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Transportation Electrification Industry Update

Presented to Arizona Transportation Electrification Strategic Plan Stakeholders

July 29, 2020

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Overview of presentation

- Arizona Context
- Zero Emission Vehicle (ZEVs) Technology
- Drivers of ZEV innovation and adoption
- Markets for ZEVs, charging infrastructure and services
- BREAK
- Potential impacts of Covid-19 Pandemic on ZEV markets and adoption
- EV Adoption, Infrastructure and Policy in Arizona Today
- Key issues for Arizona's Utilities and their Regulators
- Utility support for EV charging infrastructure and services

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Arizona Context

Where is Arizona today?

27,576

Registered Electric Vehicles
April 2020

8.8 Million

Total Registered Vehicles
June 2019

1,454

EV Charging Ports
June 2020

93%

Arizona Residents in Counties at Risk of Ozone Non-attainment

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Zero Emission Vehicle (ZEVs) Technology

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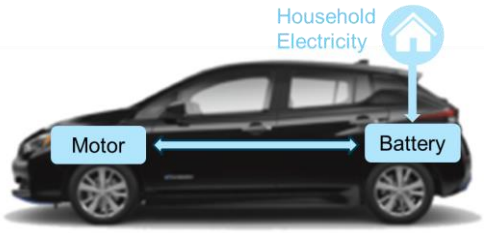
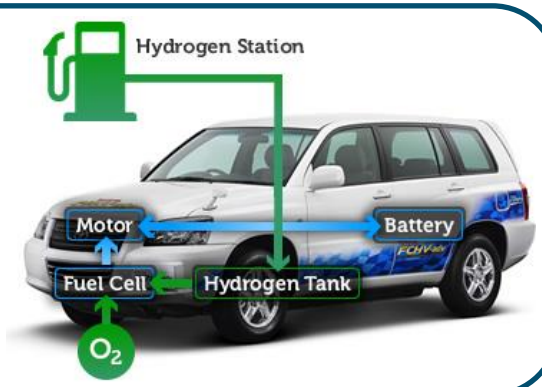
The ABCs of ZEVs

- **ZEV = Zero Emission Vehicle**
- **ZEVs can be BEVs or FCVs**
  - Both are electric drive vehicles with motors instead of engines
  - **BEV** = **B**attery **E**lectric **V**ehicle
    - Runs 100% on energy stored in the battery
  - **FCV** = **F**uel **C**ell **V**ehicle
    - Make electricity on board from hydrogen
- **PHEV = Plug-in Hybrid Electric Vehicle**
  - PHEVs can run a short distance on the electricity stored in the battery
  - They have a gasoline or diesel engine that extends their range
  - PHEVs <u>are not</u> ZEVs because they produce emissions when the engine runs
- **PEV = Plug-in Electric Vehicle**
  - **PEV = BEV + PHEV**

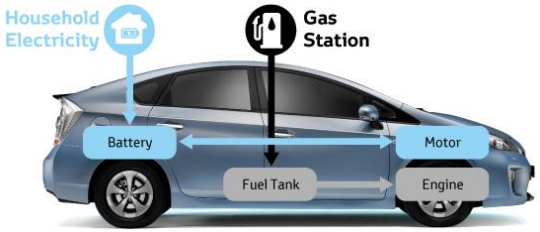
BEV



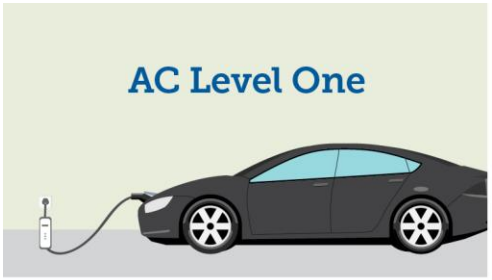
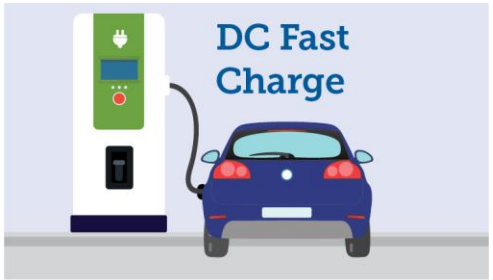
FCV



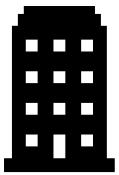
PHEV



The 1-2-3's of refueling PEVs

L1	L2	DCFC
		
VOLTAGE 120v 1-Phase AC	**VOLTAGE** 208V or 240V 1-Phase AC	**VOLTAGE** 208V or 480V 3-Phase AC
AMPS 12–16 Amps	**AMPS** 12–80 Amps (Typ. 32 Amps)	**AMPS** <125 Amps (Typ. 60 Amps)
CHARGING LOADS 1.4 to 1.9 KW	**CHARGING LOADS** 2.5 to 19.2 kW (Typ. 7 kW)	**CHARGING LOADS** 100kW and up: Typ. 100 kW
CHARGE TIME FOR VEHICLE 3–5 Miles of Range Per Hour	**CHARGE TIME FOR VEHICLE** 10-60 Miles of Range Per Hour	**CHARGE TIME FOR VEHICLE** 80% Charge in 20–30 Minutes

Newer DCFC are much faster and have loads of 350 kW and up



https://sunlightsolar.com/ev-charging/

The 1-2-3's of refueling EVs

Level 1 Charging

Source: thedriven.io

Public Level 2 Chargers

Tesla Superchargers

Source: TeslaDriversClub.com

Electrify America Ultra-Fast Charging Plaza

Source: FutureCar

Hydrogen refueling stations

- Most FCVs have a ~300 mile range, like conventional cars
- Hydrogen refueling stations are still scarce and mainly concentrated in California, where public financing has been available
- FCV truck manufacturer Nikola is starting to develop a national network of stations

The universe of ZEVs

Maturity of ZEV technology varies: Several types at or close to commercialization

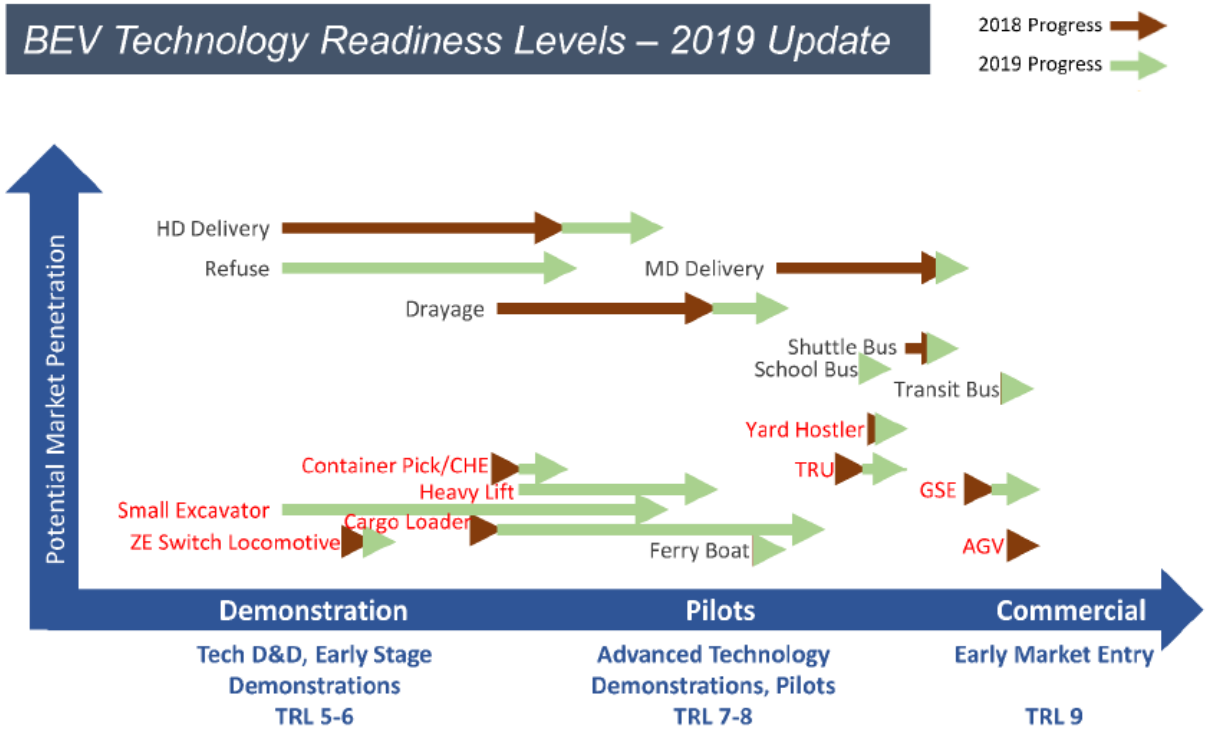


Figure 2: Technology Status Update – Battery Electric

Key: Off-road shown in red
AGV = automated guided vehicle
GSE = ground support equipment
CHE = cargo handling equipment
TRU = transport refrigeration unit
ZE = zero emission

Source: Based on CARB technology assessments, industry research, interviews with manufacturers, project data and status and other studies and publications.

https://ww2.arb.ca.gov/sites/default/files/2019-08/draft_techpathways_08012019.pdf

- The California Air Resources Board (CARB) regularly surveys ZEV technologies
- Method for survey originally developed by NASA
- CARB's analysis shows how different ZEV technologies are advancing toward commercialization
- Several types of MD/HD and off-road vehicles are at or near market readiness:
  - Buses
  - MD delivery
  - Freight handling
  - TRU

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Drivers of ZEV Innovation and Adoption

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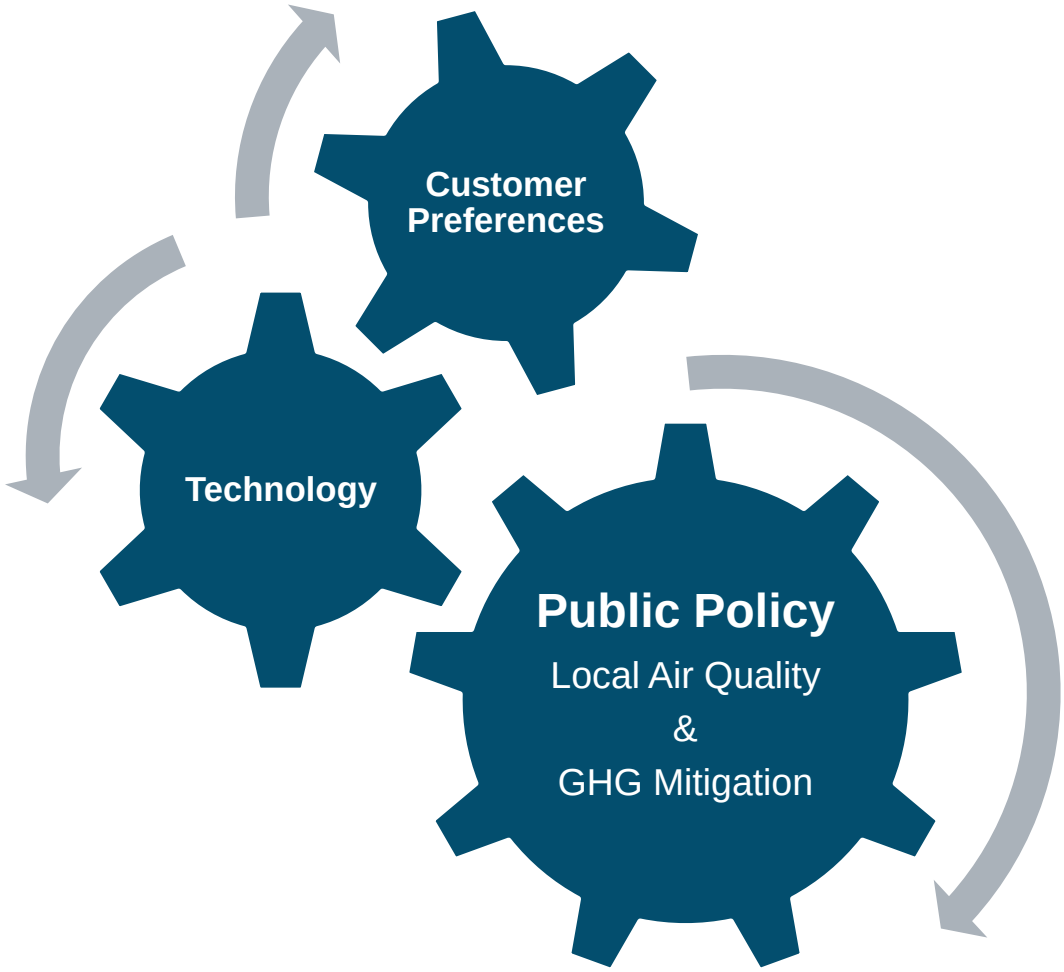
Drivers of Innovation & Adoption



Public policies around the globe are advancing ZEV technology and markets

CANADA

- GHG mitigation targets
- Strong push from federal government, cities and most provinces on ZEVs
- Expensive gasoline and cheap electricity

EUROPE

- Stringent GHG & air regulations
- Strong policy support for ZEVs at all levels of government
- Widespread public support to address climate change
- 2nd largest EV market

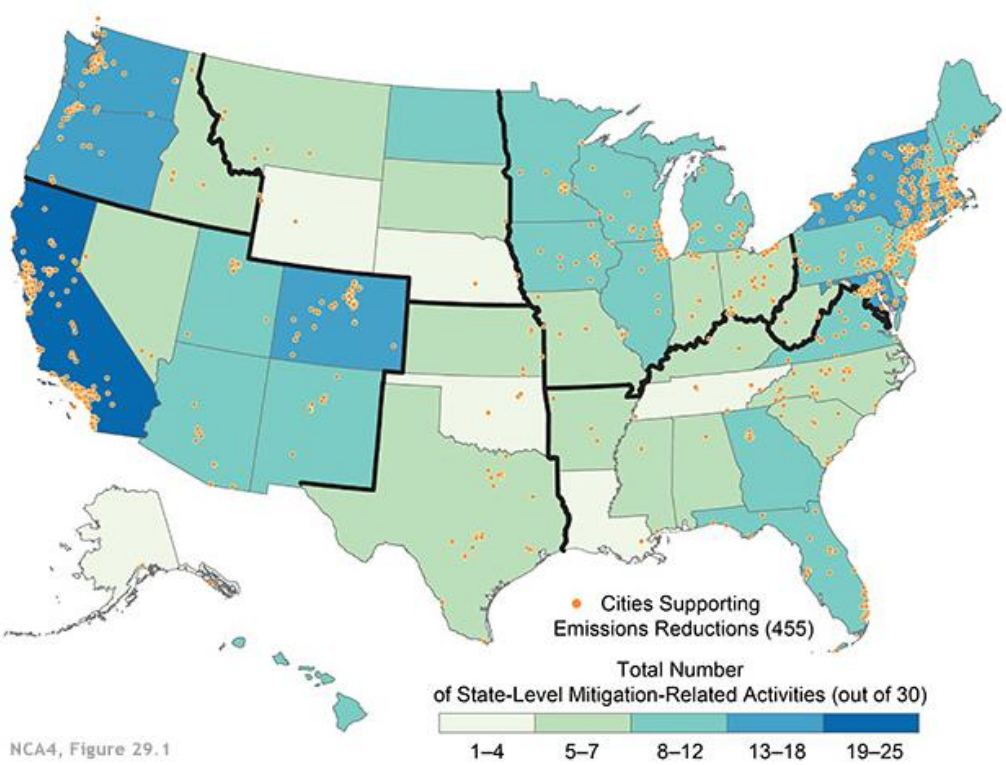
UNITED STATES

- States and local governments lead
- Cheap gasoline and electricity
- Consumer preference for trucks & SUVs and long distances hinder demand for current ZEVs

CHINA

- World's largest EV market
- Coordinated national and local ZEV, GHG, and air policies
- Cheap electricity
- Focused industrial policy favors ZEV production

States and cities lead GHG mitigation efforts in the U.S.



