Getting to 20 Million EVs by 2030

Opportunities for the Electricity Industry in Preparing for an EV Future

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THE Brattle GROUP

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Overview

The number of electric vehicles (EVs) in the U.S. is projected to increase from 1.5 million in 2020 to 10–35 million by 2030 and will be a major disruptor to the electric power sector

- Major adoption drivers include decreasing vehicle and battery costs, expanding EV models, increasing charging infrastructure, and growing market awareness of EVs
- Favorable federal and state policies create additional incentives for purchasing EVs, including federal and state tax credits, rebates, and Zero Emission Vehicle (ZEV) mandates

Market participants throughout the industry will be involved in preparing for the transition to EVs

- Commissions are weighing the appropriate regulatory and market environments for the industry to increase EV adoption
- While most chargers to date have been installed by competitive suppliers, utilities have an important role to play by building out system infrastructure, developing EV-specific rates, and increasing customer awareness

This presentation provides an assessment of the investments needed across the electric power sector to support the deployment of 20 million EVs in the U.S. by 2030 with a focus on EV charging infrastructure

- While this analysis focuses primarily on light-duty vehicles, electrification of commercial fleets and freight trucks will further magnify electrification-related opportunities.

Key Findings

$75–125 billion of investment is needed across the electric power sector to serve 20 million EVs by 2030

- 20 million EVs will add 60–95 TWh of annual demand and 10–20 GW of peak load to the system and require 12–18 GW of renewable capacity and 1–2 million public chargers to serve EV demand
- Investments will be necessary across the supply chain, including $30–$50 billion for generation and storage, $15–$25 billion for T&D upgrades, and $30–$50 billion for EV chargers & customer-side infrastructure
- Total annual fuel savings of $12 billion/year relative to Internal Combustion Engine (ICE) vehicles translates to an estimated societal payback of 8.6 years to cover the costs of electric sector investments (7.2 years if GHG benefits are included)

Over the past 5 years, public EV chargers increased by about 40% per year, a rate that must be maintained over the next decade to install an additional 1–2 million public chargers by 2030

- To date, less than $2 billion has been approved for utilities to build out the necessary EV charging infrastructure
- While CA and NY have been leading in charger deployment, utility requests for funding in other states are rising

EVs present significant opportunity, but also uncertainty, to the electricity industry over the next decade

- Industry planners and policymakers should take a three-pronged approach to planning for significantly greater EVs, including (1) proactively developing an EV roadmap, (2) crafting an EV regulatory strategy, and (3) identifying win-win-win solutions that address market barriers

Introduction

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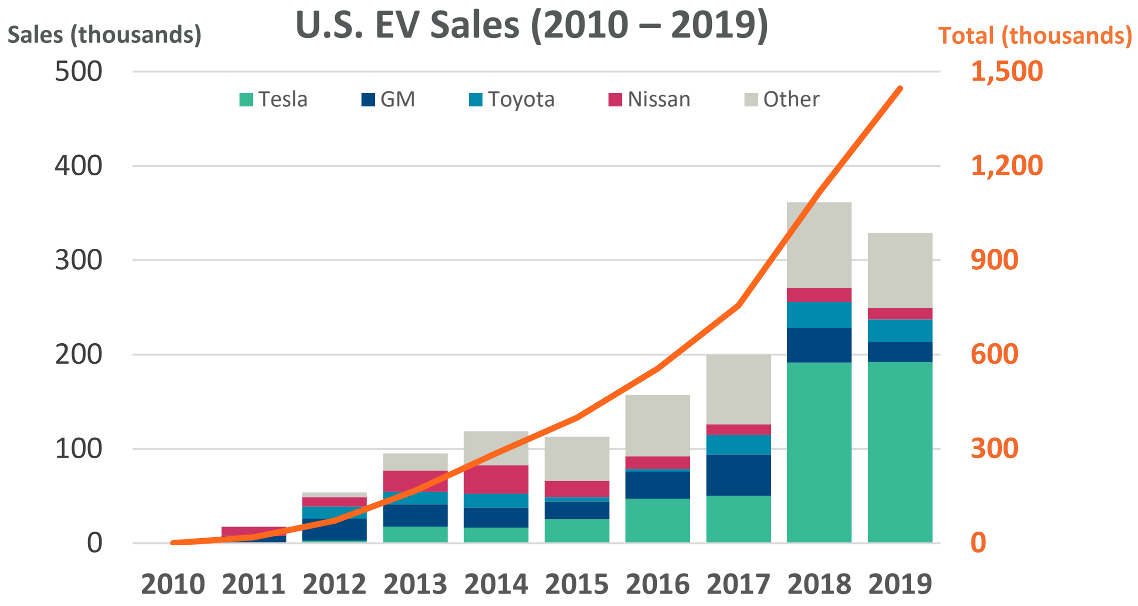
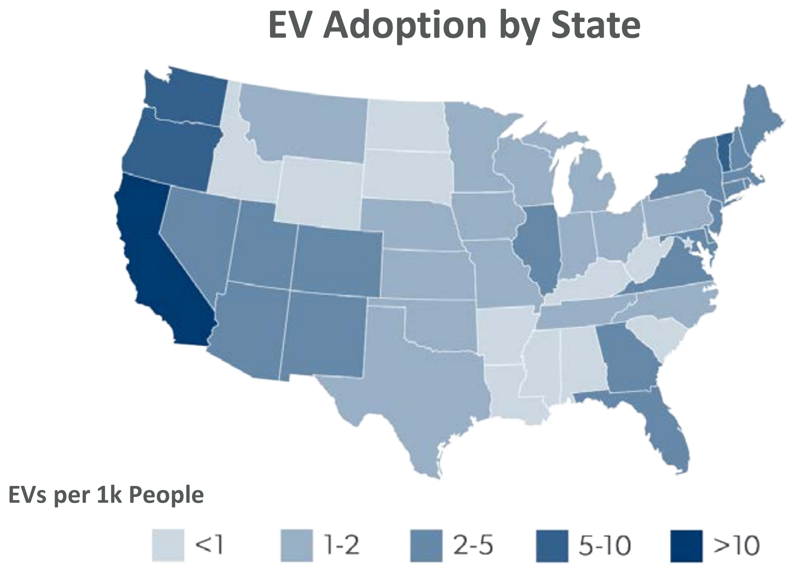
EV sales have risen significantly in the U.S., but deployment remains uneven across states

Total EVs on the road in the U.S. was approaching 1.5 million at the end of 2019

- Tesla is the leading EV automaker with 56% of market share in 2018–2019
- Battery EVs (BEVs) account for 61% of EVs; plug-in hybrids EVs (PHEV) make up the rest
- California has the most EVs (580k), which is 11x greater than the next state (New York with 52k)





