Charging.pdf

Universal Registration? What Characteristics?

Why is the AEMO DER Register being introduced?

https://www.ausgrid.com.au/Connections/solar-battery-and-embedded-generation/Distributed-Energy-Resources-Register

How Australia is Registering All DERs



https://www.ausgrid.com.au/Connections/solar-battery-and-embedded-generation/Distributed-Energy-Resources-Register

Behavior or Direct Control?

Smart Electric Power Alliance ONLINE LEARNING

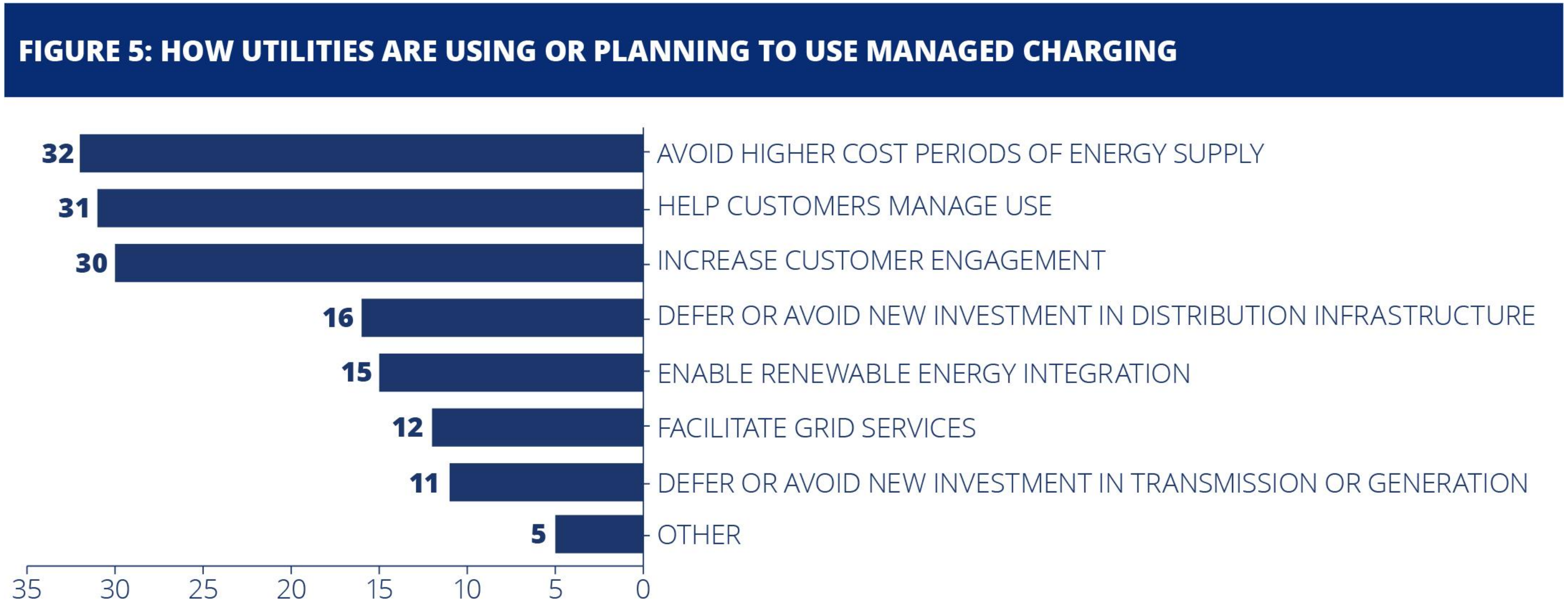
TABLE 3: EXAMPLES OF ACTIVE AND PASSIVE MANAGED CHARGING

PASSIVE	ACTIVE
EV time-varying rates, including time-of-use rates and hourly dynamic rates	Direct load control via the charging device
Communication to customer to voluntarily reduce charging load (e.g., behavioral demand response event)	Direct load control via automaker telematics
Incentive programs rewarding off-peak charging	Direct load control via a smart circuit breaker or panel

Source: Smart Electric Power Alliance, 2019.

https://sepapower.org/resource/a-comprehensive-guide-to-electric-vehicle-managed-charging/

The Value Propositions in Managed Charging



Source: Smart Electric Power Alliance, 2019. N=48. Note: Utilities selected all that applied.

https://sepapower.org/resource/a-comprehensive-guide-to-electric-vehicle-managed-charging/

Where the Opportunities Lie

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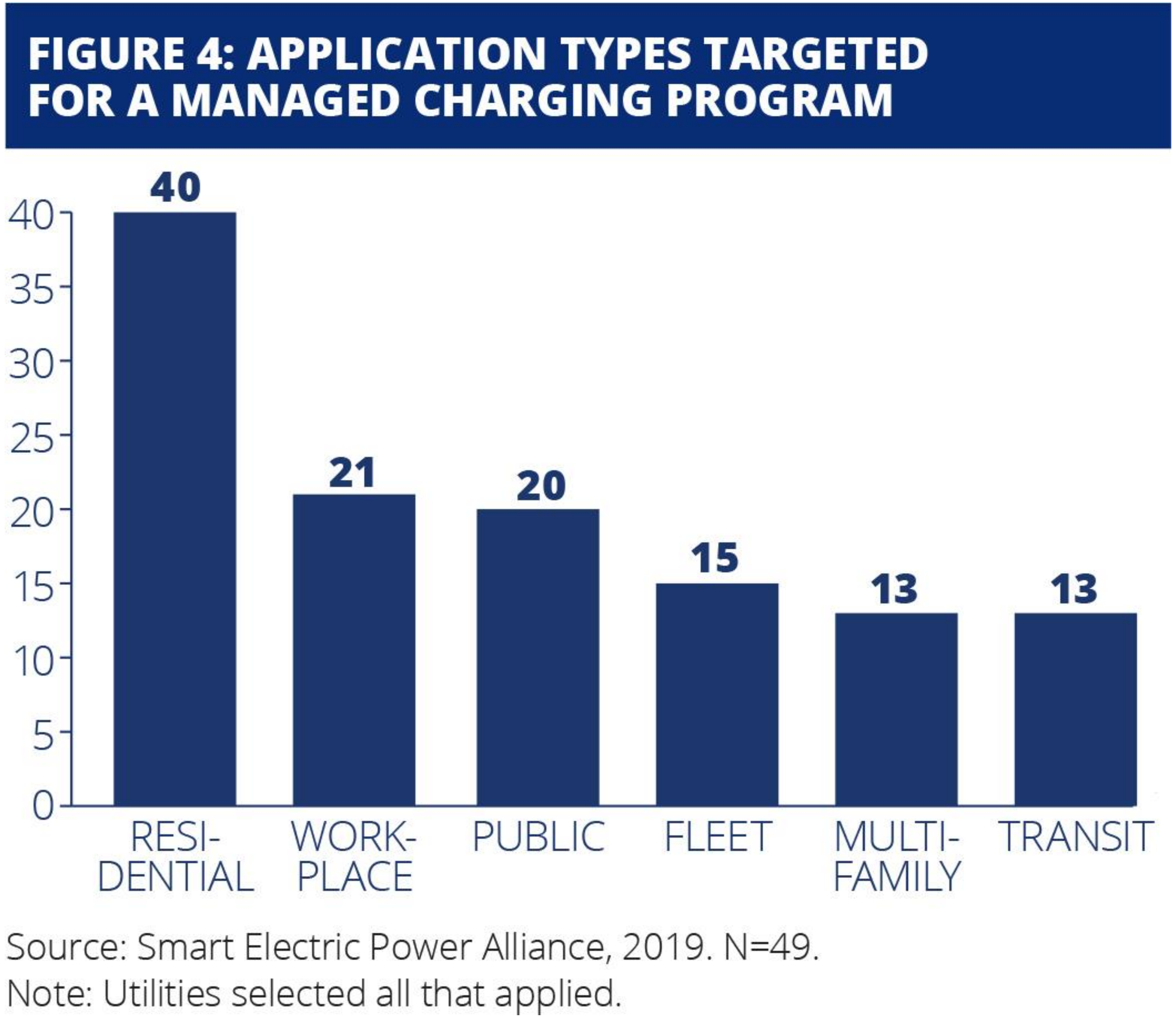