- **U.S. lags other developed countries in addressing GHGs, especially for transportation sector**
- **Pres. Obama's GHG mitigation initiatives have been mostly rolled back under current administration**
  - Many legal challenges: 2nd Trump term likely to see many court battles over rollbacks
  - Biden likely to return to, accelerate previous administration's policies

https://www.climate.gov/news-features/featured-images/national-climate-assessment-states-and-cities-are-already-reducing
https://www.americanprogress.org/issues/green/reports/2020/04/30/484163/states-laying-road-map-climate-leadership/

Partnerships are key to developing and implementing initiatives to support EVs

- **State and local governments collaborating with utilities, OEMs, stakeholders on EV strategic plans**
- **Several states have authorized utility investment in EV charging infrastructure**
- **Collaborative efforts to educate consumers about benefits of EVs**
- **Automakers (OEMs), states and cities also providing funding and other kinds of support for charger deployment**
- **Settlement agreement for VW emissions testing scandal injected new funding to support EV adoption and deployment of chargers**
  - $2B to new subsidiary, Electrify America, to deploy coast-to-coast DCFC charging network, urban charging and smart mobility solutions
  - $2.7B in NOx Mitigation Funds distributed to states to finance local purchase of low/zero emissions vehicles and charging infrastructure

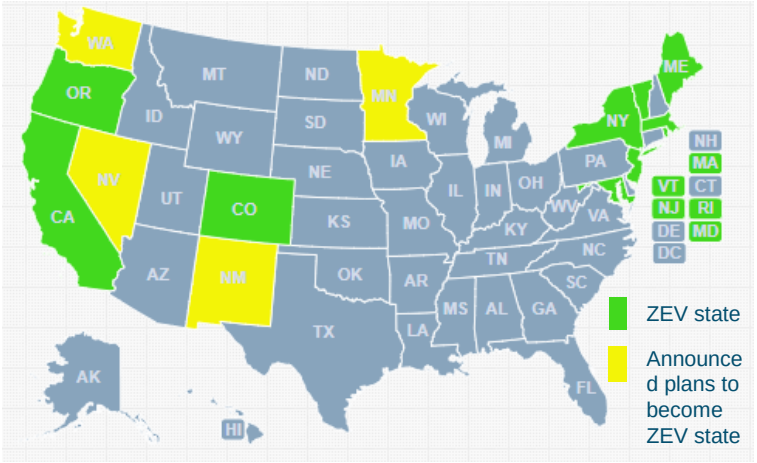
Intermountain states working together to develop regional charging corridors

- **The governors of Arizona, Idaho, Montana, Nevada, New Mexico, Utah, Colorado and Wyoming have signed an MOU that aims to:**
  - Enable EV owners to "seamlessly drive an electric vehicle across the Signatory States' major transportation corridors."
  - Foster public and private sector investment in EV charging stations and grow EV adoption in the region.
- **Signatories also have adopted voluntary standards for DCFC stations to guide development and provide a consistent, easy experience for EV owners**

MEMORANDUM OF UNDERSTANDING
Between
Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah and Wyoming Regional
Electric Vehicle Plan for the West

California exercises outsize influence

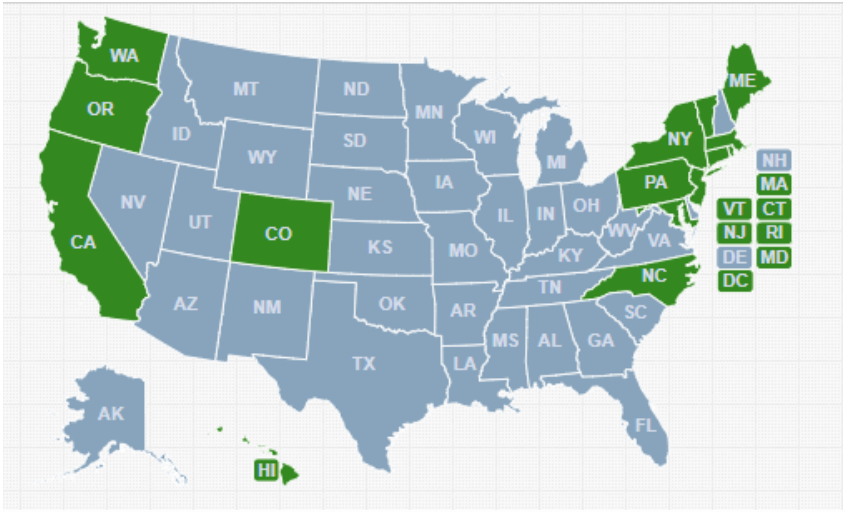
ZEV States



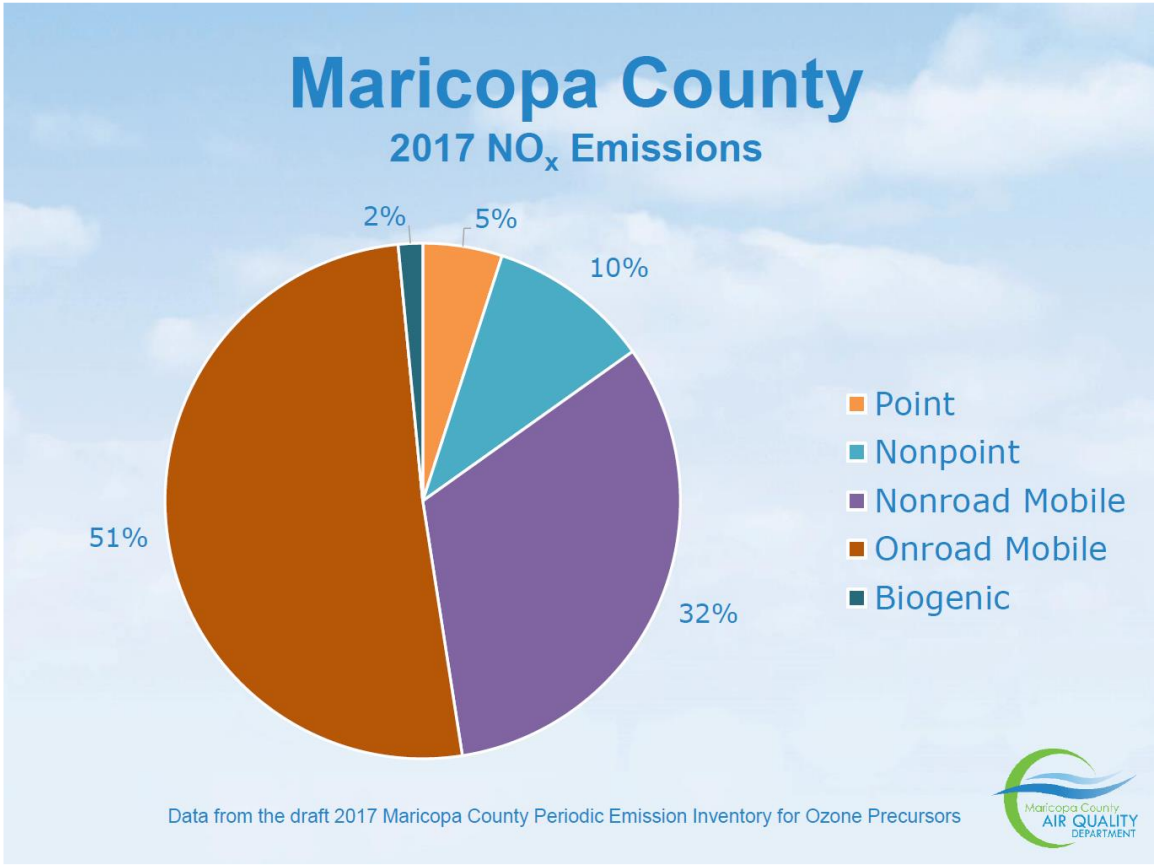
- The federal Clean Air Act lets California set its own (stricter) tailpipe standards
- §177 lets other states adopt CA's regulations
- CA has stretched this regulatory authority to extend from smog-forming pollutants to CO_2
- CA's ZEV regulation sets manufacturer sales mandates for BEVs, PHEVs and FCVs

MD/HD MOU Signatories

- California and 14 other states have pledged to transition all MD and HD vehicle sales to ZEV technology by 2050
- Interim goal: 30% ZEV sales by 2030
- Builds on ongoing CA rulemakings
- Emphasis on public health, especially improved air quality in low-income and disadvantaged communities



Air quality is a concern in Arizona, and vehicles are an important source

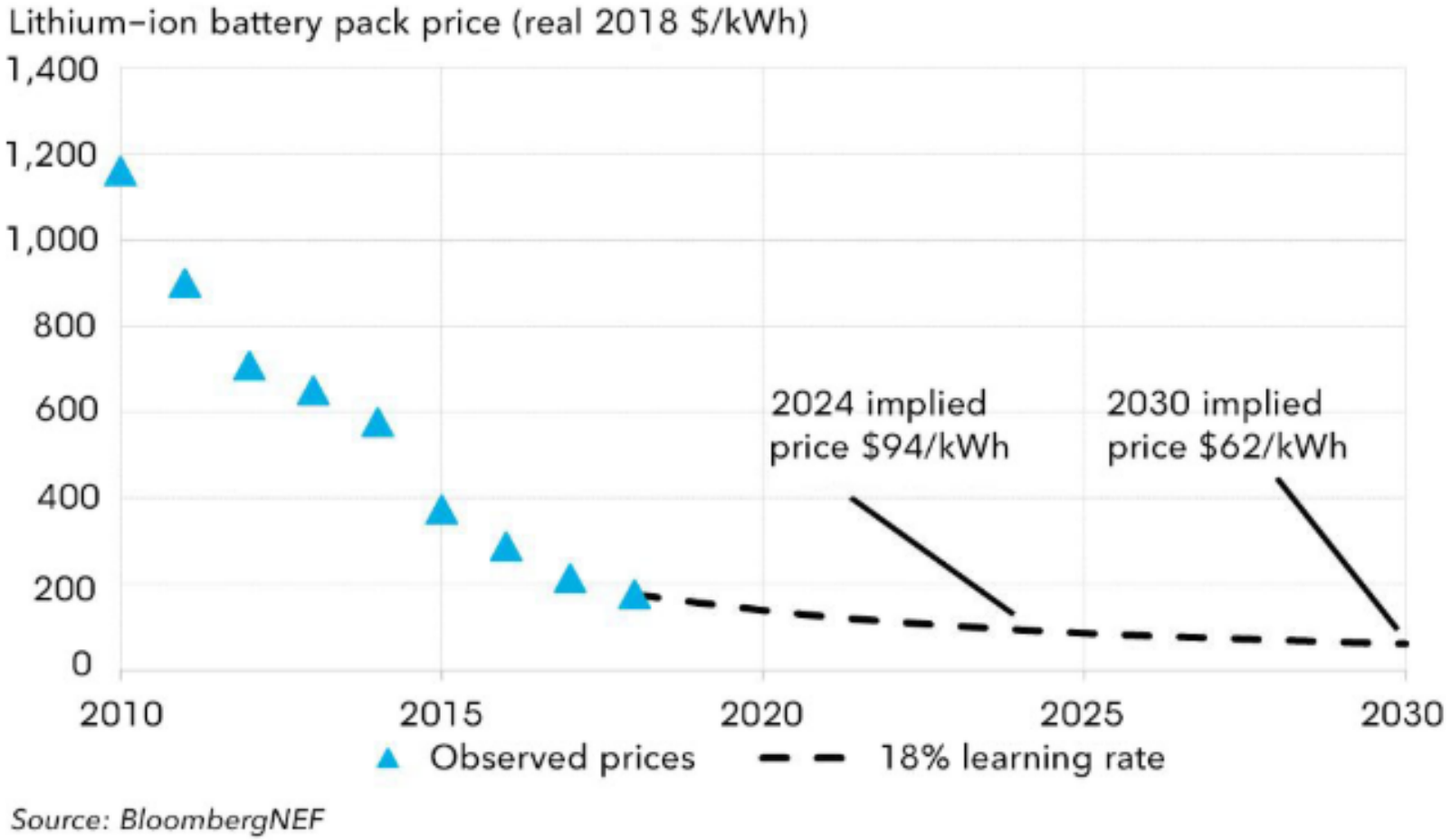


Source: Maricopa County Air Quality Department

- 93% of Arizonans live in counties that are close to exceeding federal limits on ground level ozone, the main "ingredient" in smog.
- Ozone forms when NOx and VOCs react in sunlight
- Mobile sources account for over 80% of the NOx emissions in Maricopa County
- Diesel trucks, buses and equipment also emit fine particles ($PM_{2.5}$ and PM_{10}), which also contribute to smog & respiratory disease