The electricity industry has an opportunity to drive EV adoption by building out EV charging infrastructure

Source: EV sales data aggregated by Atlas Public Policy

2030 projections ranging from 10–35 million EVs imply significant uncertainty for system planners

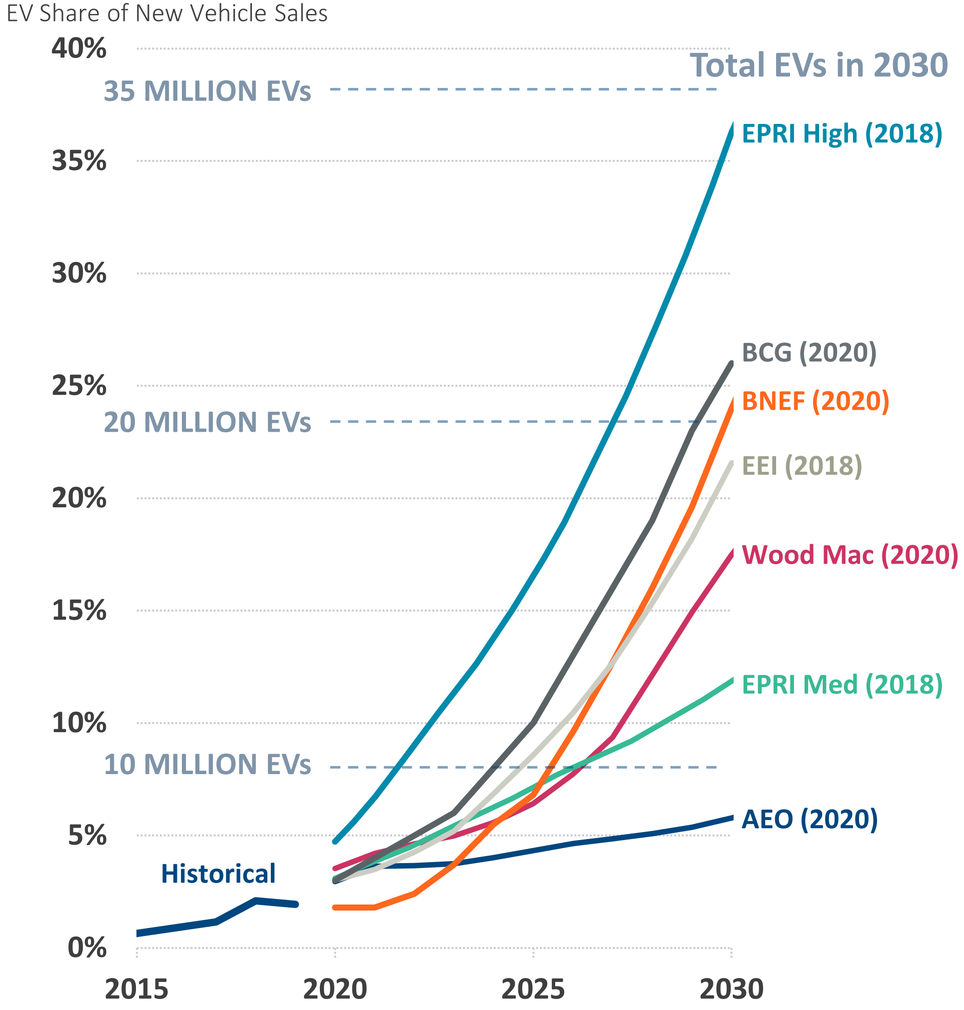
EV sales forecasts for the U.S. provide **limited insight into local adoption rates** for system planning purposes

- Most projections simply extend recent trends to a future year
- Or are based on “black-box” models that can be challenging to understand and lack insights on drivers of EV adoption

Planners will have to **develop location-specific EV forecasts** and identify key drivers of EV sales to inform system planning

- Forecasts should account for local considerations, such as state and utility incentives, ZEV goals, HOV lanes, EV sales trends, fuel prices, and charging infrastructure availability
- EV forecasts can also provide insights into effectiveness of incentives to accelerate EV adoption in their market

Projected U.S. EV Sales (2020–2030)



Sources & Notes: EPRI, PEV Market Projection Assumptions: June 2018 Update, June 2018. (EPRI Low forecast not shown because its 2030 forecast is below the levels already obtained.); BCG, Who Will Drive Electric Cars to the Tipping Point?, January 2020.; BNEF, Electric Vehicle Outlook, 2020; IEI/EEI, Electric Vehicle Sales Forecast and the Charging Infrastructure Required through 2030, November 2018; Wood Mackenzie, Electric car forecast to 2040, accessed May 2020; EIA, Annual Energy Outlook: Light-duty vehicle sales by technology type and Census Division: United States, 2020.

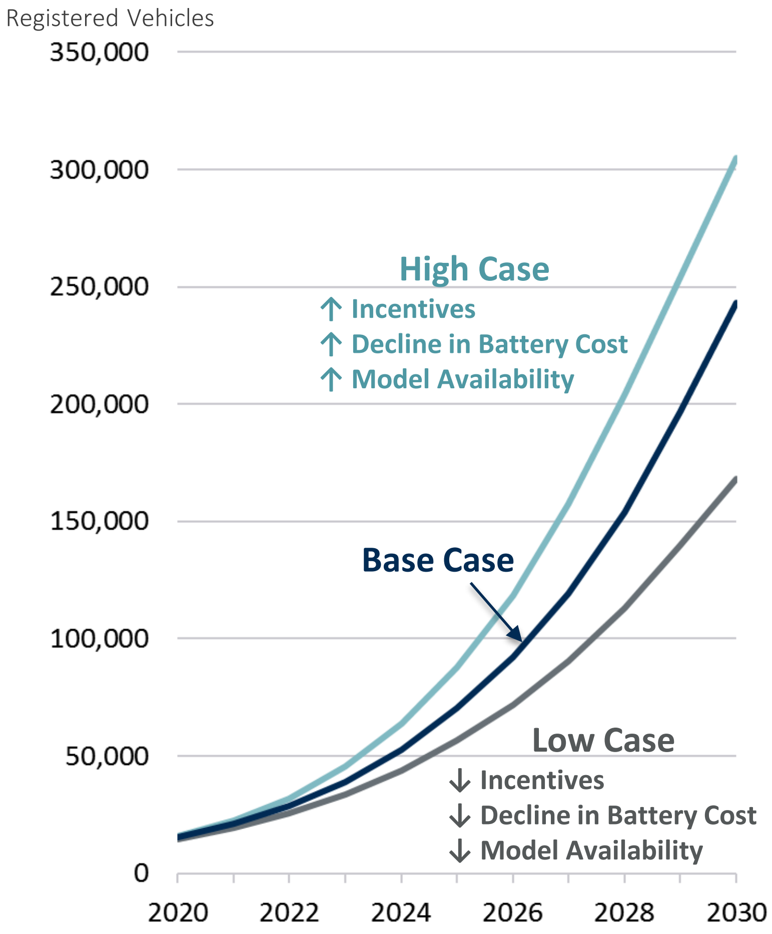
What is driving EV adoption so far?