https://sepapower.org/resource/a-comprehensive-guide-to-electric-vehicle-managed-charging/

A Mature Planning Approach to DERs (incl EVs)

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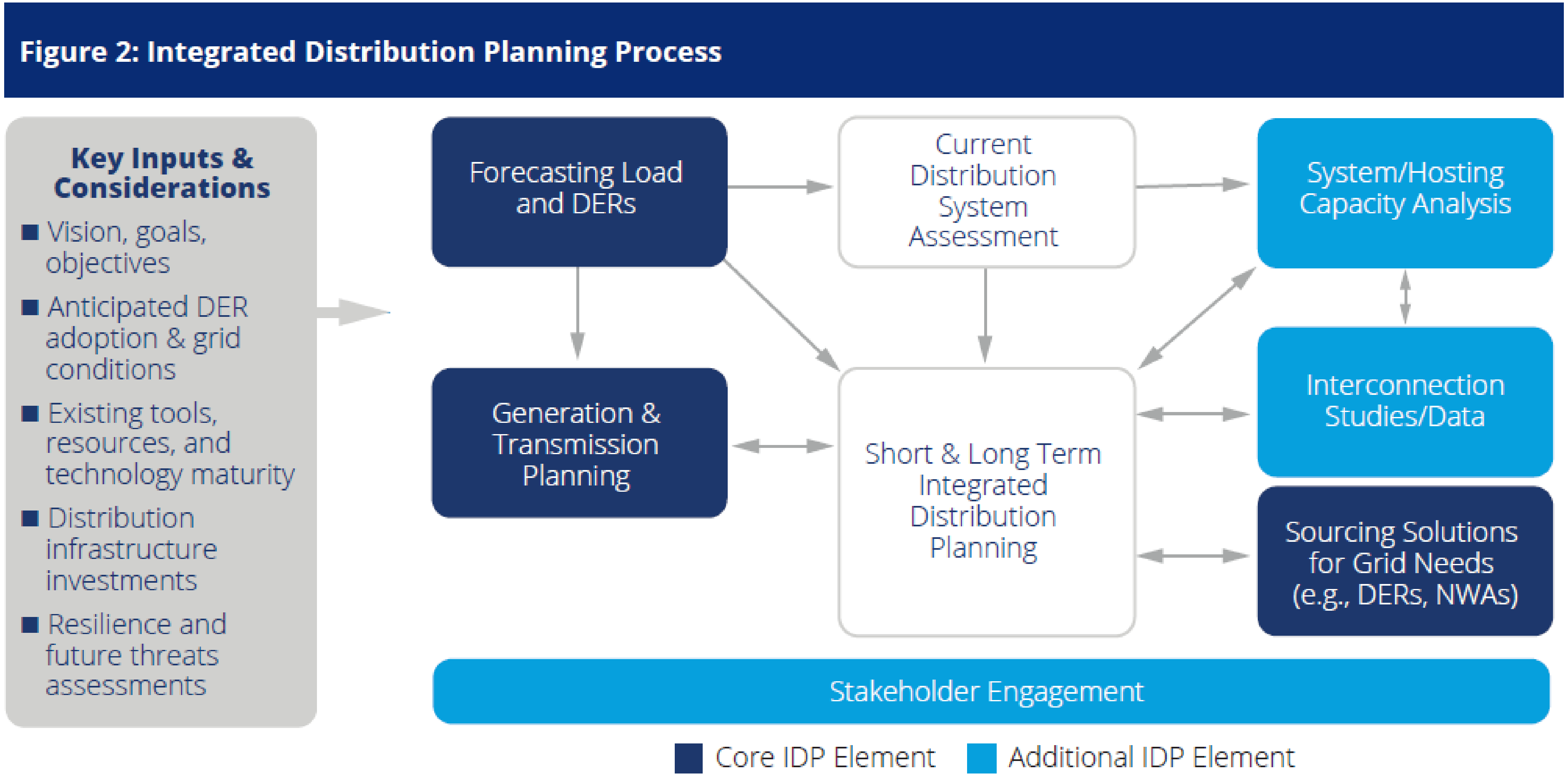