Drivers of Innovation: Technology

+ **The steady decline in battery prices is projected to continue…**



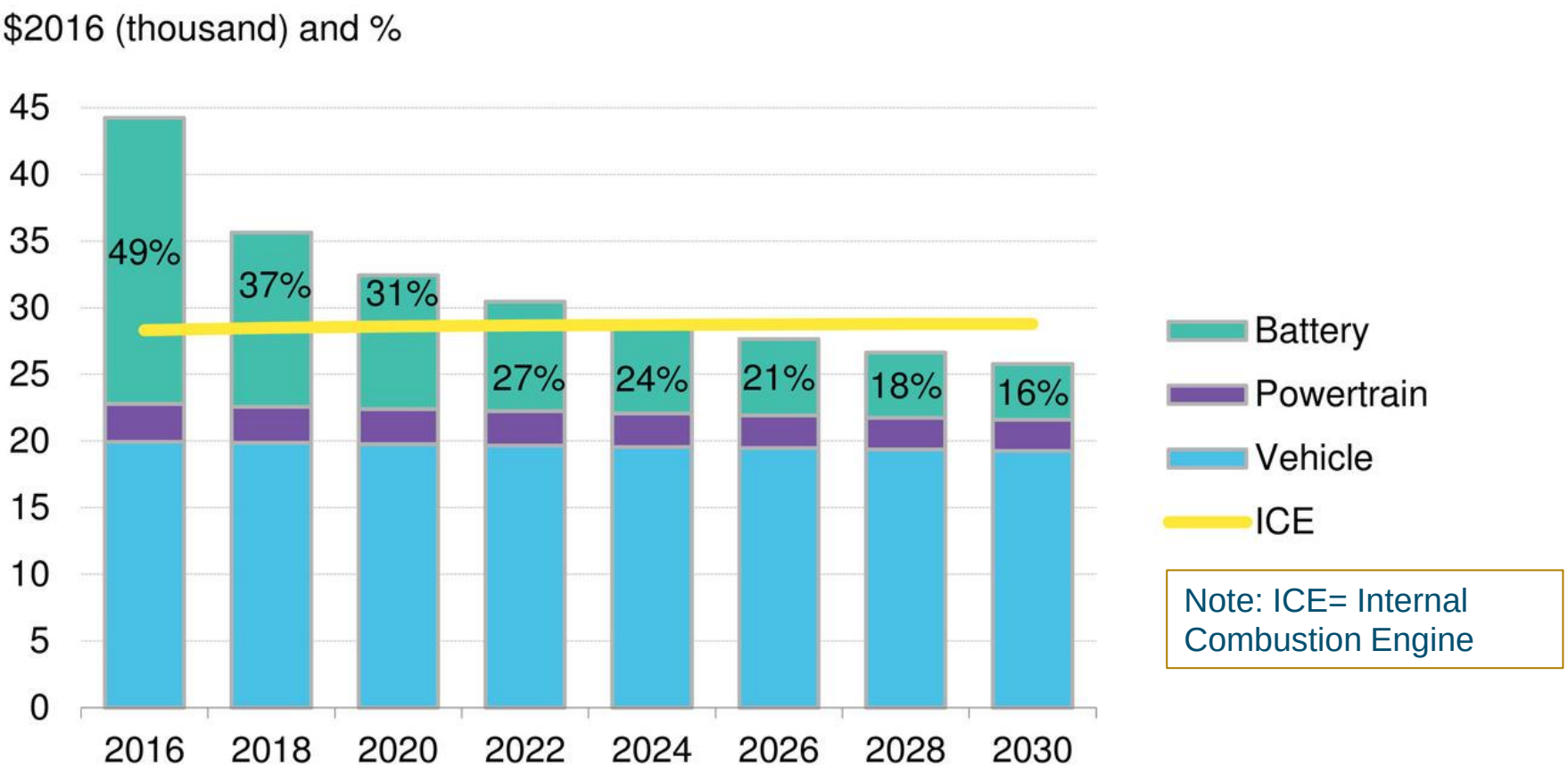
Source: BloombergNEF

Battery forecast chart: https://about.bnef.com/blog/behind-scenes-take-lithium-ion-battery-prices/

Drivers of Innovation: Technology

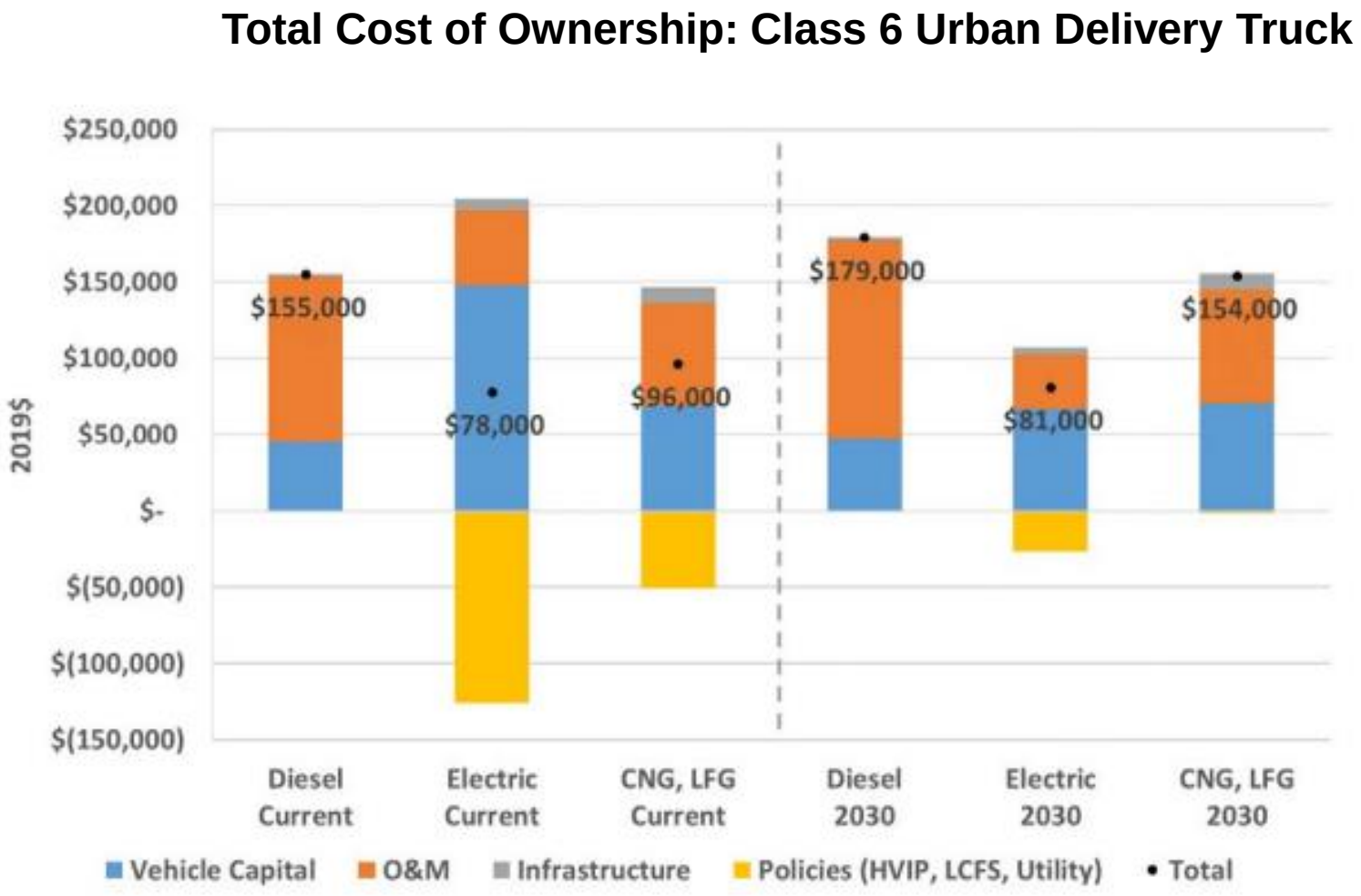
+ PEVs could reach price parity with conventional vehicles by 2024

EV and ICE vehicle upfront cost projection



Source: BNEF. "Electric Vehicle Outlook 2019" (2019). Available at: https://about.bnef.com/electric-vehicle-outlook/.

Total Cost of Ownership is declining for Medium and Heavy Duty ZEVs



Source: Comparison of Medium- and HeavyDuty Technologies in California, CalETC and NRDC. Available at: https://caletc.com/wp-content/uploads/2019/12/ICF-Truck-Report_Final_December-2019.pdf

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State of markets and ZEV adoption: US and global

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Purchase considerations for cars vary across market segments

Personal Transportation

- **Range**
- **Ability to meet buyer's mobility needs**
- **Purchase cost**
- **O&M costs**
- **Make green choice**
- **Image**

Commercial Fleets

Taxi/Ride-share

- **Top priorities for purchaser:**
  - Total cost of ownership (TCO), including purchase price, fuel and O&M.
  - Ability to serve fleet's needs (range, size, etc…)
- **Additional considerations:**
  - Green brand image
  - Support/comply with local policies

Consumers will soon have many more choices, expanding the potential buyer pool

Number of Planned BEV Product Launches as of 1/1/2020

Start of production	2019	20	21	22	23	24	2025	Total
Large	35	49	30	39	35	15	15	
Medium	23	39	33	24	17	9	7	
Small	38	25	13	15	10	6	8	
Total	96	113	76	78	62	30	30	485

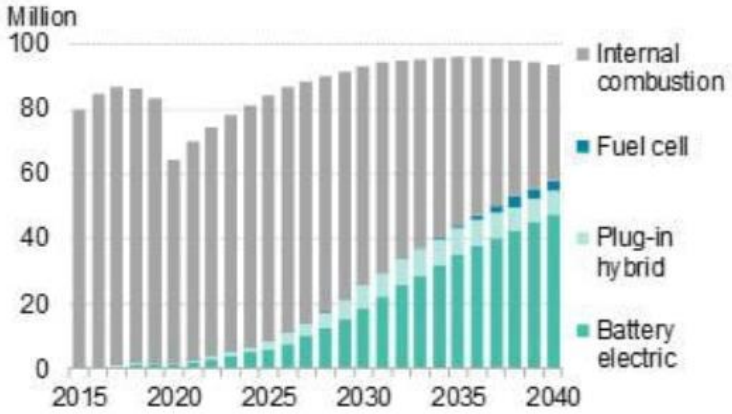
Note: Small = A/B, medium = C, large = D/E segments

+ Not all will be offered in US markets
+ Pandemic likely to delay introduction of some new models in U.S.

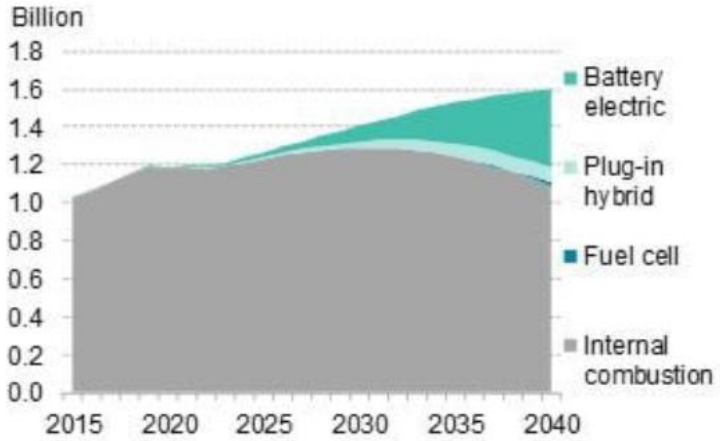
Source: McKinsey & Co., The Road Ahead for e-mobility. Available at: https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/the-road-ahead-for-e-mobility

Current state of adoption and forecast market growth: Light Duty Vehicles

Global annual passenger vehicle sales by drivetrain



Global vehicle stock by drivetrain

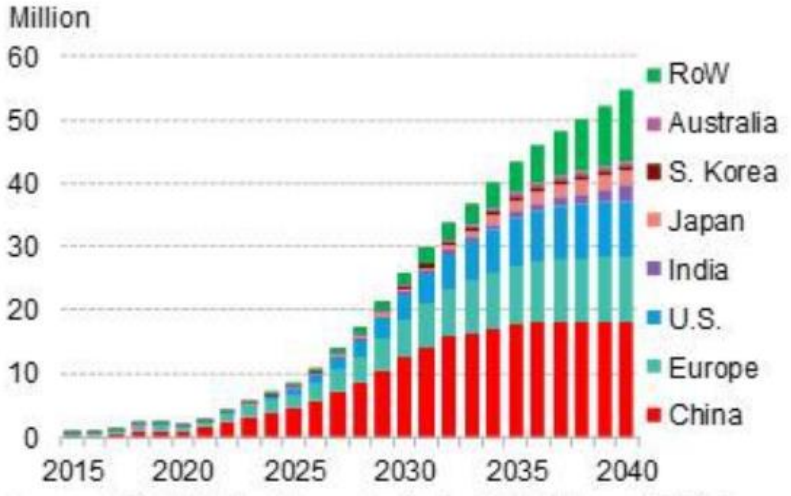


- **ZEVs will account for over 50% of the passenger vehicle market by 2040**
- **The impact of the Covid-19 epidemic on vehicle sales lasts several years**
- **ZEV's share of the vehicle stock will fall more slowly unless public policy promotes (or requires) early retirement of conventional vehicles**
- **Other researchers are less optimistic than BNEF, but all project rising ZEV market share**