Based on a study of 2011–2019 EV sales across all 50 states, **Brattle's Econometric EV Adoption Model** yields several important insights

- **Policy Mandates**
  States with a ZEV mandate have 26% higher EV sales
- **Vehicle Incentives**
  $1,000 increase in total incentives increases EV sales by 7.5%
- **Battery Price**
  $10/kWh decrease in battery price increases EV sales by 4%
- **Model Availability**
  Every 10 additional EV models increase EV sales by 8%
- **Fuel Costs**
  10% decrease in "fueling" cost savings increases EV sales by 3%

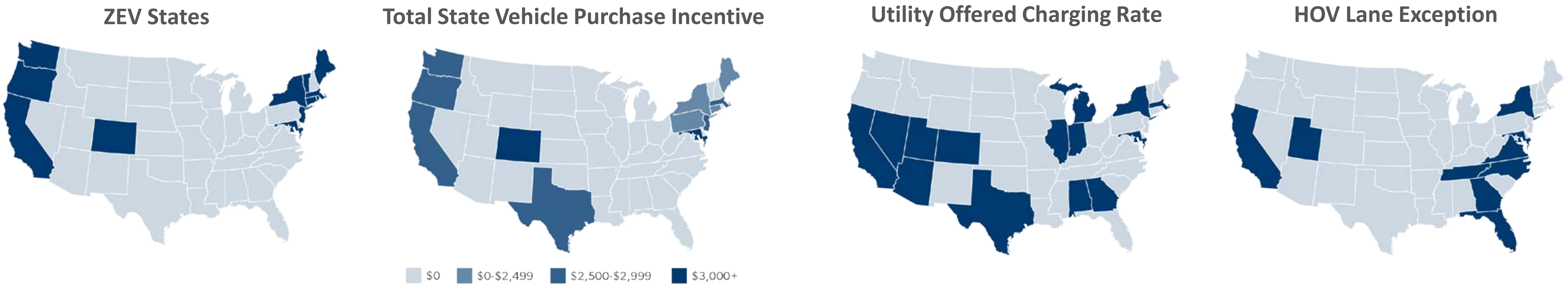
The Econometric EV Adoption Model can generate **location-specific EV forecasts** that are calibrated to local market conditions and able to **identify cost-effective incentives** to increase EV adoption

Example Output of Brattle's Econometric EV Adoption Model



Consumers and industry participants have to navigate a patchwork of policies aimed at increasing EV adoption

- **Zero Emission Vehicle (ZEV) mandates** in 12 states covering 30% of the U.S. population (see map); CO, NJ & WA joined since 2018 and MN, NM, & OH recently proposed to adopt the program
- **$7,500 federal EV tax credit** for the first 200,000 units sold for each OEM (Tesla & GM recently exceeded the cap)
- In addition, 13 states provide **up to $5,000 in EV rebate/tax credit** for EV purchase
- **$282 million of VW Settlement Funds** was directed towards EV adoption and charging infrastructure
- **30% federal tax credit for charging infrastructure** (up to $1,000 for residential, $30,000 for commercial customers)
- Utilities in several states are permitted to **build charging infrastructure or provide rebates for chargers**



Source: Brattle EV policy database

EV market is trending towards increased adoption, but barriers could limit growth if left unaddressed

Declining Vehicle and Battery Costs:

- Battery costs has decreased by 87% since 2010
- EV cost of production projected to decline by 30% by 2025 and nearly break even with ICE vehicles

Approaching Total Cost of Ownership (TCO) Parity with ICE:

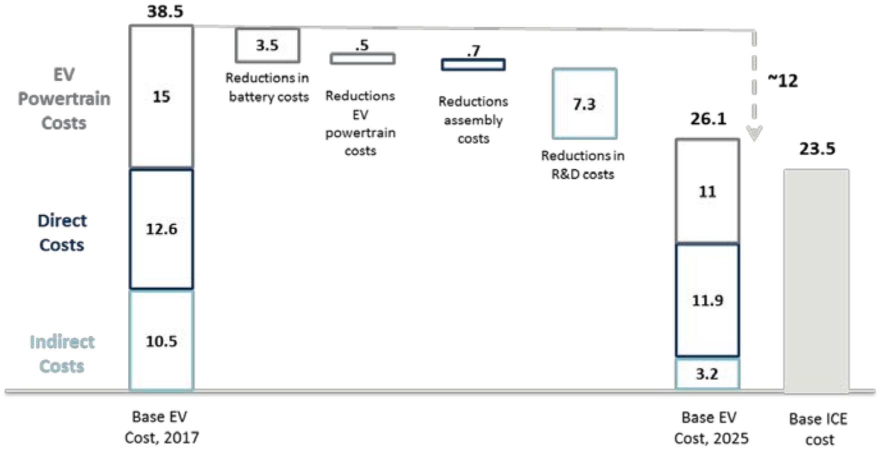
- EV TCO expected to be equal to ICE in 2-4 years due to fuel & maintenance savings offsetting higher upfront vehicle costs
- However, U.S. dealers and consumers continue to lack understanding of EV fuel and maintenance cost savings during sales process

Increasing Market Availability & Awareness:

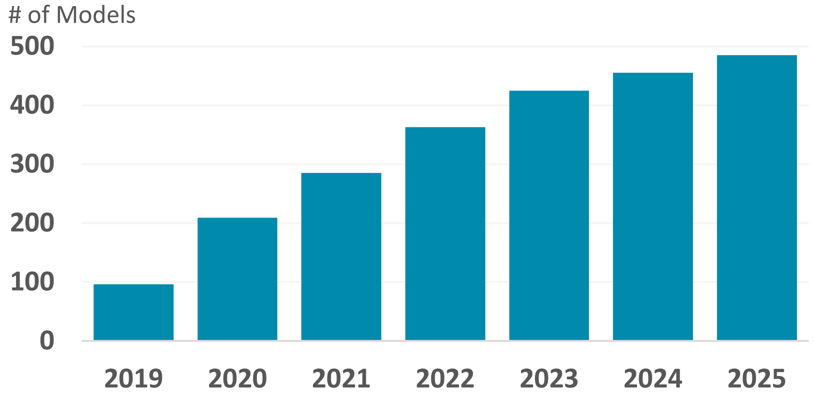
- Manufacturers expected to roll out nearly 500 EV models by 2025
- Yet only 0.3% of OEM advertising focused on EVs in 2019, limiting consumers exposure to new options

Utilities can play a key role in increasing customer awareness of the benefits of EV ownership and the availability of new EV models

2025 EV Cost of Production



New Worldwide EV Models (2019 – 2025)



Sources: Battery cost declines: BNEF; EV cost of production and TCO: The International Council on Clean Transportation, "Update on electric vehicle costs in the United States through 2030"; New EV models: McKinsey & Company, "The road ahead for e-mobility", 2020; EV Advertising: The New York Times.