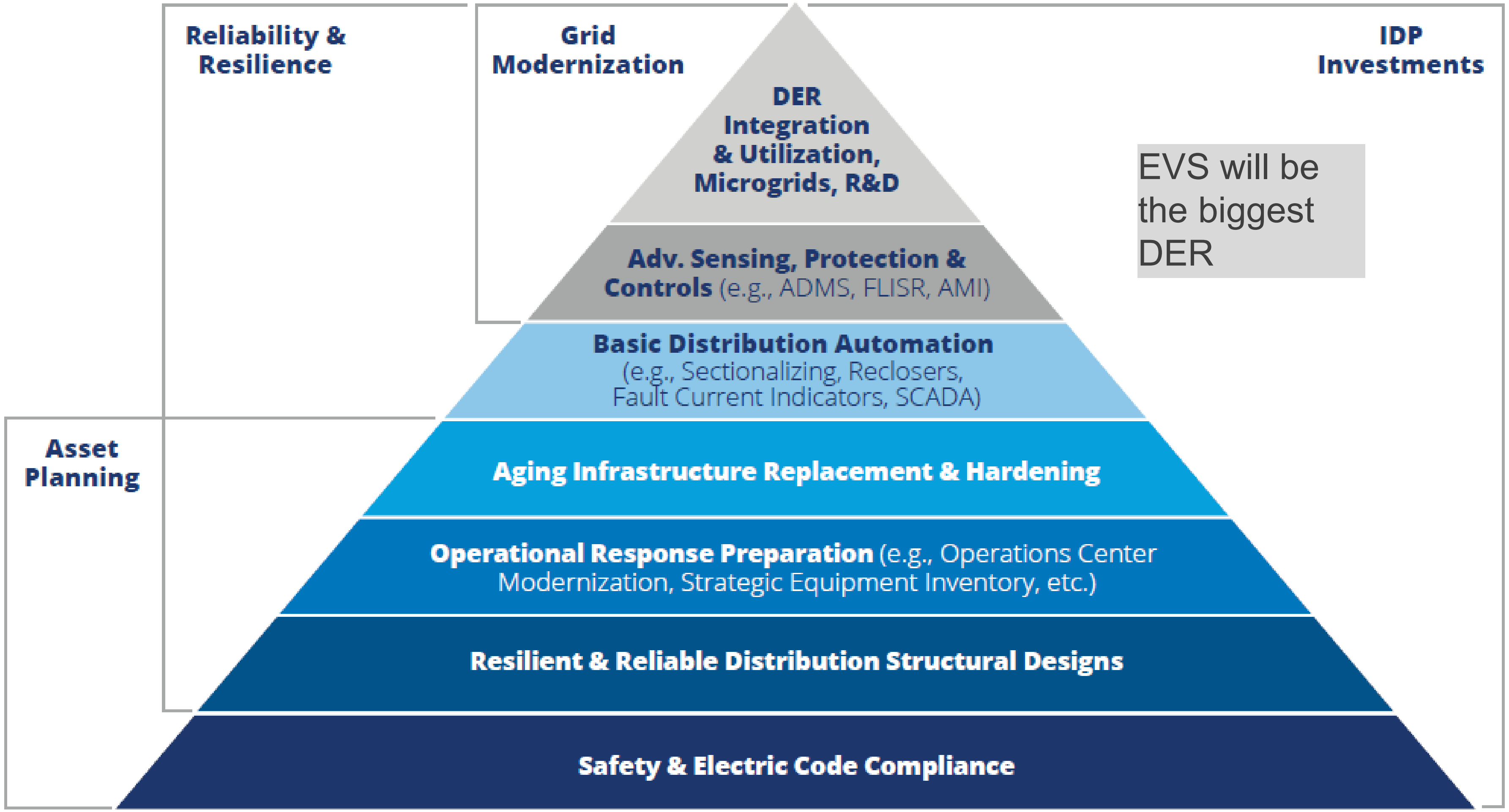
Source: Adapted by Smart Electric Power Alliance based on Department of Energy (DOE) (2017), Modern Distribution Grid Decision Guide Volume III, 2020.

https://sepapower.org/resource/integrated-distribution-planning-a-framework-for-the-future/

Value Creation at Different Levels

Smart Electric Power Alliance ONLINE LEARNING

Figure 3: Distribution Infrastructure Investment Prioritization Pyramid



Source: Paul De Martini with modifications by Smart Electric Power Alliance, 2020.

https://sepapower.org/resource/integrated-distribution-planning-a-framework-for-the-future/

Planning/Forecasting Must Migrate to Locational Level

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Table 3: Progression of Forecasting in IDP

Progression	Description
Phase 1	**Load forecasting with limited visibility:** Limited visibility, with little to no data available from the substation to the meter service point, requiring load surveys to extrapolate forecasts.
Phase 2	**Load forecasting with standard visibility:** Forecast load growth and peak demand based on load data at the substation and/or feeder level. Deterministic forecasting is generated based on static historical load data and can be adjusted based on other factors such as, weather, planned new development, anticipated load growth (system wide), circuit reconfigurations, etc.
Phase 3	**Load forecasting with increased visibility:** Locational data increasingly captured and analyzed from devices located along individual feeders, potentially including AMI data to provide more visibility throughout the distribution system. May include basic forecasts for specific DER adoption and associated load impacts including limited temporal impacts as well as multiple scenario planning.
Phase 4	**Advanced, integrated granular forecasting:** Streamlined integration of load forecasting and expected DER adoption. Includes increased coordination between load and DER forecasting processes as well as more locational data included in analysis. At this future state, planners can both see and model DER hourly output across DER types and account for temporal as well as locational DER impacts as part of the forecasting model. May include stochastic modelling of DERs based on potential variation in operating parameters.

Source: Smart Electric Power Alliance, 2020.

https://sepapower.org/resource/integrated-distribution-planning-a-framework-for-the-future/

Future Approaches to Forecasting

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Table 4: Additional Forecasting Methods	
System-Level Forecasting (e.g., corporate or economic forecasting)	Forecasting to account for annual peak demand in a utility service territory based on previous system peaks, energy efficiency, economic growth, generation capacity and retirements, service territory demographics and other factors. System level forecasts can be "allocated" to lower levels of the system by accounting for coincidence/diversity. *Commonplace at utilities today*
DER Propensity-to-Adopt Analysis	Assesses the likelihood of technology being adopted, based on factors such as policy, economic environments, customer needs, demographics, locational economic factors (e.g. income levels) and technology maturity among other factors. Analysis can be done at varying degrees of granularity (e.g., zip code, substation, customer level). Propensity-to-adopt analysis may already be a component of system-level forecasting at the substation or zip-code level today. *Likely to be incorporated in Forecasting Phases 2-3*
Multiple Scenario Analysis	Accounts for multiple possible outcomes. In reference to DER, multiple scenario analysis can be used to analyze the effects of varying levels of DER adoption on the distribution system and variation in electric rates and tariff structures that may impact participation and energy use. Multiple scenario planning is dependent on sensitivities as inputs into analysis—which may be contingent on propensity analyses, stakeholder input/consensus, and visibility into the system. *Likely to be incorporated in Forecasting Phase 3*
Stochastic Forecasting	Stochastic forecasting builds off multiple scenario analysis to add different combinations of sensitivities to potential scenarios (e.g., variability of DER output profiles, different adoption levels, weather variability, uncertain program participation). Stochastic analysis accounts for some elements of randomness, producing multiple outputs based on a set of parameters. *Not conducted to date, likely in Phase 4*

Source: Smart Electric Power Alliance, 2020.

https://sepapower.org/resource/integrated-distribution-planning-a-framework-for-the-future/

The Path to EV/DER Planning Maturity

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Table 6: Progression of Sourcing Solutions for Grid Services in IDP

Progression	Description
Phase 1	**DERs not considered as solution for addressing distribution system constraints/needs.**
Phase 2	**Piloting:** Explore use of DERs and other non-traditional solutions for new business models, procurement, contracting, and technology performance to address distribution system constraints.
Phase 3	**Evaluation of DERs and other non-traditional solutions are integrated into the IDP process:** Includes incorporating an evaluation or screening process to examine the ability of DERs to avoid or defer infrastructure investments along the grid. Also includes mechanisms to source DERs for grid services.
Phase 4	**Streamlined DER solutions sourcing based on Locational and Temporal Value:** Leveraging both pricing and system constraint data, DERs are further integrated onto the distribution system based on their locational and temporal benefits. The sourcing method could include procurements, pricing tariffs, and streamlined strategies via customer programs. Reaching Phase 4 requires confidence in predicting customer behavior and DER performance to meet system reliability requirements, as well as the ability to control or reliably call on DERs such as storage for volt/var or grid power quality.