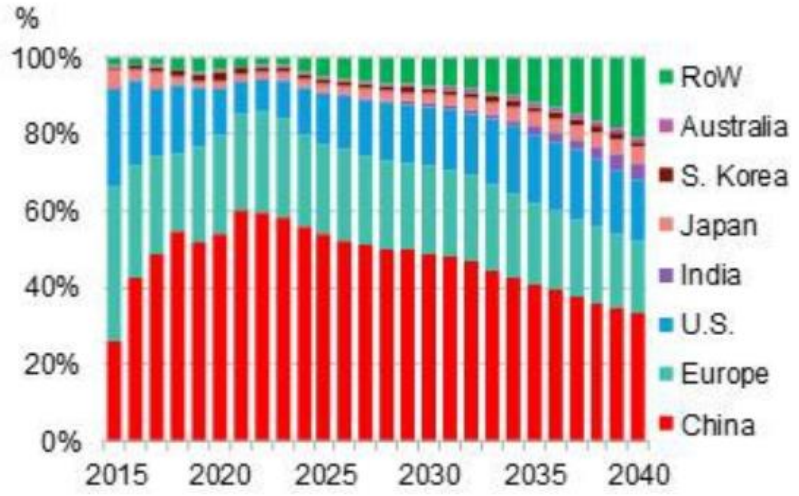
Charts from BNEF EV Outlook 2020. Available at: https://about.bnef.com/electric-vehicle-outlook/

Bloomberg: China and Europe dominate EV sales in near-term

Annual passenger EV sales by region



Regional shares of annual passenger EV sales



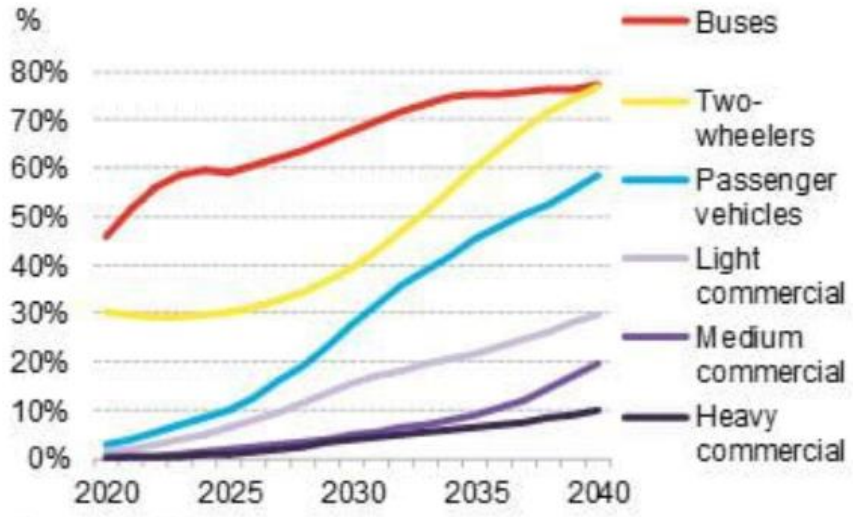
+ **China dominates EV market through 2030**
  - Economic growth and rising middle class drives car sales
  - Strong policy support at all levels of government drives EV market share
  - Development of EV manufacturing is a key element of national industrial policy
+ **Europe is 2nd largest market in near term due to public policy**
  - GHG and air quality goals begin to "bite" in early 2020s
  - National governments and cities incentivize EV adoption

Charts from BNEF EV Outlook 2020. Available at: https://about.bnef.com/electric-vehicle-outlook/

Projected global adoption of commercial EVs

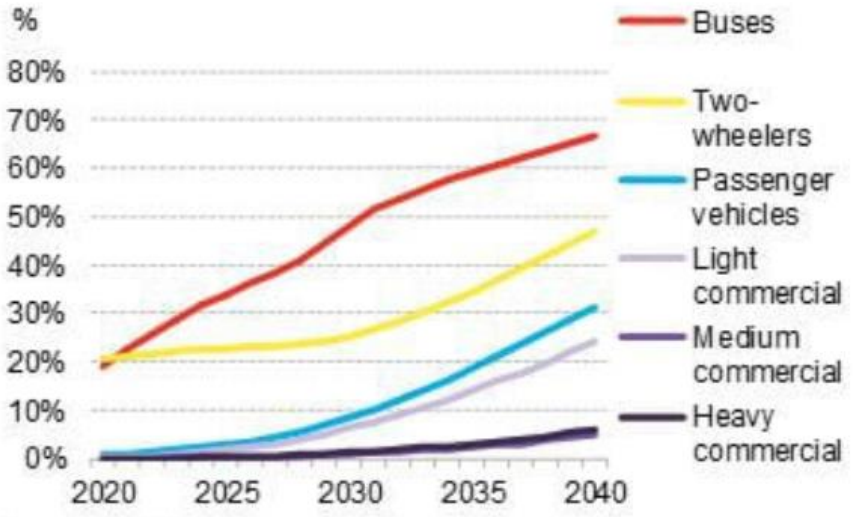
- Electric buses account for over half of global sales within a few years and dominate fleets by 2040
- Slower but steady growth for medium and heavy-duty trucks, starting with local and regional fleets
- Light commercial category includes most delivery vans and trucks

Figure 15: EV share of global new vehicle sales by segment



Source: BNEF.

Figure 16: EV share of global vehicle fleet by segment



Source: BNEF.

Trucks have diverse vocations and will electrify at different rates

Long Haul Freight

Regional distribution

Final mile delivery

Local service delivery

Drayage

Transport Refrigeration Unit

Sources, clockwise starting top left: TFL Truck, Wikipedia, Green Fleet Magazine, Clicon Solutions, Dray Hub, Ricor Inc

Delivery fleets are poised for rapid electrification

- Vehicles have been developed through long-term collaborations between delivery companies and truck manufacturers.
- Amazon has invested in start-up Rivian and plans to deploy 100,000 of its electric delivery vans by 2030, with a goal of 10,000 on the road by end of 2021
- FedEx deployed 1,000 electric delivery vans in 2019
- Amazon has also recently acquired Zoox, an autonomous vehicle developer, for $1B
- Ford and Volkswagen have announced a partnership to build 8 million delivery vans and pickup trucks globally
- GM recently announced plans to develop an electric van for fleets like Amazon and UPS scheduled to go into production in late 2021

Regulation and grants encourage adoption of ZEV transit, school and shuttle buses

+ Zero Emission transit buses in US cities

- Almost every state has a transit agency that owns an e-bus thanks to federal grants and VW settlement funds
- New York, Philadelphia and King County, WA (Seattle) currently running tens of e-buses and plan to purchase hundreds as older buses are replaced
- California has mandated that all transit bus fleets must be zero emission by 2040 and requiring that all buses purchased in 2029 and after are BEVs or FCVs
- King County plans to build a new 250-bus charging base in an area with historically poor air quality

+ BEV school buses

- Several states using VW settlement funds to replace diesel school buses with BEVs
- Dominion Energy partnering with Virginia school districts to replace 100% of their 1,000 diesel buses by 2025
- Demonstration projects are exploring V2G applications for school buses

+ Many shuttle bus vocations well-suited for ZEV

Electric options emerging for off-road: construction, agriculture, mining, warehouses

- **Large manufacturers across construction, agriculture and mining (e.g. John Deere, Komatsu, Caterpillar) collaborating with tech start ups to advance electrified equipment**
- **"Born electric" models will be more powerful, reliable and affordable than earlier versions built off existing platforms.**
- **Convergence of three trends:**
  - Falling battery costs and improved electric drive technology
  - Digitization/connectivity
  - Robotics/automation
- **Benefits may include lower O&M costs, increased efficiency, reduced emissions, improved indoor air quality, lower noise levels**

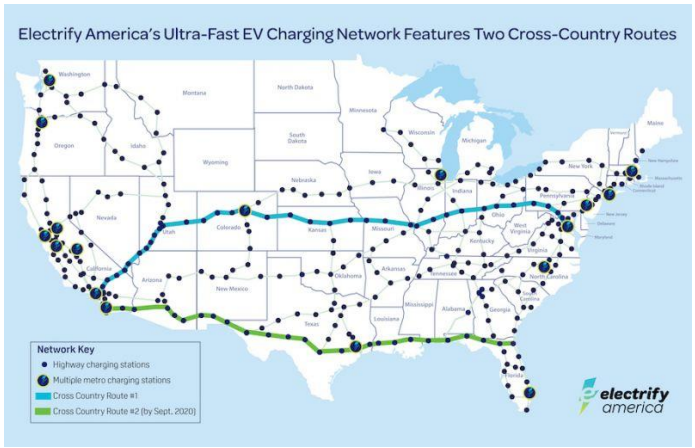

Developments and challenges in charging technology

- **DCFC becoming more powerful as OEMs/EVSPs seek to emulate gas station experience of "quick fill"**
- **Stakeholders weigh the costs and benefits of networked vs. non-networked chargers**
- **Challenges for MD/HD:**
  - No standards yet for charging equipment
  - Business models developing for support services
  - Balancing grid needs with operational considerations

Many business models for EVSPs, but no clear winner yet

Volta

Electrify America



Tesla

EVGo

ChargePoint

Utilities

Sources, clockwise from top left: SF Gate, Future Car, Tesla, Pepco, ChargePoint, Slashgear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Potential impacts of Covid-19 pandemic on ZEV markets and adoption

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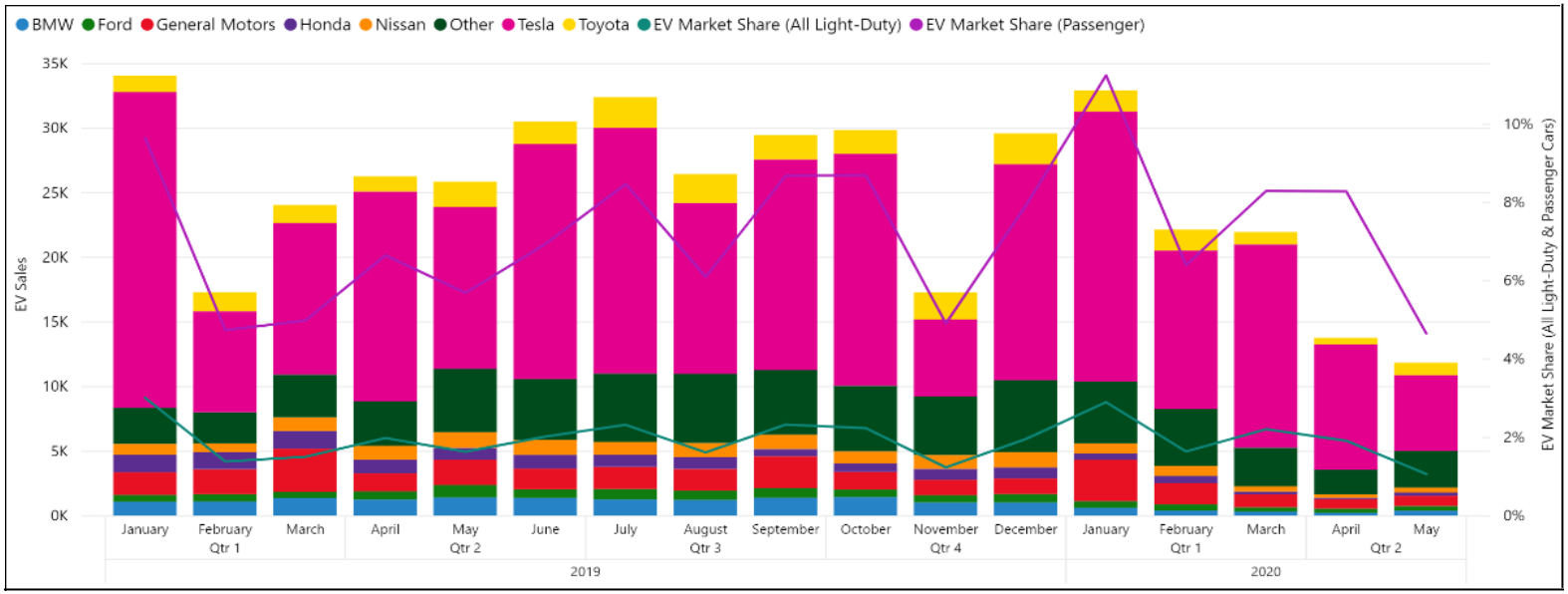
The Covid-19 pandemic has severely affected auto sales, EVs especially

- **<u>Immediate</u> impacts on light duty vehicle and EV markets:**
  - Economic crisis has caused auto sales to plunge: Q2 2020 was down 33% from 2019
  - EVs' share of sales has dropped by over half
  - OEMs have had to close plants at times and supply chains have been disrupted
- **Public transit faces an existential crisis**
- **Freight volumes are mostly down and volatile, truck sales down**
- **Last mile deliveries have surged by a factor of ten**