What does it take to deploy 20 million EVs by 2030?

Projected EV sales vary significantly, and the exact number of EV deployment is not possible to predict precisely. In this section, we'll explore what it takes to deploy 20 million electric vehicles by 2030.

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Growing EV fleet will significantly increase electricity demand and infrastructure needs

System planners will need to account for several uncertainties in projecting the impacts of EV on their system and the required system upgrades

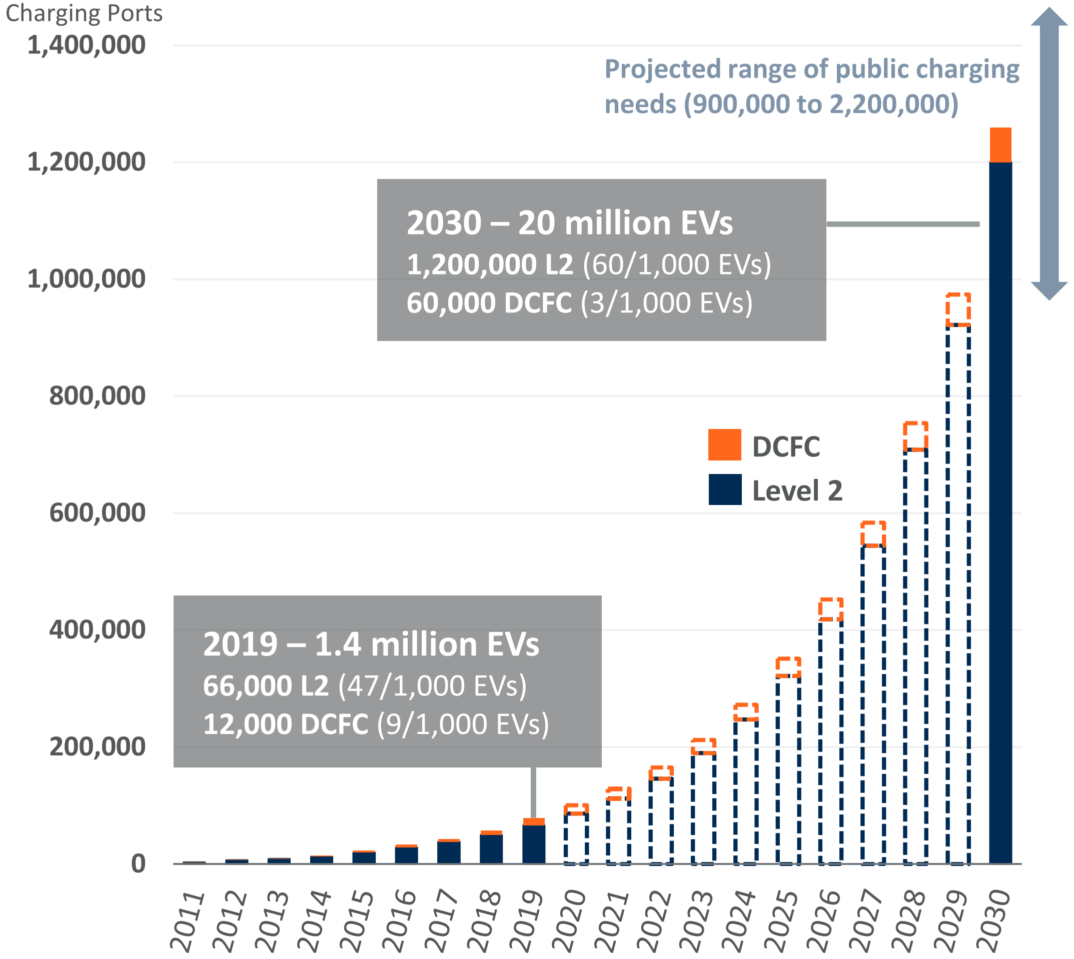
SYSTEM IMPACT	IMPACT OF 20 MILLION EVS	PRIMARY CONSIDERATIONS
Energy Demand from EV Charging	**60,000 – 95,000 GWh** of energy per year	Types of EVs (BEV vs PHEV), how they are used (commuting, local trips, road trips), and fuel efficiency
Increase in Peak Load from EV Charging	**10 – 20 GW** increase in peak loads	Charging timing and patterns; availability of TOU rates & managed charging to limit on-peak charging
Renewable Generation to serve 50% of EV Demand	**12 – 18 GW** of renewable capacity	Scale of state-level RPS mandates that require a portion of electricity demand to be met by renewables
Public Chargers to Serve EVs	**0.9 – 1.7 million** total public L2 & DCFC chargers	The scale and types of public chargers required to serve EV charging needs and reduce range anxiety

In addition, batteries on-board 20 million EVs contain up to **1,600 GWh of energy storage capacity** and can provide up to **300 GW of power output.** EVs could play a key role in **integrating renewables** once vehicle-to-grid (V2G) is viable.

Notes: BEVs account for 60 – 80% of all EVs; PHEVs use electric motor for 33 – 50% of miles driven; 12,000 vehicle-miles per vehicle per year, 3.1 miles/kWh efficiency, 85% charging efficiency and 8% T&D losses; 0.4 – 1.0 kW peak demand per EV; 30% renewable generation capacity factor; renewables provide 15% capacity value; 80 kWh battery per EV and 15 kW charge/discharge rate per EV. Charger assumptions are on Slide 13. All assumptions reflect average values.