Source: Smart Electric Power Alliance, 2020.

https://sepapower.org/resource/integrated-distribution-planning-a-framework-for-the-future/

Integrated and Iterative

Table 7: Progression of Transmission, Distribution, Generation Integration in IDP	
Progression	**Description**
Phase 1	**Siloed Planning Processes:** Distribution planning done separate from other planning processes (e.g., transmission planning, IRP) and focused on planning for load growth.
Phase 2	**Annual Iterative Approach:** Linking transmission, distribution and generation planning (as applicable). DERs at this stage do not pose material risk to transmission and bulk system operations. Distribution planners share their static load analysis and limited DER forecasting with transmission planners and compare with existing IRPs.
Phase 3	**Increasingly Iterative Approach:** Linking transmission, distribution and generation planning. Net load characteristics on distribution systems begin to impact transmission and bulk system operations. DER growth patterns, timing and net load shape assumptions and plans shared iteratively.
Phase 4	**Continuous and co-optimized planning processes:** Integration between distribution, transmission and generation planning. Net load characteristics with DERs on distribution systems can significantly impact transmission and bulk system operations, requiring coupled, iterative analysis of distribution and transmission planning with DERs, and incorporation into integrated resource planning processes.

Source: Smart Electric Power Alliance, 2020.

https://sepapower.org/resource/integrated-distribution-planning-a-framework-for-the-future/

The Challenge of Interconnection for Chargers

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Table 8: Progression of Interconnection in relation to IDP

Progression	Description
Phase 1	**Manual interconnection process:** Within the context of low DER adoption, interconnection applications are collected and processed through a static technical screening process.
Phase 2	**Increasingly digitized and streamlined interconnection process:** With growing DER adoption, expedited processes and greater digitization are needed for smaller capacity systems to meet the growing interconnection queue demand and improve efficiency. Interconnection processes expand to integrate different technologies and their unique circumstances (e.g., energy storage, solar + storage, community solar).
Phase 3	**Increasingly automated and streamlined interconnection process, coordinated with other IDP processes:** A high DER penetration scenario necessitates an enhanced screening process. At this phase, it may be tied or more coordinated with hosting capacity to assist customers and other stakeholders in adopting DERs in areas that most support the grid.
Phase 4	**Fully integrated process with other IDP elements:** In this future state, interconnection may no longer exist in the form of streamlined studies but may function as a highly-coordinated function within a fully streamlined IDP process. Locational benefit analysis (informed by hosting capacity) may play a larger role at this phase to actively direct locational and temporal specific deployment of DERs to maximize grid support and minimize the system impacts of DERs.

Source: Smart Electric Power Alliance, 2020.

https://sepapower.org/resource/integrated-distribution-planning-a-framework-for-the-future/

And Hosting Capacity

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Table 9: Progression of Hosting Capacity in IDP

Progression	Description	Paths for Phased Advancement
Phase 1	**Limited, manual analysis:** Hosting capacity analysis conducted reactively in response to customer interconnection requests.	May advance along phases focusing on one or a few of the following: 1. Level of automation 2. Depth of analysis 3. Frequency of analysis 4. Level of integration with other systems *Note: Dependent on goals and objectives of utility and stakeholder. Level of hosting capacity data shared and how data is shared outside of the utility is based on utility and stakeholder context.*
Phase 2	**Basic functionality with static analysis:** Assessment and evaluation of a determined area, providing more general attributes (e.g., substation and feeder voltage, design limits, three-phase vs single phase).	
Phase 3	**Increasingly complex, iterative and/or coordinated analysis:** Established process conducted on a more regular basis and could be coordinated with other systems or processes (e.g., interconnection process). Analysis in Phase 3 requires more sophisticated modeling capabilities, (e.g., feeder-level analysis with power flow modeling).	
Phase 4	**Fully integrated, continuous analysis with other IDP elements:** Hosting capacity analysis may converge with other IDP elements (e.g., interconnection process and forecasting) in a streamlined and integrated manner. The future state of hosting capacity analysis may still be an unknown.	

Source: Smart Electric Power Alliance, 2020.

https://sepapower.org/resource/integrated-distribution-planning-a-framework-for-the-future/

EVs: The Quantities Could be Enormous

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"By 2025 we will have 350 gigawatt hours worth of energy storage at our disposal through our electric car fleet. Between 2025 and 2030 this will grow to 1 terawatt hours worth of storage…We can guarantee that energy will be used and stored and this will be a new area of business." VW Chief Strategist Thomas Jost: March 2020

https://www.reuters.com/article/us-volkswagen-electric-energy/volkswagen-plans-to-tap-electric-car-batteries-to-compete-with-power-firms-idUSKBN20Z2D5

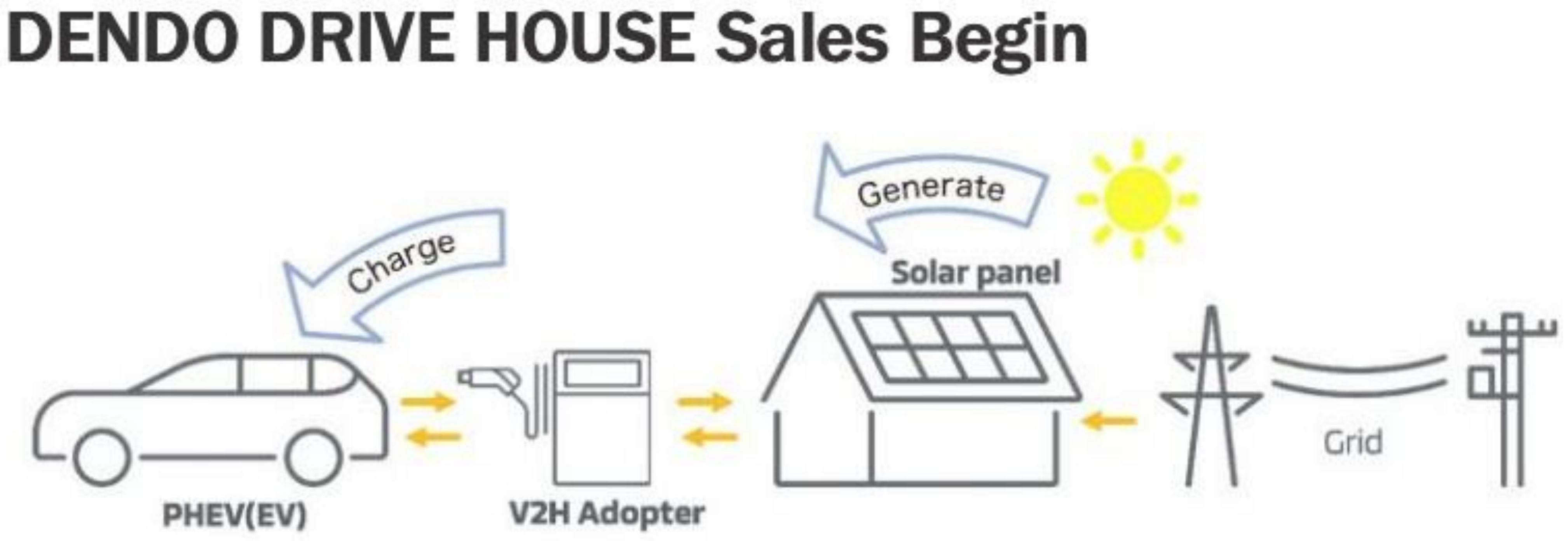
The Future? Integrated and Market-Aware Homes/EVs?