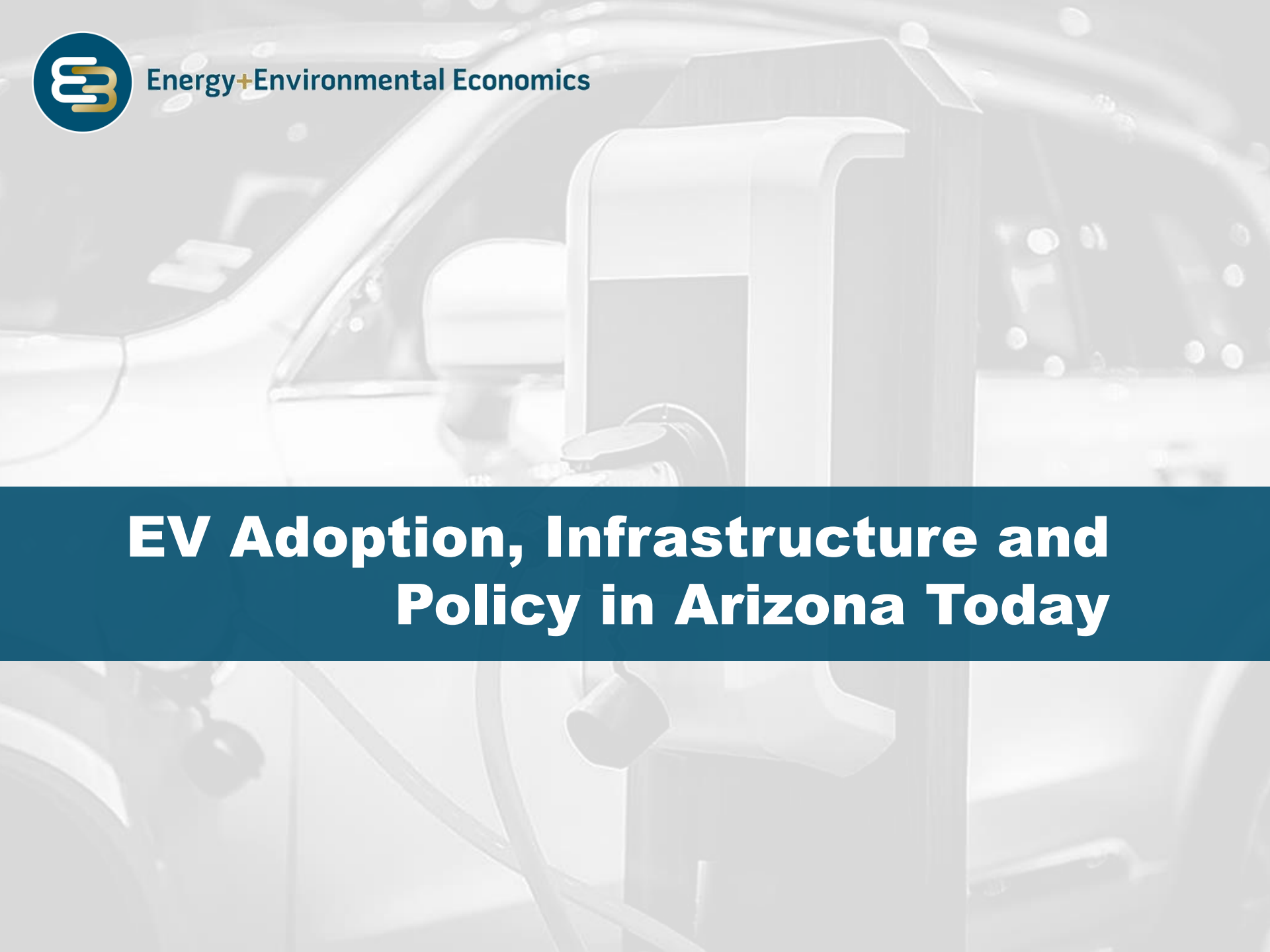


Source: Atlas EV Hub

Impacts of the Covid-19 Pandemic are unclear, likely to unfold over several years

+ **Personal transportation**
  - More remote work means less commuting and traffic
  - Driving personal vehicle seen as safer and (for now) easier than before
  - Ridesharing saw 70-80% declines during shutdowns, picking up now with new protective measures

+ **Accelerated shift to on-line shopping expected to stick→ tailwind for electrification of delivery fleets?**
+ **Implications of economic downturn:**
  - Reduced freight traffic and profits are headwinds for HD electrification
  - Transit fleet electrification could be delayed by fiscal crises from low ridership: but transit users prefer buses to rail when they have an option
  - Fiscal crisis for state and local governments may reduce resources to support TE
  - Potential infusion of federal funds, perhaps some targeted to EVs
+ ***Will the Pandemic cause a reappraisal of the risk of climate change?***



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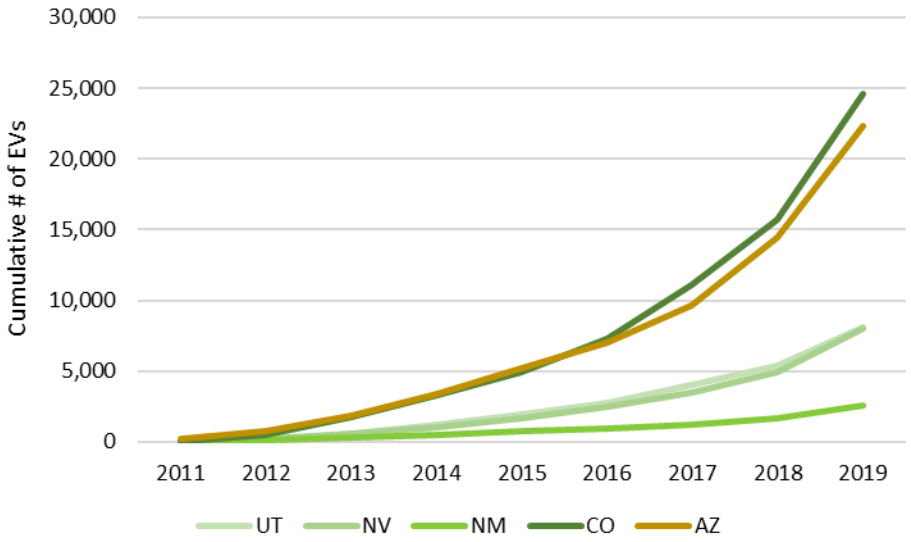
EV sales and market share growing in Arizona

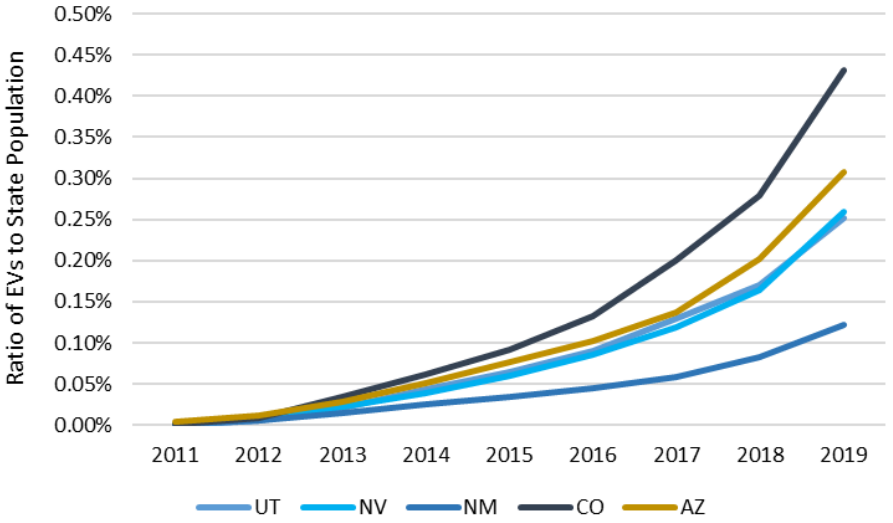
+ EVs sales have been increasing in Arizona and its neighboring states

Cumulative sales in AZ and neighboring states



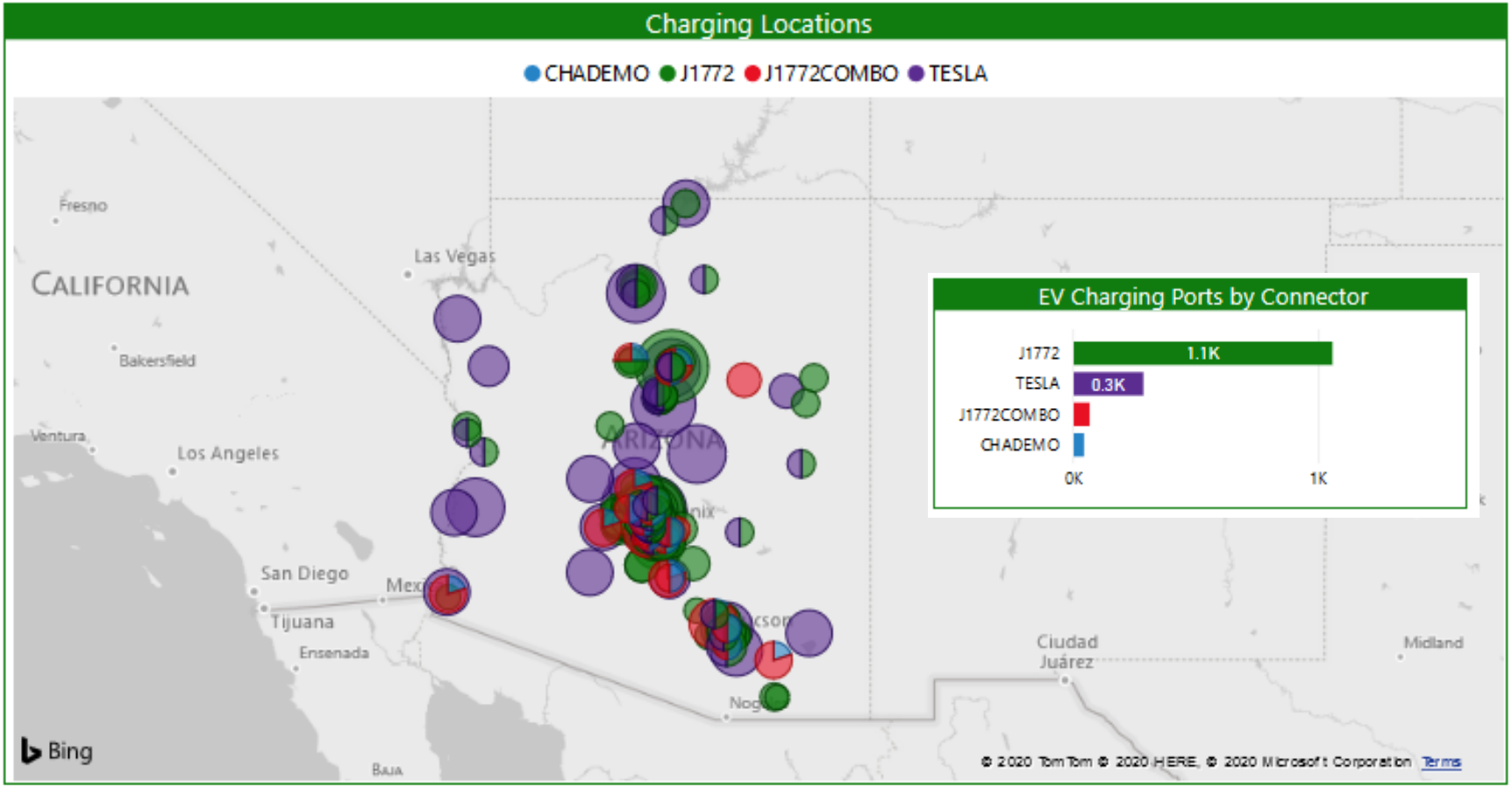
For reference, CA reached 605,000 EVs in 2019

Sales as a portion of state population



For reference, CA reached a ratio of 1.5% in 2019

Arizona charging infrastructure today: Mostly Level 2 and Tesla



Source: EV Atlas Hub

Arizona charging infrastructure

# of chargers by charger power		
Charger type	**Public L2**	**Public DCFC**
# of ports	1,111	343
# of locations	489	66

# of chargers by charger brand		
Charger type	**Tesla**	**Non-Tesla**
# of DCFC ports	232	111
# of L2 ports	108	1,003

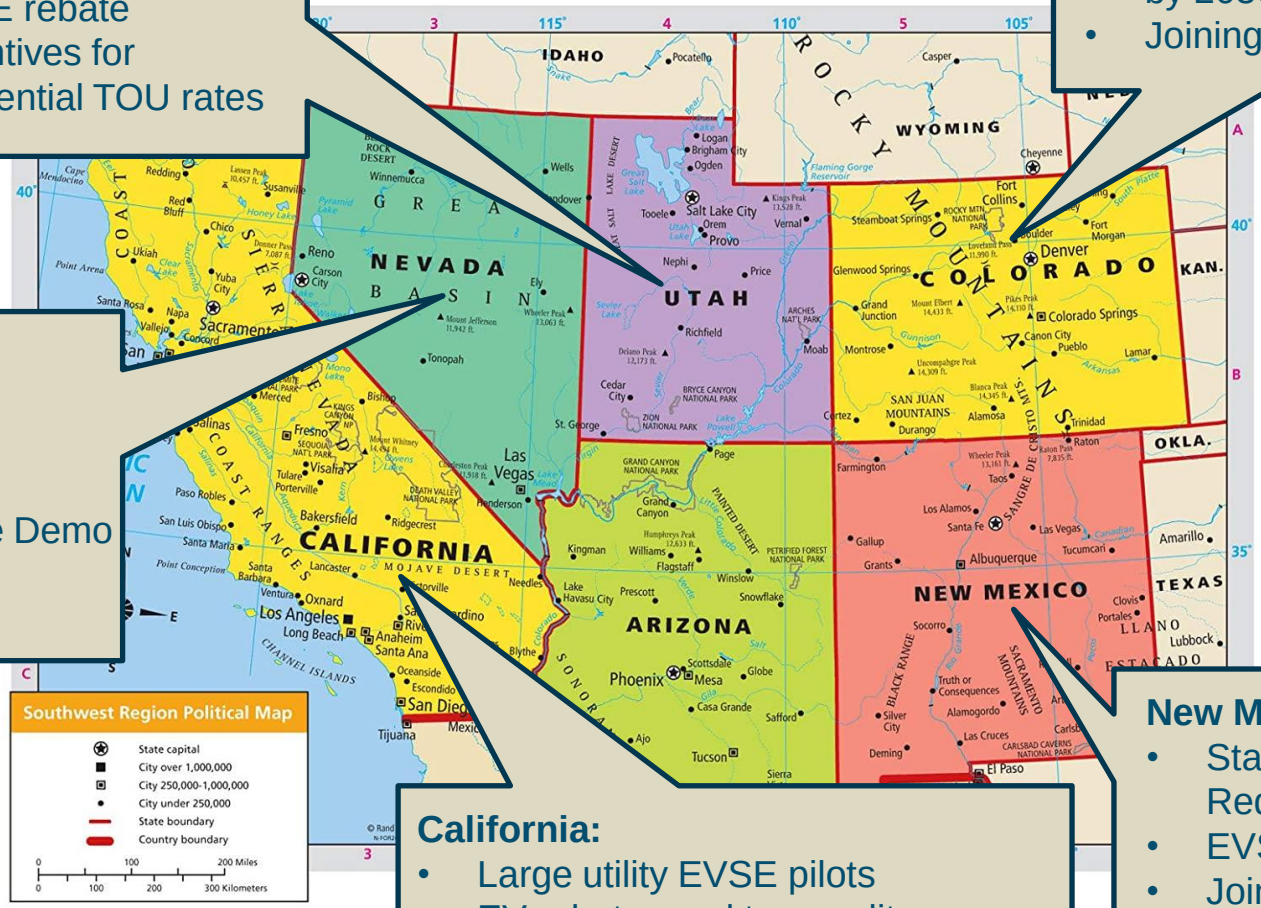
Source: EV Atlas Hub

Minding the neighbors

Utah:
- EVSE Plan
- HD AFV tax credit
- EVSE rebate
- Incentives for residential TOU rates