Public chargers will need to increase by 15–30% per year (or more) to meet 2030 needs

Projected Public Charger Needs for 20 million EVs by 2030



From 2014 to 2019, public EV chargers increased by 6x, or **40% per year** (including workplace chargers)

- 66,000 Level 2 chargers (10 – 15 kW)
- 12,000 DC Fast Chargers (typically 50 – 150 kW)
- About a third of the chargers are located in California

U.S. will need about **1.25 million public chargers** to supply 20 million EVs by 2030

- 20x increase in Level 2 (30% per year growth rate)
- 5x increase in DCFCs (15% per year)

In addition, **6-10 million at-home Level 2 chargers** will likely be installed at single family homes

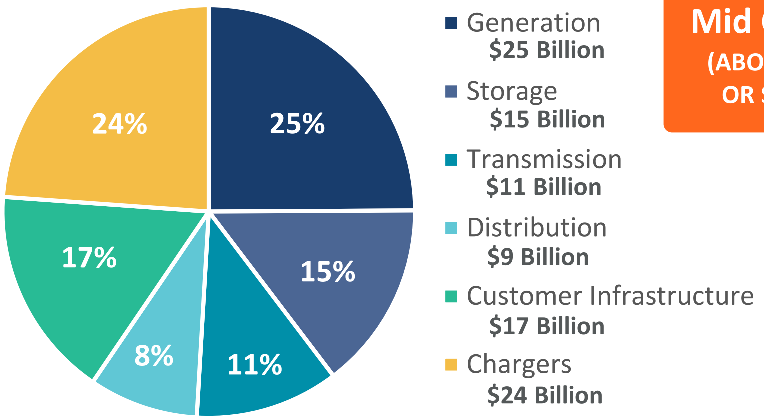
Sources and notes: Historical chargers: U.S. DOE, Alternative Fueling Station Counts by State, May 2020; 2030 range based on projections from U.S. DOE, National Plug-In Electric Vehicle Infrastructure Analysis, September 2017 and EEI/IEI, Electric Vehicle Sales Forecast and the Charging Infrastructure Required Through 2030, November 2018. We assume for every 1,000 EVs, 40-80 L2 and 2-5 DCFC public charges are needed; Assume 40% of light-duty vehicle owners will require L2 chargers at home.

20 million EVs require $75-125 billion of electric sector investment by 2030

Investment will come from **market participants across the supply chain**, including electric utilities, merchant developers, competitive suppliers, and EV owners

- **$30-50 billion** for Generation & Storage to meet higher energy demand & peak loads
- **$15-25 billion** for T&D upgrades to serve peak demand, access renewables, and connect to charging infrastructure
- **$30-50 billion** for Chargers & Customer-Side Infrastructure to provide sufficient home, workplace, and public chargers

Electric Sector Investment Costs

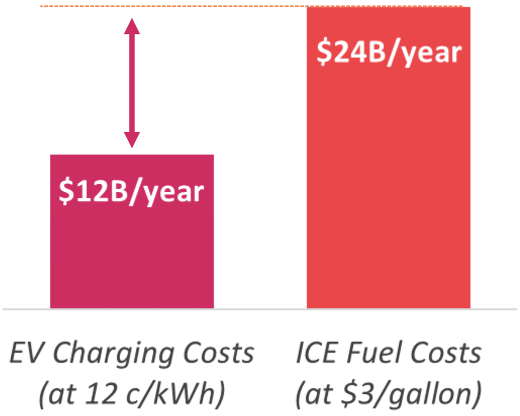


Mid Case = $101 billion
(ABOUT $9 BILLION PER YEAR OR $450 PER EV PER YEAR)

$12 billion per year of fuel savings
($600 PER EV PER YEAR)

Societal payback for electric investments:
8.6 years

Annual Vehicle Fueling Costs



Payback time is 7.2 years if avoided GHG emissions (46 MMT/year) included

Sources and notes: Renewable capacity cost: $1,500/kW; Energy storage cost: $1,200/kW; Transmission needs from Brattle's report for WIRES; Distribution costs of $300/kW of peak demand; Utility-side and customer-side infrastructure costs from CA EV programs and *Overcoming Barriers to Deployment of Plug-in Electric Vehicles* (National Research Council, 2015); ICE fuel economy: 30 mpg; ICE GHG emissions rate: 8.87 kg/gallon; Gasoline costs: $3/gal with no taxes; Avoided GHG benefit: $50/ton.

The Role of Utilities in the EV Transition

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Electric utilities have an important role to play in the transition to EVs

While regulatory and market environments influence the extent of utilities' involvement, utilities are well-positioned to build charging infrastructure to help drive EV adoption and achieve ambitious EV targets

- Clean energy plans provide opportunities to the utilities for greater involvement in the electrification activities
- Approved funding for utilities is primarily aimed at "make-ready" infrastructure from the distribution system up to the charger, including line transformers, service lines, meters, and panel
- Chargers mostly installed by non-utility suppliers (see next slide)

Tension between private and utility investment needs to be resolved to be able to leverage each player's unique strength in the ecosystem

- Commissions are balancing the need to provide sufficient charging infrastructure with the desire to keep the market open to competitive suppliers

Increased EV adoption can be a Win-Win-Win outcome across market participants

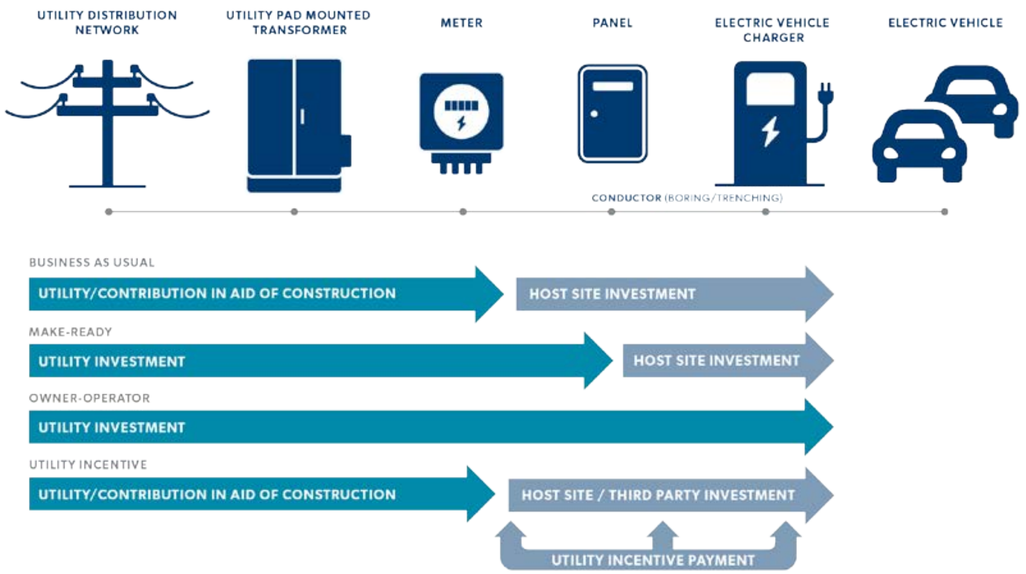
- **Customers** will have access to a larger network of chargers and reduced costs of achieving EV policy goals
- **Private infrastructure companies** will see increased demand for their products
- **Utilities** will see increased sales and improved asset utilization and contribute to infrastructure investments