Figure 3

The home area network (HAN) will partly act as an extension of the wide area network (WAN) portion of the Smart Grid. In addition to smart metering, it will allow intelligent interaction with major appliances as well as electric vehicles.

http://archive.rtcmagazine.com/articles/view/102315

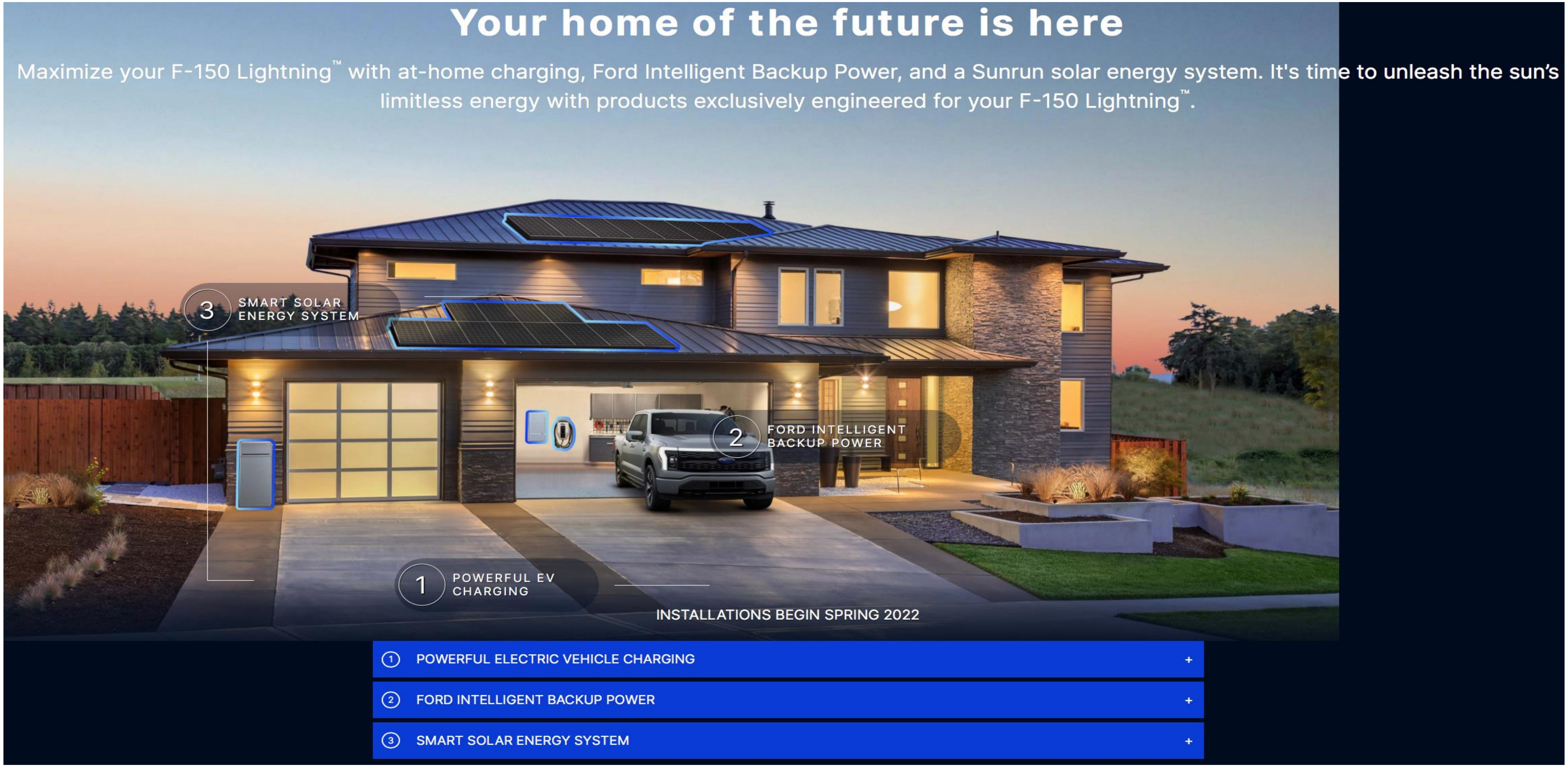
Mitsubishi Concept



DENDO DRIVE HOUSE

https://thenewswheel.com/dendo-drive-house-sales-begin/

Largest Residential Solar Co + Largest Pick-Up Automaker



https://www.sunrun.com/ev-charging/ford-f150-lightning

FERC 2222 for All Distributed Assets

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‘This rule enables DERs to participate alongside traditional resources in the regional organized wholesale markets through aggregations, opening U.S. organized wholesale markets to new sources of energy and grid services…This rule allows several sources of distributed electricity to aggregate in order to satisfy minimum size and performance requirements that each may not be able to meet individually.‘

‘Regional grid operators must revise their tariffs to establish DERs as a category of market participant. These tariffs will allow the aggregators to register their resources under one or more participation models that accommodate(s) the physical and operational characteristics of those resources.’

FERC 2222 for All Distributed Assets (Cont'd)

The tariffs also must address technical considerations such as:

- locational requirements for DER aggregations;
- distribution factors and bidding parameters;
- information and data requirements;
- metering and telemetry requirements; and
- coordination among the regional grid operator, the DER aggregator, the distribution utility and the relevant retail regulatory authority.