Colorado:
- Colorado EV 2020 Plan
- Programs for DCFC and fleets
- MD/HD zero-emissions by 2050 goal
- Joining ZEV

Nevada:
- Utility EVSE incentives
- Utility EV Infrastructure Demo program
- Joining ZEV



California:
- Large utility EVSE pilots
- EV rebates and tax credits
- Mandates for ZEVs across vehicle types, fleets in place or on the way

New Mexico:
- State Emissions Reduction Strategy
- EVSE funding
- Joining ZEV

Key Arizona policies

- **AZ has enacted a number of policies to support Alternative Fuel Vehicles (AFVs), which include ZEVs.**
  - AFVs have access to HOV lanes (ARS 28-2416, 23-24106.01, 28-2511)
  - Requirements for federal and state fleet make-up and purchasing in AZ
    - Federal fleets that operate in populous AZ counties must be composed of at least 90% AFVs (ARS 49-573)
    - State fleet purchasing requirements ARS 41-803
  - Tax credits for residential charger installations ($75 tax credit)
- **Cities throughout AZ have also been establishing TE policies**
  - Phoenix City Council has adopted GHG emissions reduction goals (80% below 2012 levels by 2050, 30% by 2025, carbon neutrality by 2060)
  - Flagstaff recently declared a climate emergency and plans to reach carbon neutrality by 2030
  - Tucson preparing a city-wide transportation master plan
- **AZ has a AV-friendly regulatory environment as a result of several executive orders signed by Governor Ducey**
  - Institute for Automated Mobility established in Executive Order 2018-09
  - Public agencies required to support testing and operating of AVs, enables pilot programs on university campuses (Executive Order 2015-09)

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Key issues for Arizona's Utilities and their Regulators

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- Drivers of ZEV innovation and adoption
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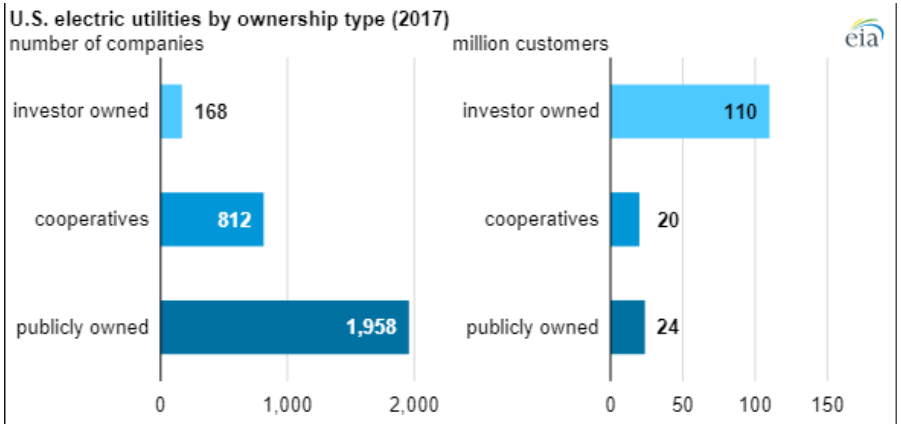
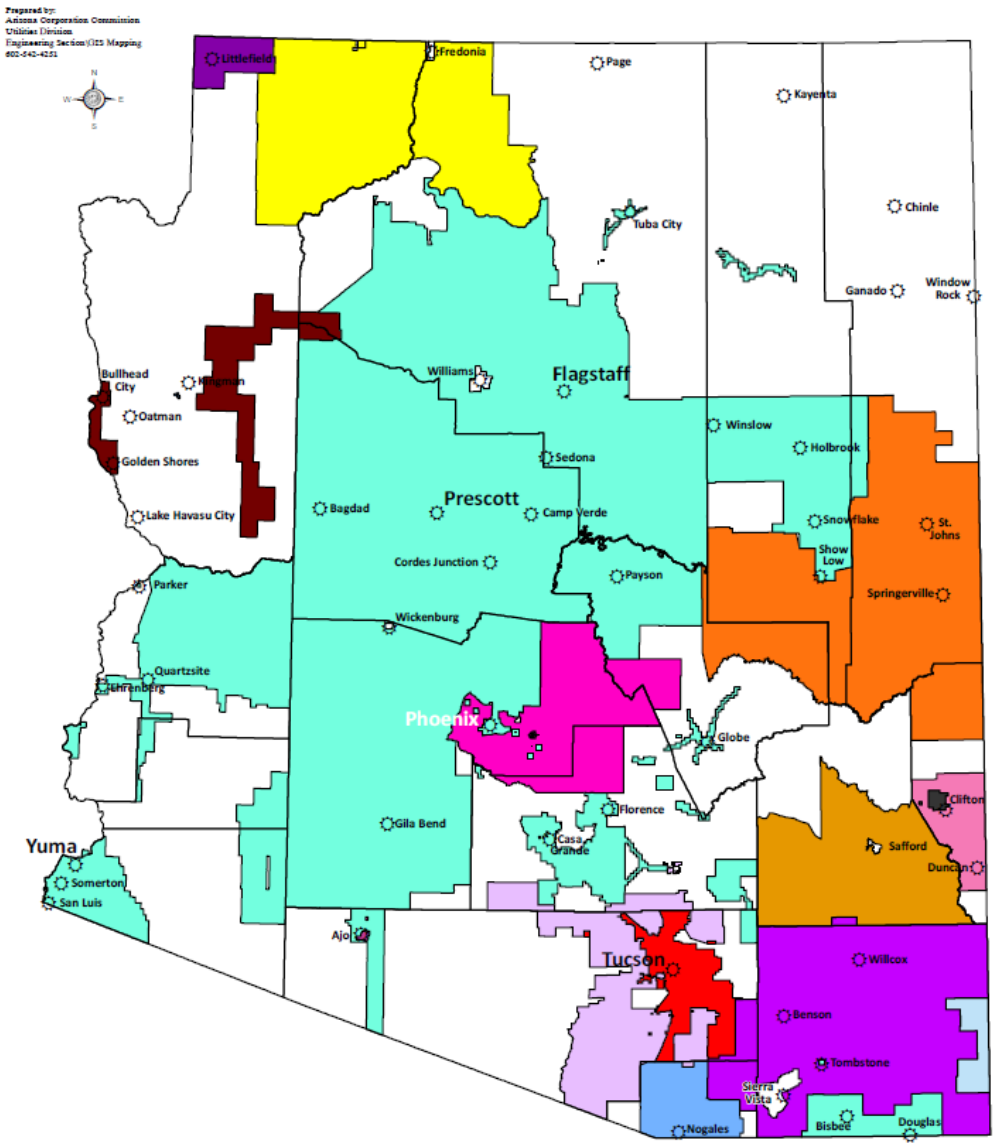
- Utility support for EV charging infrastructure and services

US electric utilities are local monopolies: Balkanized but most load served by IOUs



Source: https://www.eia.gov/todayinenergy/detail.php?id=40913

Arizona has a mix of utility types



Arizona Electric Utilities

- Ajo Improvement Company
- Arizona Public Service
- City of Mesa
- Columbus Electric Co-op
- Dixie Escalante Rural Electric Association
- Duncan Valley Electric Cooperative
- Garkane Power Association
- Graham County Electric Cooperative
- Mohave Electric Cooperative
- Morenci Water & Electric Company
- Navopache Electric Co-op
- Salt River Project
- Sulphur Springs Valley Electric Co-op
- Trico Electric Cooperative
- Tucson Electric Power

IOUs regulated at the state level

- **IOUs are regulated monopolies**
  - Public utility commissions regulate almost all aspects of vertically integrated utilities' operations
  - Monopoly franchise and commission oversight limited to Distribution (and sometimes transmission) in restructured states (mostly in the middle and NE parts of the US)
  - California has a hybrid structure, of course…
- **Public utility commissions are usually appointed by governors subject to legislative confirmation, but some states (including Arizona) elect their commissioners**
- **Traditional responsibilities of PUCs:**
  - Safety, reliability, affordability
  - Rate levels and designs
  - Long and short term resource planning
  - Cost recovery for utilities' operating and capital expenses

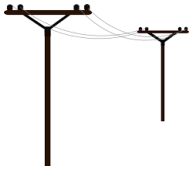
How can electric utilities support transportation electrification?

EV Adoption Barriers, Challenges & Opportunities:

Adoption Barriers:

- Limited awareness, info, enthusiasm
- Insufficient charging infrastructure & range anxiety
- Lack of dealer incentives to sell EVs
- Limited vehicle model availability (outside CA)
- Upfront cost premium vs. conventional vehicles

Integration Challenges:

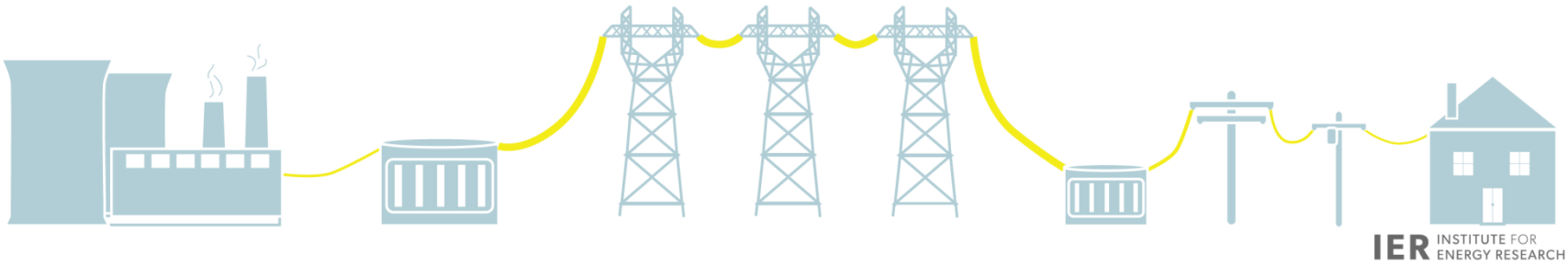


- Control loads to minimize distribution costs
- Shape loads to support renewable integration

How will EVs affect the grid?

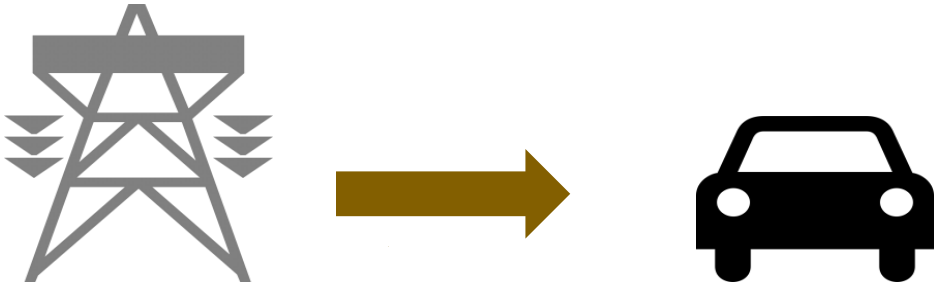
Bulk Power System | **Local Grid**

GENERATION TRANSMISSION DISTRIBUTION

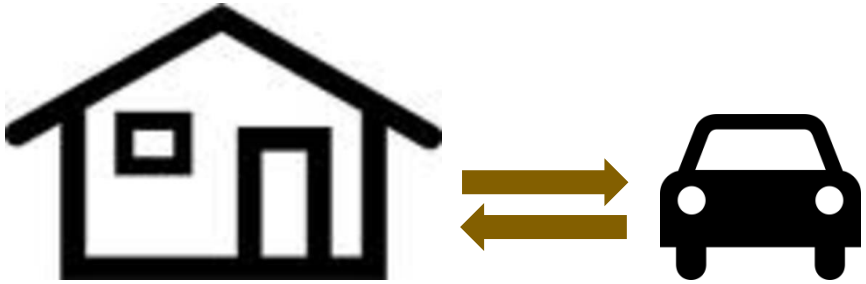


- **Do we need new power plants or transmission lines to support PEV charging?**
- **What are the opportunities to exploit the latent flexibility in PEV charging load to balance out fluctuations in renewable energy generation?**
- **Will EV charging overload local distribution circuits?**
  - New upgrades needed?
  - Safety/Reliability affected?
- **Can PEV charging be timed to coincide with rooftop solar generation?**

Technologies and policies are developing to support vehicle-grid integration (VGI)



'Smart' charging (or 'V1G') through targeted utility tariffs or communication from grid operator to aggregator / vehicle



V2H/V2B/V2X capability can enhance PEV value proposition

V2G capability allows PEV to discharge to grid, receive payment for services

Smart Charging Approaches: V1G

+ Price signals:

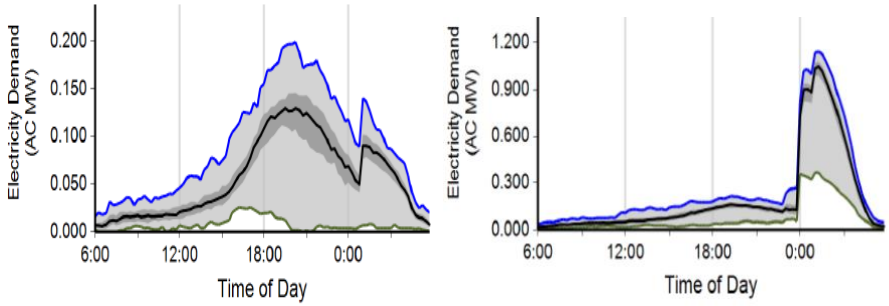
- Time of use (TOU) rates vary on a fixed schedule and are higher during periods of peak demand on the bulk power system
- Dynamic rates vary from hour to hour with conditions on the bulk system or local grid

+ Managed charging:

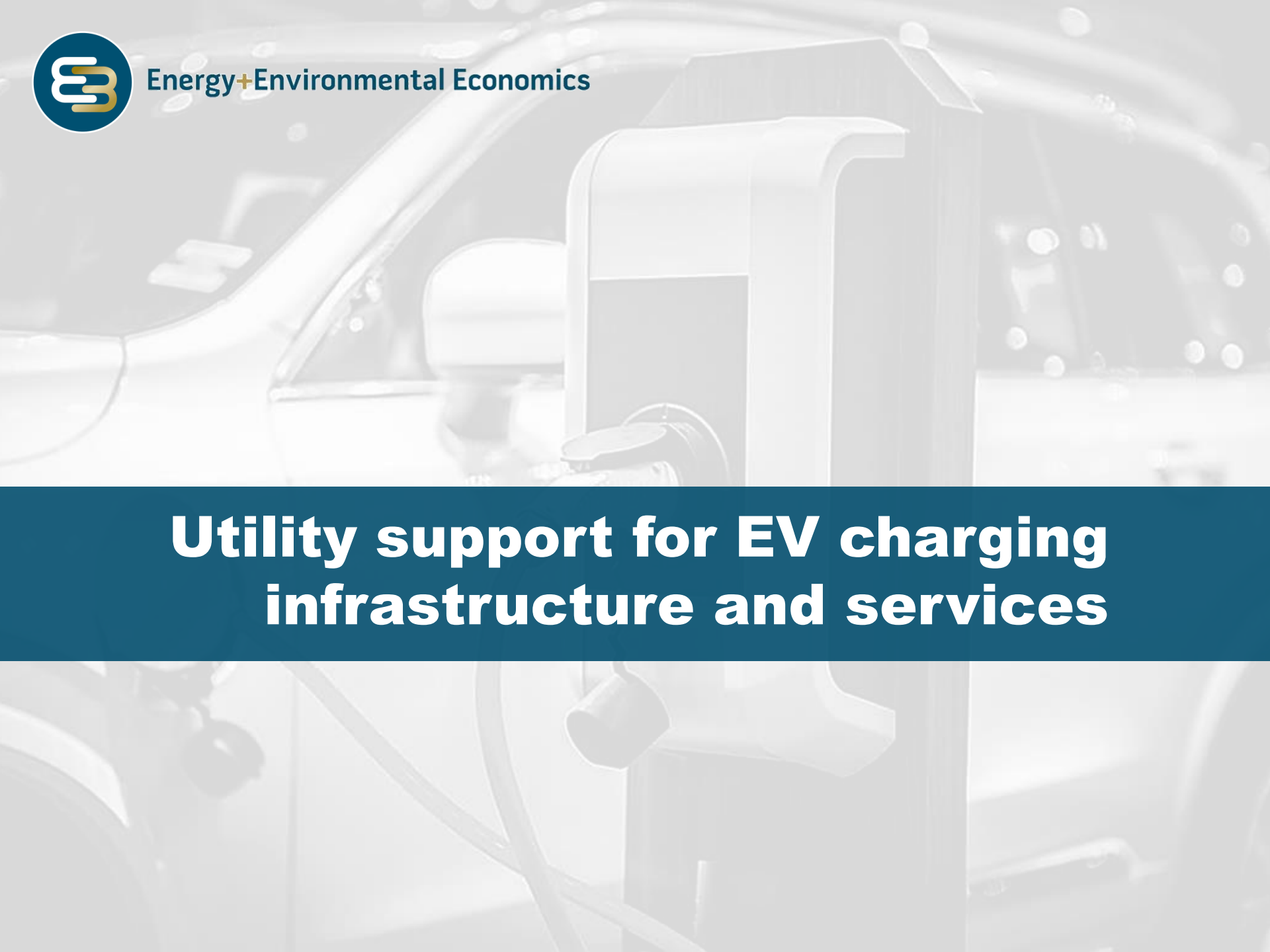
- The utility or a third party directly controls when or at what rate a vehicle charges
- Customer is paid for performance and can over-ride if necessary

Washington DC
(No Time Varying Rates)

San Diego
(TOU Rates)



GET UP TO $1,540* FOR CHARGING YOUR BMW i3.



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Utility support for EV charging infrastructure and services

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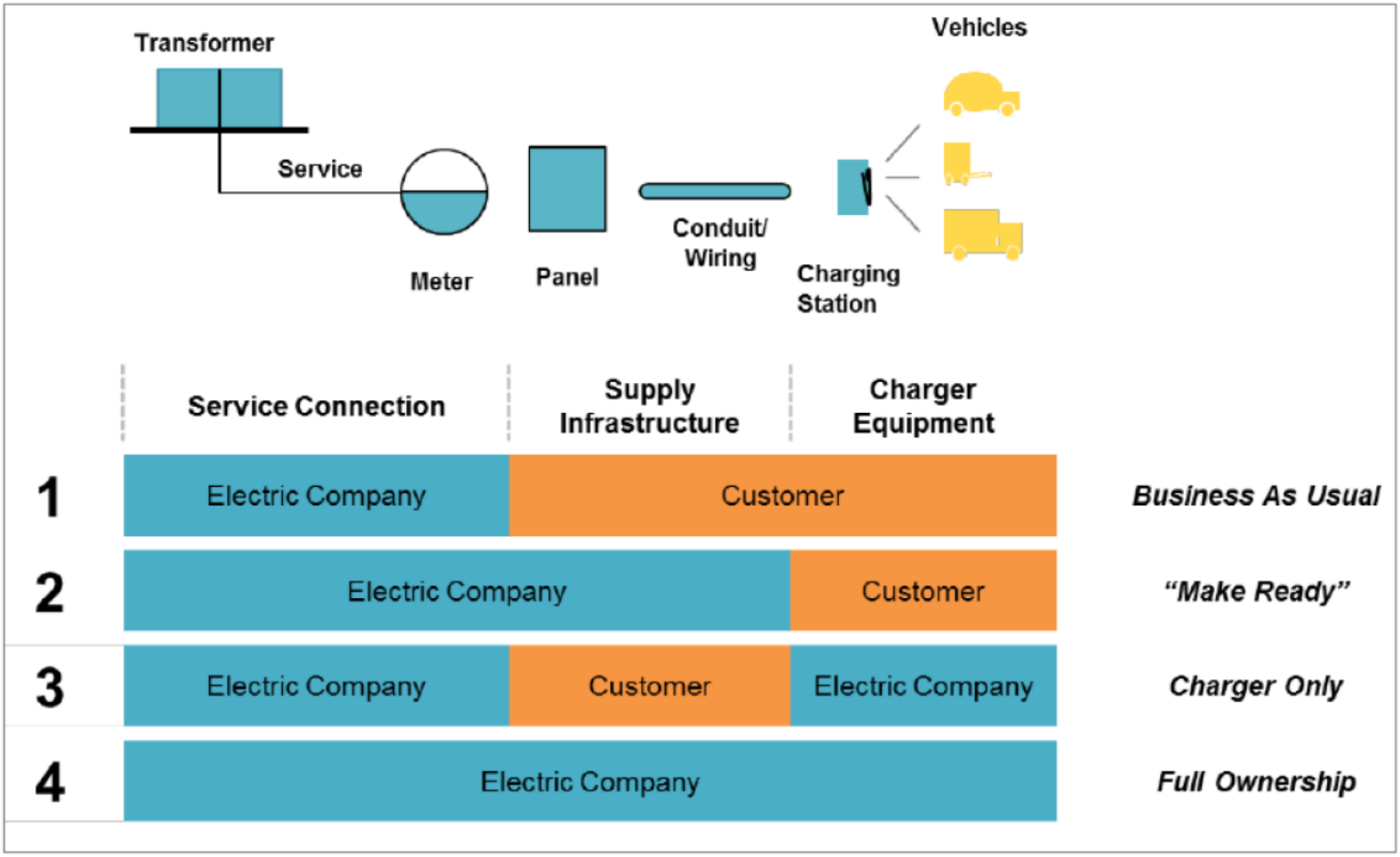
- **Utility support for EV charging infrastructure and services**

Different models for utility role in providing and/or supporting charging services



Source: EEI

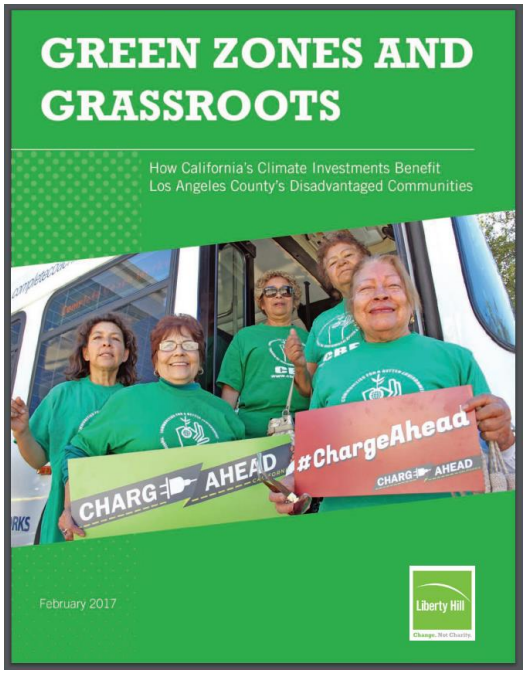
Roles for utilities in some leading states

+ Has allowed various models
+ Converging on make-ready model
+ Exceptions for DACs, MUDs, pilots
+ VW & public funds for DCFC

+ NYPSC has approved $701M in utility funds for make-readies for 50,000 L2 and 1,500 DCFC statewide
+ Provide necessary subsidies to seed competitive market for EVSP
+ Incentives are higher– up to 100%-- in DACs

+ The Maryland PSC approved a 5-year pilot to deploy over 5,000 L2 and DCFC statewide
+ Rebates for customers installing chargers
+ Utilities to own and operate some chargers to seed the network

Bringing EV Benefits to Low-Moderate Income Customers and Disadvantaged Communities



+ **Targets for EVSE in disadvantaged communities (DACs) or at multi-unit dwellings (MUDs)**
  - National Grid to locate a percentage of DCFC in/near DACs
  - CA: 10% of ports in SCE's program to be deployed in designated DACs
  - CPUC has proposed increased shares of EVSEs utilities for DACs
+ **NY & CA allow larger rebates for chargers in DACs**
+ **Some programs directly target low or moderate income (LMI) customers**
  - PG&E's Empower EV program is a direct install program and incentive for EVSEs for LMI residences
  - CA incentive payments for EV purchases are means-tested
+ **Focus on bringing immediate benefits to these communities via electrifying transit and reducing fleet emissions (CA, NY, MA)**

How many EVs will be on Arizona's roadways in 2030?

How will we all work together to get from here to there?

Energy+Environmental Economics

Thank You

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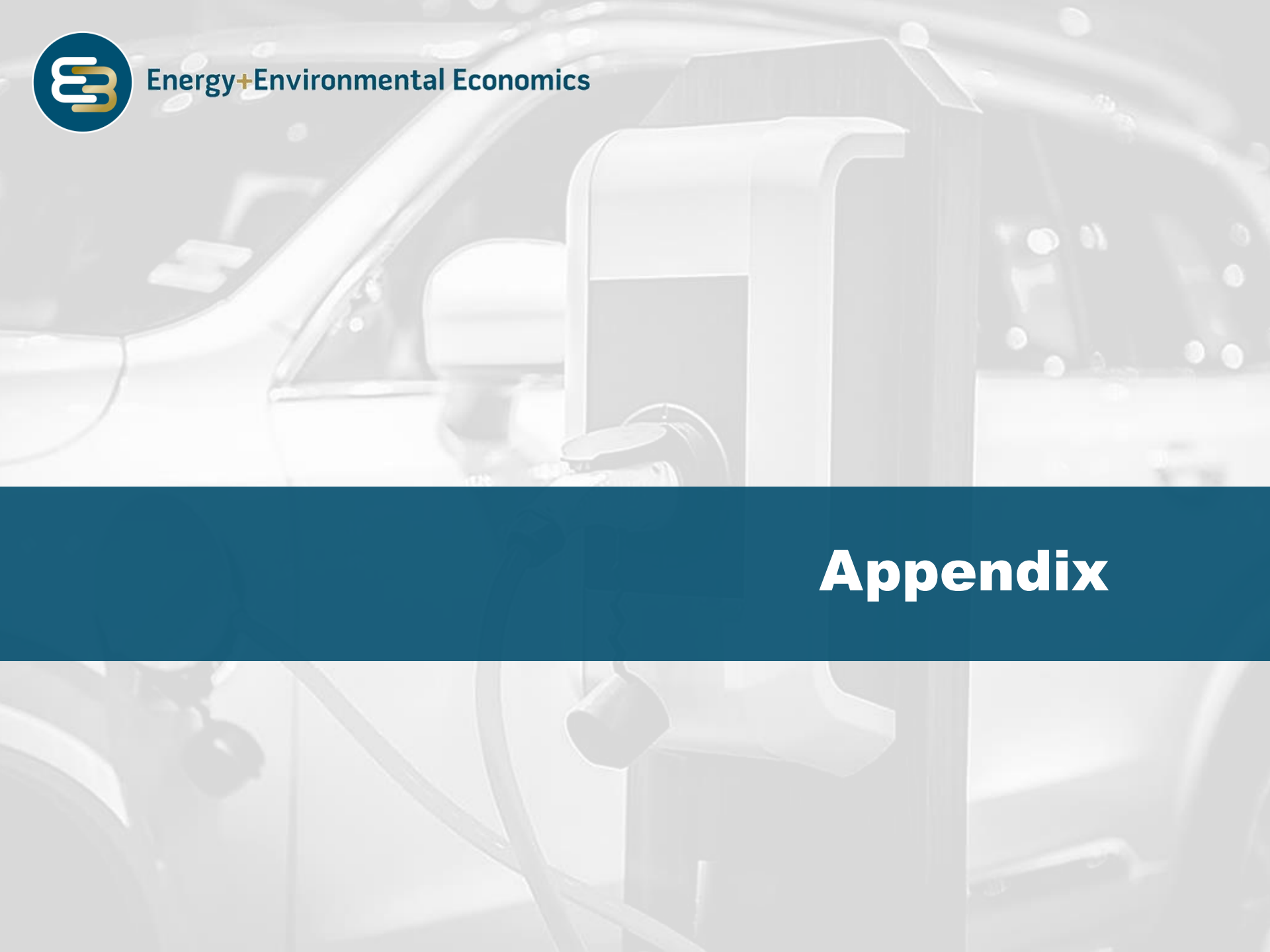
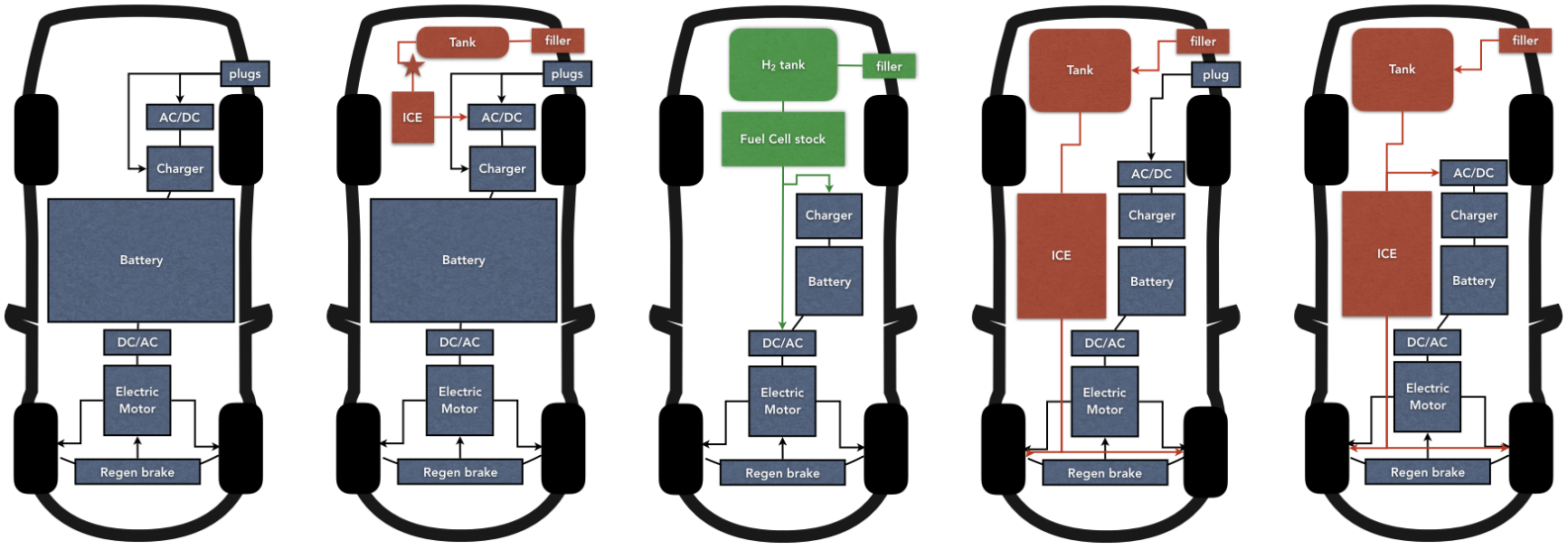