Private sector focuses primarily on installing publicly-available EV chargers

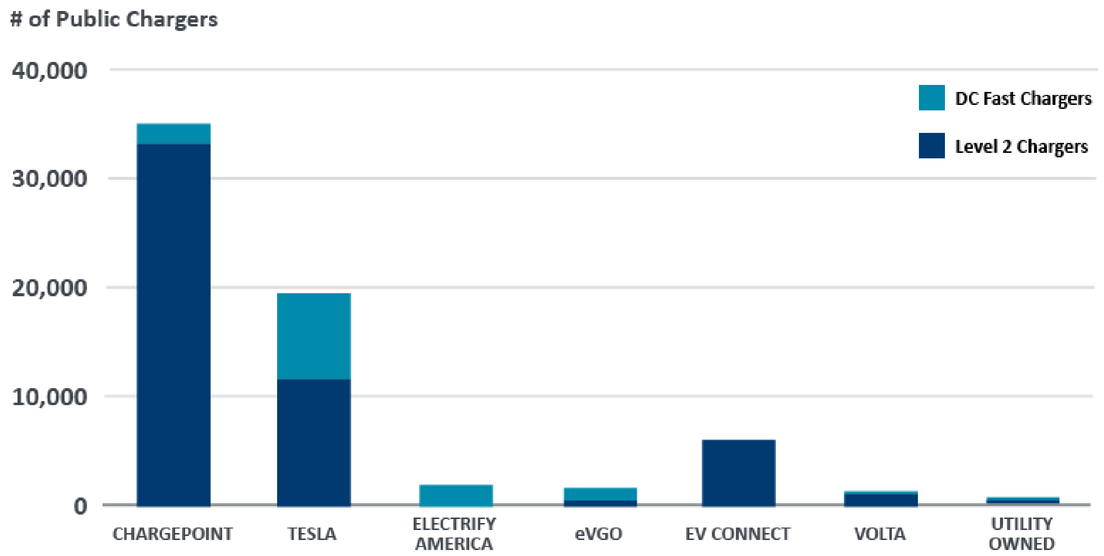
ChargePoint and Tesla have more EV charging stations than any other networks, although Electrify America will likely have a larger role going forward

- To date, only 159 public charging stations are utility-owned (or 0.6% of total U.S. public charging stations)
- Tesla spent about $220 million building out its Supercharger network of over 800 stations
- Electrify America is set to invest $2 billion in Zero Emission Vehicle infrastructure by 2027 (including hydrogen refueling stations)
- ChargePoint network has 38k chargers with plans for 2.5 million globally by 2025 (majority in North America and Europe)

Models of Utility EVSE Investment



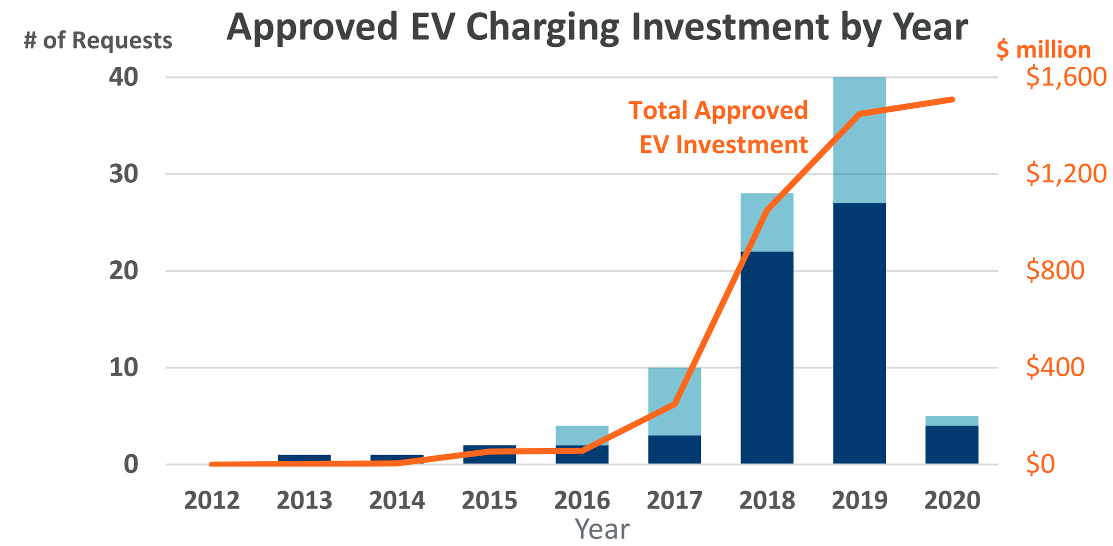
Installed EV Chargers by Network

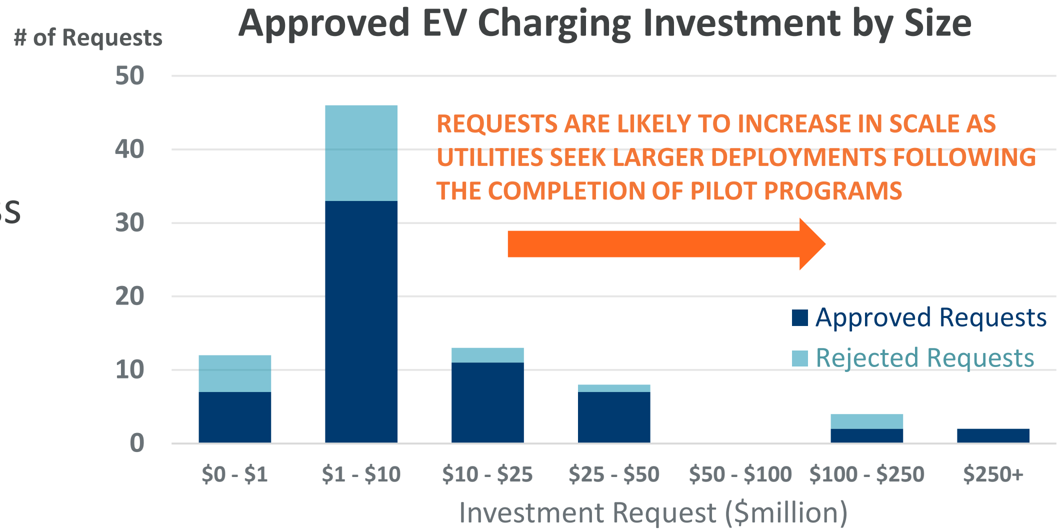


Sources and notes: Utility models graphic from M.J. Bradley & Associates, "Utility Investment in Electric Vehicle Charging Infrastructure: Key Regulatory Considerations". Investment data from ChargePoint's 2018 announcement, Electrify America's investment plan, DOE's Alternative Fuels Data Center. We assume $270,000 in costs for each Supercharger.