- Filings due by next September

CA Rule 21 Updates (Sept 2020)

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Three most notable changes:

1. incorporation of data on actual grid conditions at project locations where interconnections are requested;
2. an option for developers to propose project operating schedules that are based on grid conditions; and
3. more advanced interconnection policies for energy storage projects

(Smart inverters already a sine qua non)

Multi-Use EVs, w/Value in Multiple Domains

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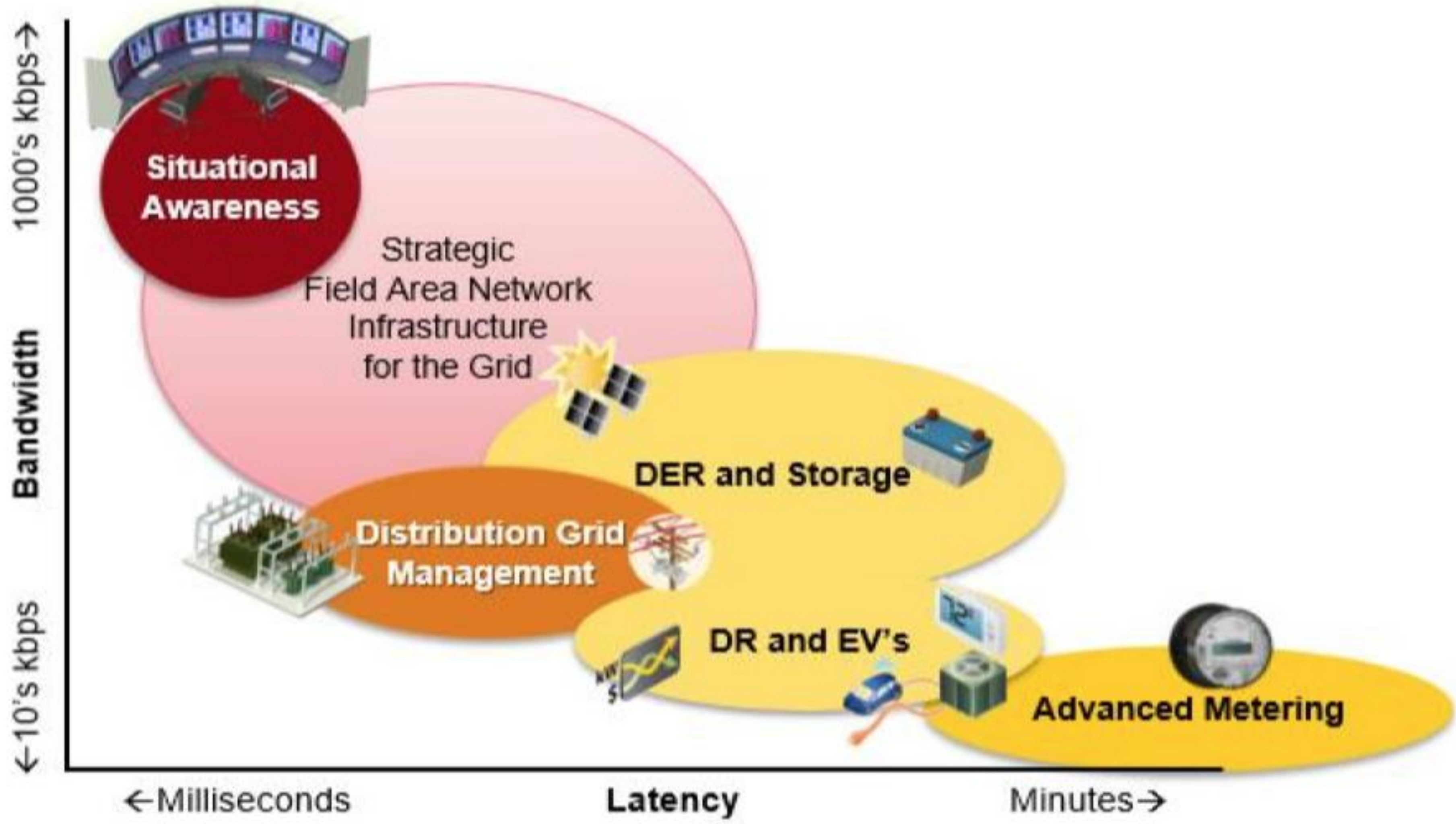
Table 1: Examples of services that can be delivered by DERs across the four high-level power system domains

Power System Domain	Behind-the-Meter	Distribution System	Transmission System	Wholesale Market
Value / Paying Entity	Individual Customer	Distribution Utility	Transmission Operator[4]	Market Operator
Services	• Retail bill management • Backup power • Microgrid / islanding • Power quality	• Distribution capacity • Reactive power / voltage support • Resilience • Community microgrid /islanding	• Transmission capacity • Primary frequency response • Transmission voltage support • Black start	• Wholesale energy • System capacity • Flexible capacity • Frequency regulation • Spinning / non-spinning reserves • Flexible ramping

https://sepapower.org/resource/multiuse-distributed-energy-resources-in-wholesale-retail-markets/

Bandwidth and Latency Increasingly Critical

Figure 23 Bandwidth and Latency Requirements



https://www.hawaiianelectric.com/Documents/about_us/investing_in_the_future/final_august_2017_grid_modernization_strategy.pdf

How Transactive Energy w/EVs May Look in the Future

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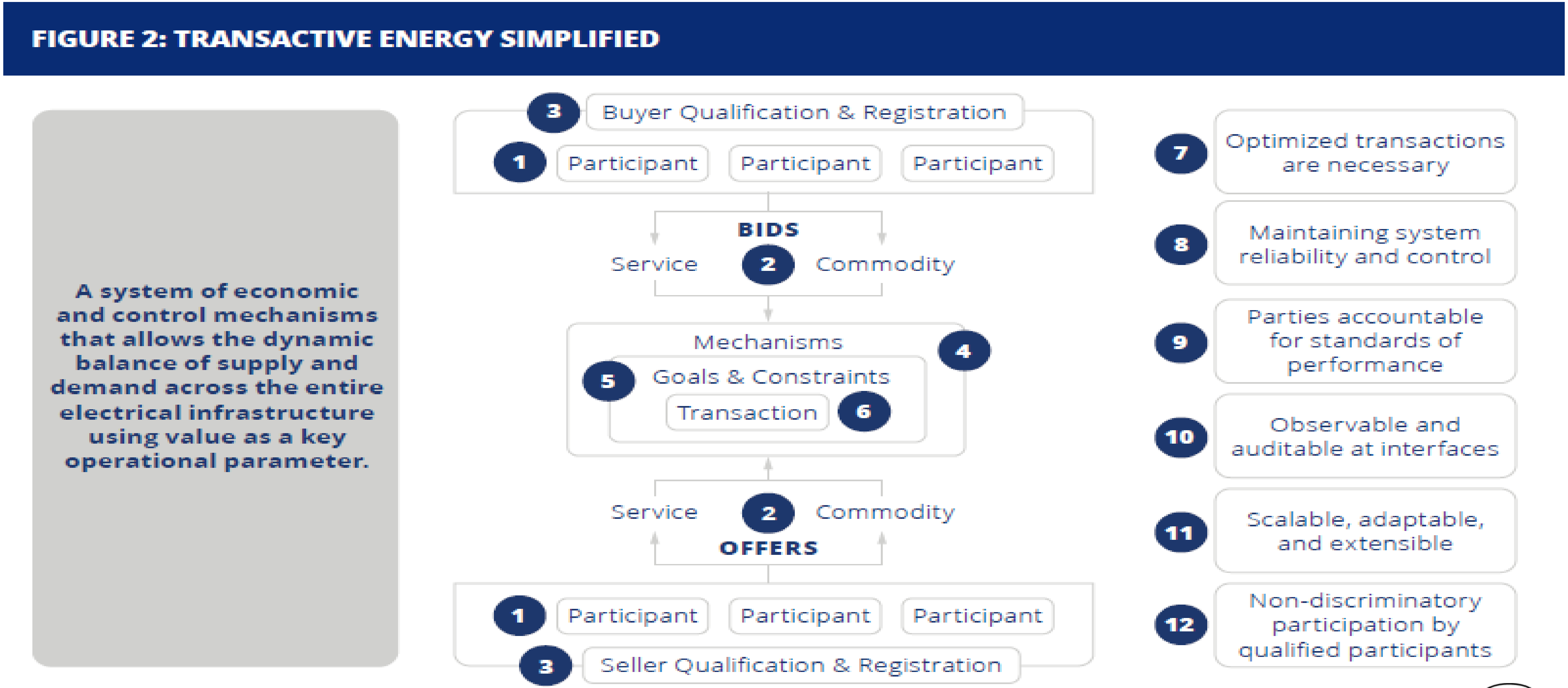