Appendix



BEV	BEV + REx	FCEV	PHEV	HEV
Example: Tesla Model S	BMW i3	Toyota Mirai	Mini Countryman Plug-In	Toyota Prius
Energy efficiency: 73%	73% ↔ 20%	22% (???)	60% ↔ 17%	54% ↔ 15%
Transmission: NO	NO	NO	YES	YES / HSD
Gearshift: NO	NO	NO	YES	YES
Engine: AC induction/synchro	AC synchronous	AC synchronous	AC synchronous	AC synchronous
Emissions: -66% CO_2	-66% ↔ -8% CO_2	-50% (???) CO_2	-58% ↔ +2% CO_2	-57% ↔ +11% CO_2

https://onewedgecom.files.wordpress.com/2018/02/corso-ev-002.png

China: National government's EV adoption goals and policies

- **Severe air quality problems in China's cities and associated health impacts add urgency to addressing tailpipe emissions**
  - Government studies found that vehicle exhaust was the leading cause of air pollution in Beijing, Shenzhen and other major cities
  - National and city governments have worked to address air pollution for 20+ years
- **Aggressive national policies support ZEV deployment**
  - China's national government has targeted 5 million EVs by 2020
  - Chinese OEMs must make or import at least 12% ZEVs in 2020
  - National subsidies ranging from $5,000-$8,600 per vehicle (more for full BEVs)

https://www.ccacoalition.org/en/news/beijing%E2%80%99s-air-quality-improvements-are-model-other-cities

http://english.sina.com/china/p/2015/0401/797284.html

China: Cities implement and augment national EV goals and policies

+ Examples of city policies encouraging consumers to choose EVs

- New vehicle purchase subsidies
- Vehicle tax exemption/reduction
- Providing charging facilities and/or charging fee reduction
- Preferential access to license plate/registration

+ Aggressive electrification of transit and taxi fleets

- Shenzhen has electrified its entire fleet of >16,000 buses
- 99% of Shenzhen's >21,000 taxis are now EVs

https://techcrunch.com/2019/01/04/shenzhen-electric-taxis-push/

https://www.bloomberg.com/news/articles/2018-05-08/in-china-shenzhen-electrified-its-entire-bus-fleet

European Union: National and local policies drive EV demand in leading markets

- **Substantial purchase and/or tax incentives for EV purchasers**
- **Bans on diesel and gasoline vehicles**
  - Paris, Madrid and Athens have announced plans to ban all diesel vehicles by 2025 and gasoline vehicles by 2030
  - Norway (2025), Denmark (2030), France (2040) and UK (2050) plan to phase out conventional cars within the next three decades
  - The EU has no laws or regulations yet, but will consider statutory requirements later this year.
- **Examples of city measures:**
  - Preferential and/or free/discounted parking
  - **London:** congestion charge for entering city center waived for EVs until 2025, extra charge for high emitting vehicles
  - **Amsterdam:** the city must install a curbside charger upon a resident's request

3 states: 3 procedural approaches

+ *"Let a thousand flowers bloom"*

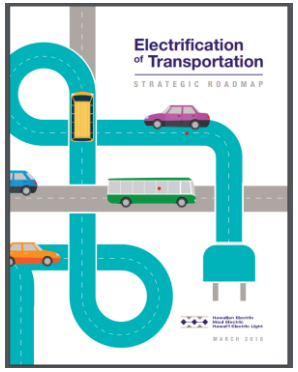
- Multiple applications to CPUC, many "pilots"
- Litigation, litigation, litigation!
- 10 years in CPUC is now developing a holistic Transportation Electrification Framework

+ *"We're in charge here"*

- NYPSC white paper lays out vision
- Compact stakeholder process
- Currently out for comment, so…

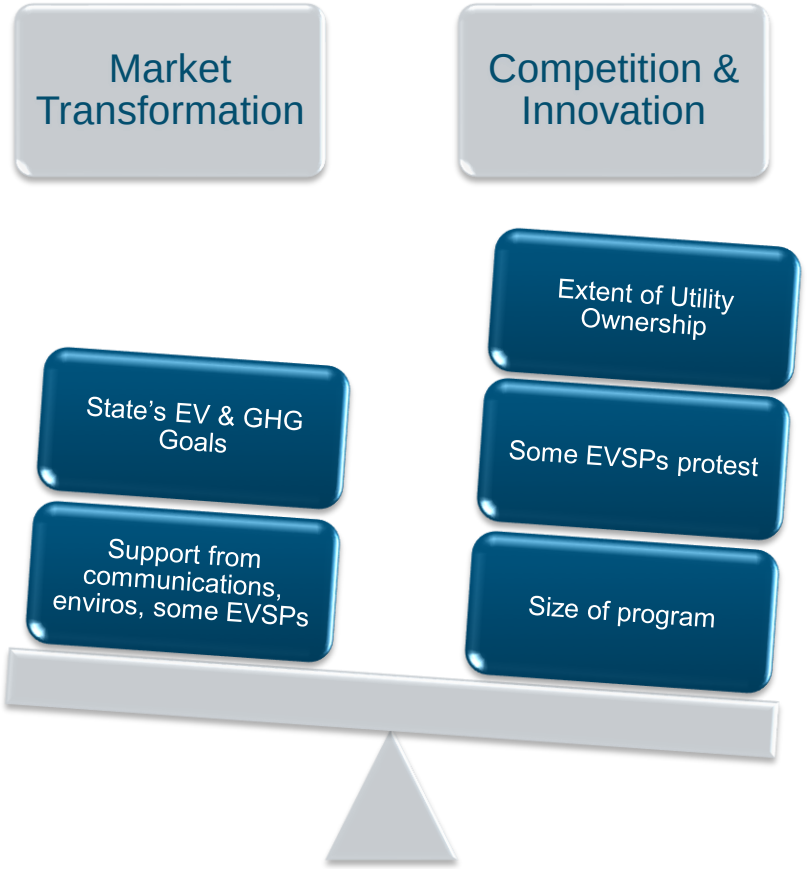
+ *"Consult with stakeholders & figure it out"*

- HPUC directed HECO to file a 10-year comprehensive Electrification of Transportation Strategic Roadmap
- Well received by stakeholders & HPUC but…
- HPUC continuing to direct HECO



Energy regulators' balancing act

<u>Key issue for regulators:</u> Balance goal of accelerating EV adoption with desire to promote competition and innovation in the emerging market for EV charging services



Role of Cost-Benefit Analysis (CBA)

- **Most utility programs to date have been characterized as pilots, and have been filed without cost-benefit analysis**
- **Filed CBAs seldom scrutinized or considered in approval**
- **Our three states:**
  - California: Has steadfastly refused to think about cost-effectiveness.
  - New York: Chair commented on need for wise use of ratepayer dollars - can there be analysis that shows costs, benefits, ratepayer impacts of different investments?
  - Hawaii: HPUC more focused on utility presenting coherent plan
- **Some states (MI, OR, WA) have established expectations for CBA for current or future proposals**
- **CBAs are expected to be featured more prominently in large scale applications**
  - Some commissions have expressed desire to see ratepayer benefits
  - NGOs and some EVSPs argue this conflicts with goal of motivating adoption and that ratepayers will benefit in long-term in any case

Alternative CBA perspectives

Ratepayer Perspective

Costs	Benefits
Cost to serve EV load	Revenues from EV charging

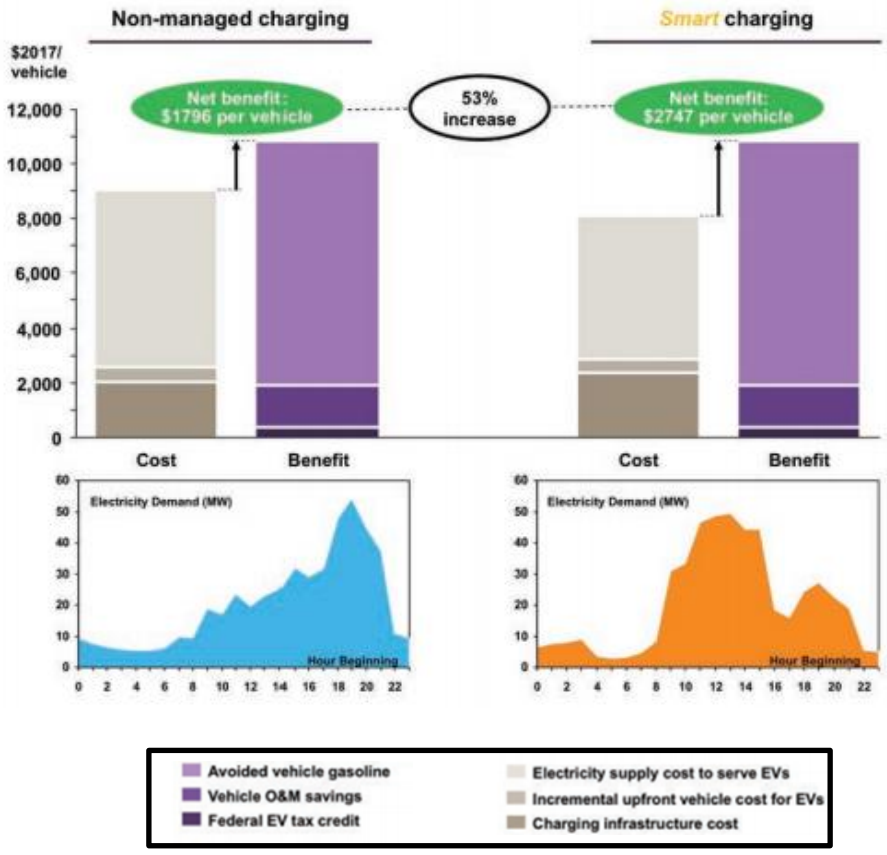
EV Buyer's Perspective

Costs	Benefits
Incremental Cost of EV	O&M savings
Higher electricity bills	Savings on gasoline
	Federal Tax Credit

Regional vs ratepayer benefits

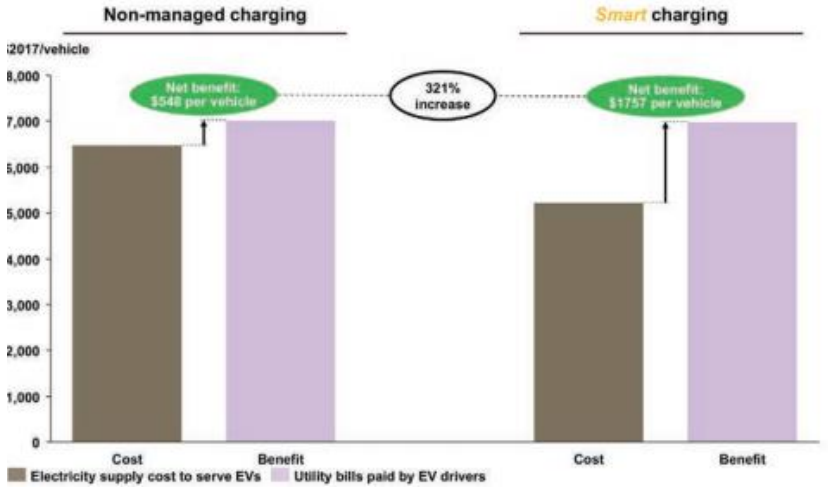
TRC Test for EV Adoption:

Do benefits exceed costs for the entire region?



RIM Test for EV Adoption :

Do benefits exceed costs for all customers?



- **So far, CBA has focused on costs and benefits of EV Adoption *per se***
- **No CBAs for specific programs or investments as there for**