Approved utility EV charging infrastructure investments rose to $1.5B through Q1 2020

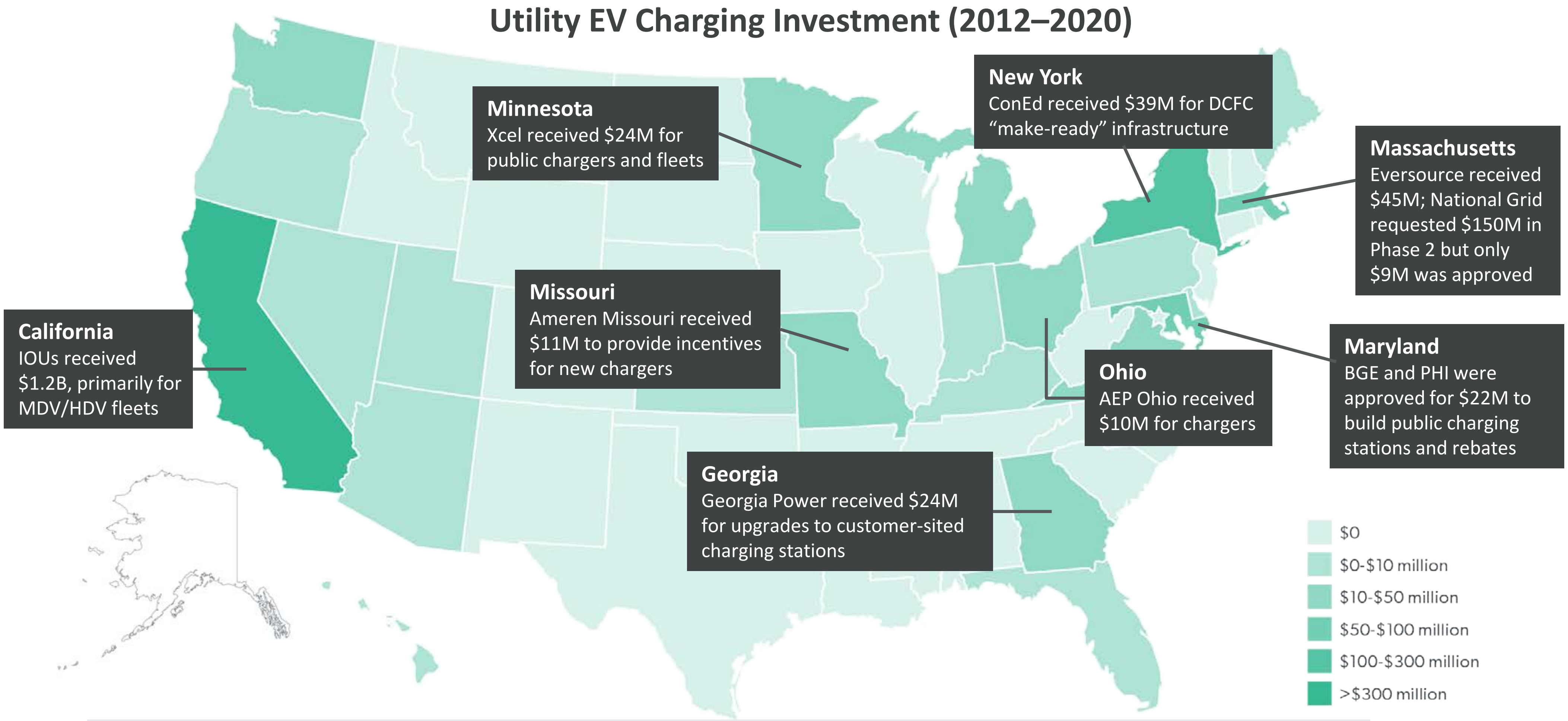
- Majority of approved funding has been for installing **“make-ready” infrastructure,** not chargers
- EV-related program requests have increased sharply since 2016 with **27 programs approved in 2019**
- To date, most programs are less than **$25 million**
  - Only 4 requests for over $50 million approved, all in Calif.
  - Small initial approvals are likely to lead to larger requests in future rate cases
- Utility programs are primarily approved on the basis of **supporting state-level EV deployment goals**
  - Utilities will increasingly need to perform cost-effectiveness analysis as they transition from pilots to larger programs
- An additional **$1.4 billion is pending approval** (about $60 million per request on average)





Sources : Brattle analysis of data on EV-related investments approved by state utility commissions aggregated by Atlas Public Policy.

Utility investments in EV charging infrastructure have been approved across the U.S



Utilities seeking to increase their EV charging investments can take important lessons away from the states that have already approved the most significant utility programs

Sources: Brattle analysis of EV-related investment requests approved by state utility commissions using metadata from Atlas Public Policy. NY includes NYPA's $40 million EVolve program.

California approved $1.2 billion in utility funding for EV charging infrastructure since 2016

In 2014, CPUC issued a decision that allowed for utility ownership of EV charging infrastructure

- Determined utilities have “a critical role” in EV adoption
- Utilities have requested EV funding on a case-by-case basis

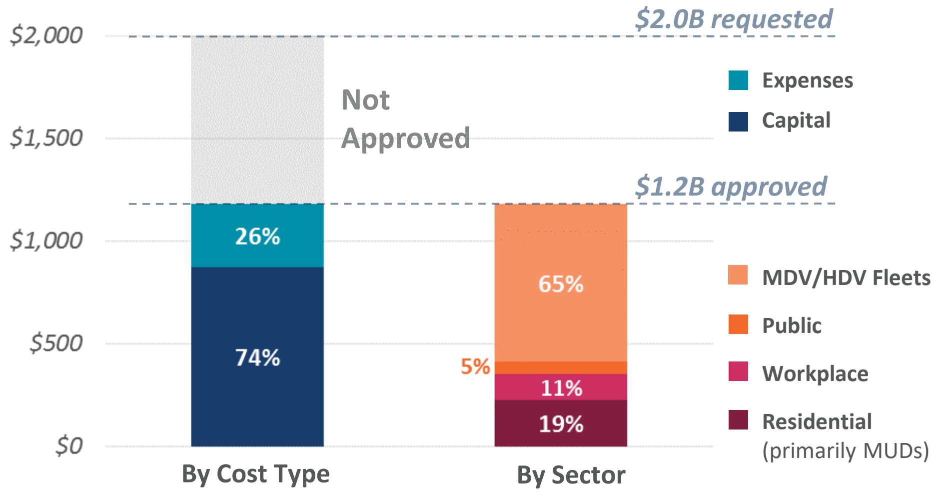
CA utilities have since received ~60% of the $2B in requested funding, primarily targeting fleets