Source: Burns & McDonnell, 2019

https://sepapower.org/resource/transactive-energy-real-world-applications-for-the-grid/

Today: Little Coordination, No Interoperability

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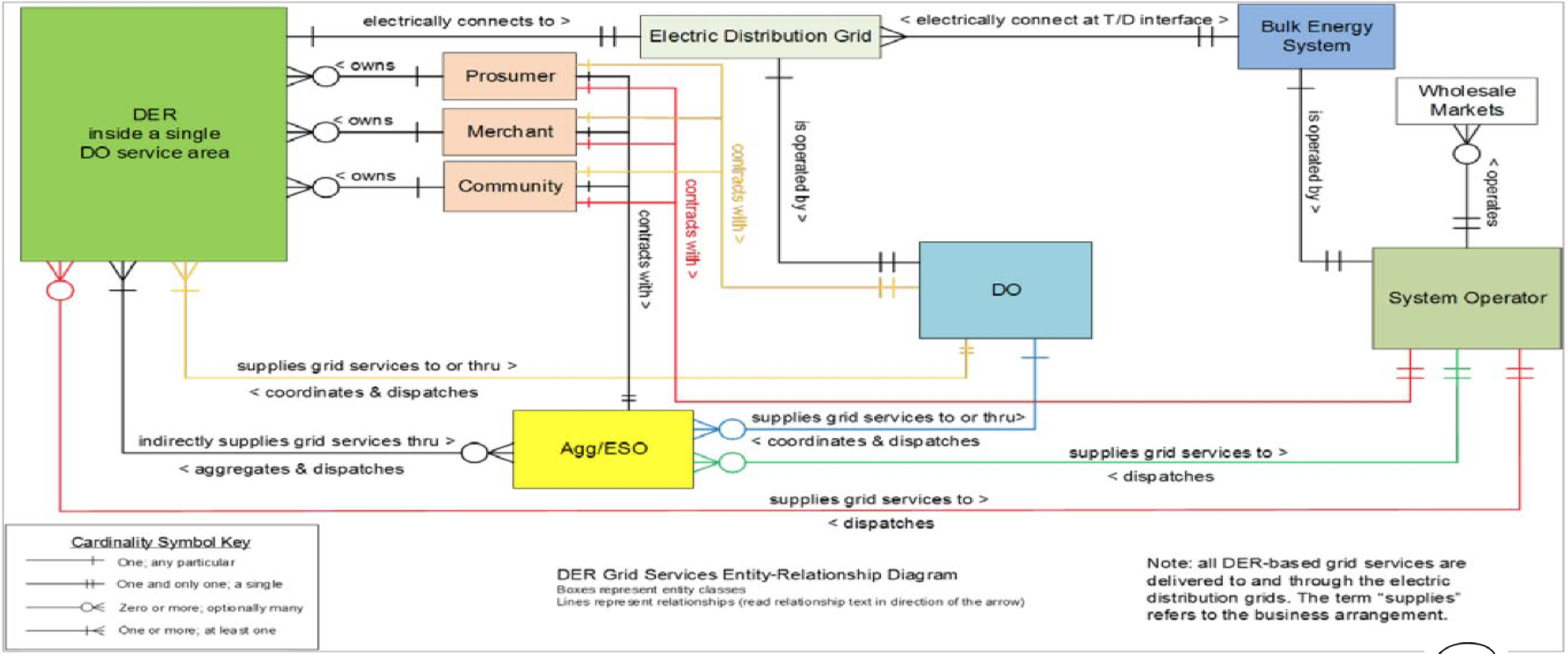

Figure 3. Existing DER Integration Industry Structure

https://gridarchitecture.pnnl.gov/media/advanced/DER_Communication_Structure_final_GMLC.pdf

A Possible Future Outcome for DERs/EVs

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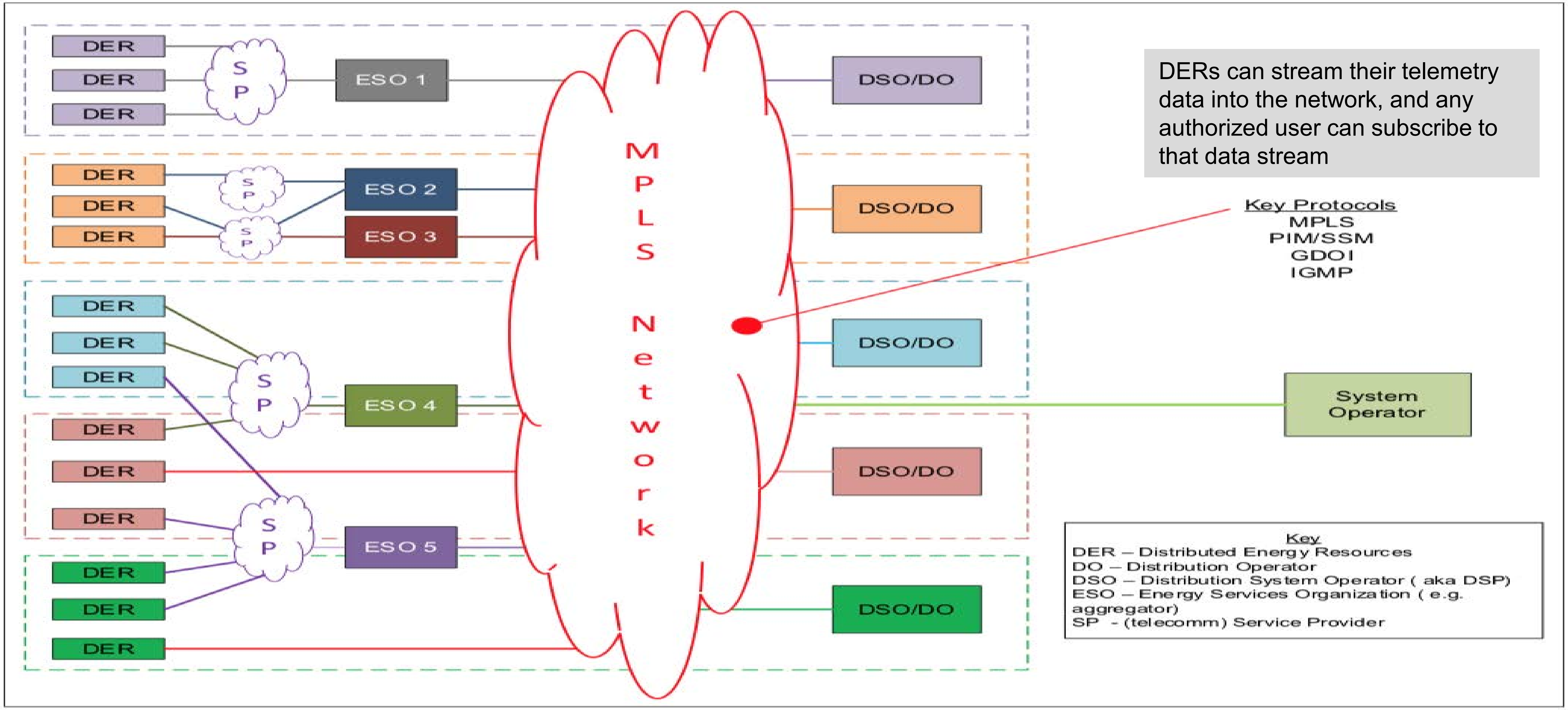

Figure 10. Network Approach to DER Telemetry Collection

Multiprotocol Label Switching - routing technique in telecoms networks directing data from one node to next based on short path labels rather than long network addresses

https://gridarchitecture.pnnl.gov/media/advanced/DER_Communication_Structure_final_GMLC.pdf

A Possible Future ‘Plug and Play’ Approach

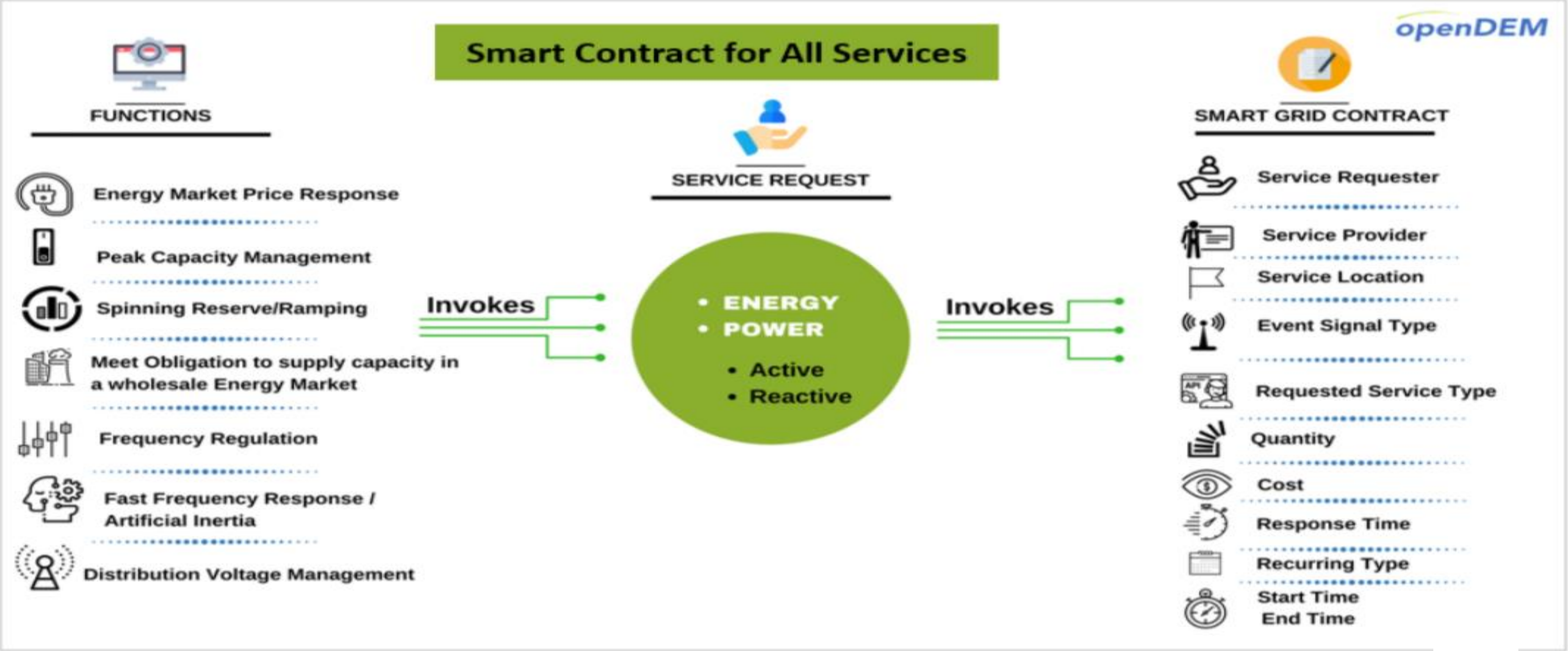

Figure 13 Smart Grid Contracts

One Final Word:
Let’s Try Not To Trade One Problem For Another

Smart Electric Power Alliance ONLINE LEARNING

https://www.transformative-mobility.org/assets/publications/TUMI-BATTERY-POSTER-March-2022-PRINT.PDF

Thank You for Joining Us!
EV Fundamentals

- Course questions? Contact Peter Kelly-Detwiler
    - pkd@northbridgeep.com
- SEPA questions? Contact Cynthia Hunt Jaehne
    - cjaehne@sepapower.org

Electrification of Transportation Fundamentals - Resources for More Information

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SEPA Resources

SEPA members are free to join any of our SEPA Working Groups and Sub-Committees. The Groups cover a number of industry-related topics and provide a community for peers to share and collaborate. The main SEPA Groups are: ***Community Solar, Cybersecurity, Electric Vehicles, Energy Storage, Grid Architecture, Microgrids, Testing and Certification****, and* ***Transactive Energy****. You can join and browse Groups and their content on the Groups site.*

- Interoperability Profile for Electric Vehicle Fleet Managed Charging
- Opportunities for Microgrids and Managed Charging to Accelerate Fleet Electrification
- Transportation Electrification Planning Framework
- Utility Best Practices for EV Infrastructure Deployment
- Residential Electric Vehicle Rates That Work
- The State of Managed Charging in 2021
- Preparing for an Electric Vehicle Future: How Utilities Can Succeed
- A Comprehensive Guide to Electric Vehicle Managed Charging
- Blog: Addressing EV Equity: Advancing Charging at Multi-Family Dwellings
- Blog: A Coordinated Approach to Fleet Electrification
- SEPA TV: Making Transportation Electrification Real for All Utilities
- Webinar: Going from 0-60: How Utilities Can Prepare for Electric Vehicle Infrastructure Deployment