- **$360M approved** for MUD and workplace make-ready infrastructure
- **$770M approved** for MDV/HDV fleet electrification
- SCE requested $760M to expand its Charge Ready program for MUD/workplace chargers in 2018; still awaiting decision

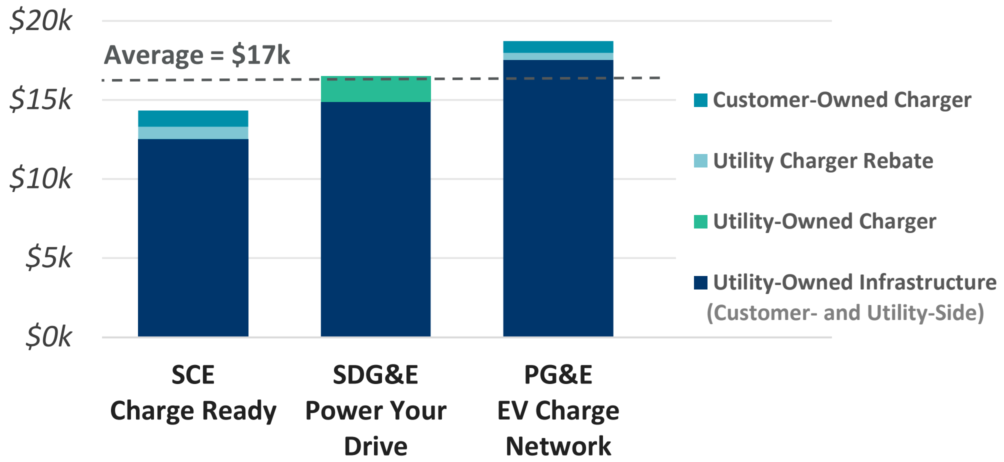
Utilities have installed 6,000 Level 2 ports to date with average costs of about $17k per port

- Utility-owned “make-ready” infrastructure costs average $15k/port, about 90% of total costs, including utility and customer-side upgrades
- Chargers costs average about $2k/port, split between customers and utility rebate of 25-100%; SDG&E approved to own some residential chargers

Approved EV Charger Investments ($ million)



EV Charger Installation Costs ($/port)



Sources and notes: Brattle analysis of CPUC decisions and IOU program reports. MUD is short for Multi-Unit Dwellings.

CPUC's Proposed Transportation Electrification Framework developed to guide future EV investments

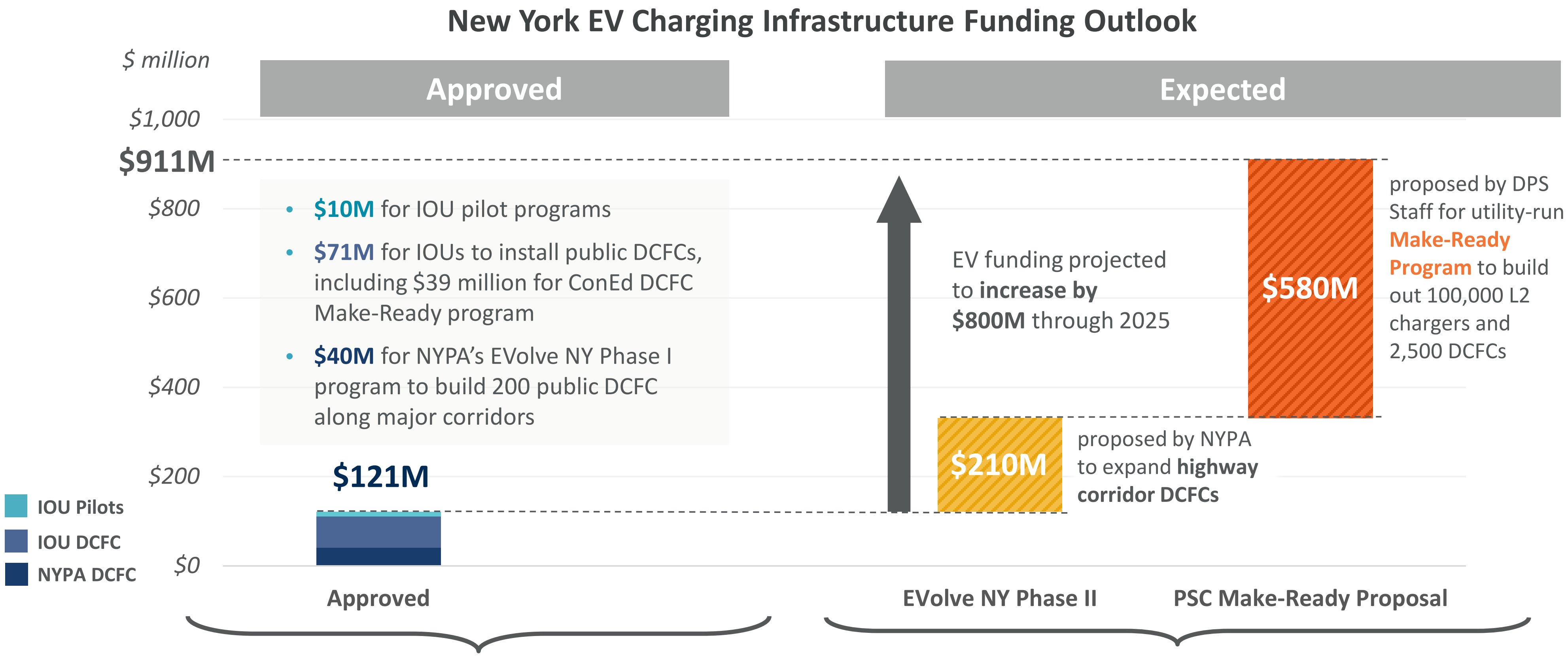
Key Elements of the Proposed Transportation Electrification Framework

FOCUS AREAS	FRAMEWORK GOAL	PROPOSED APPROACH
(1) Identify EV Infrastructure Needs and Define Utility's Role	Ensure utilities **target high value investments** to increase EV adoption without limiting opportunities for non-regulated entities	• CPUC identifies key market barriers to widespread EV adoption • State agencies then identify the priority market segments and infrastructure needs to meet emissions targets • CPUC assesses whether non-regulated entities can build necessary infrastructure or if utilities should do so
(2) Develop Utility Transportation Electrification Plans (TEP)	Establish a **structured, repeatable process** for identifying and approving future EV investment	• IOUs submit strategic 10-year TEPs every two years to CPUC • Propose investments based on CPUC-approved EV Scorecard that identifies needs to meet CA policy goals • Identify role in transforming the transportation sector • Ensure load is optimally integrated into the T&D system
(3) Set Near-Term EV Infrastructure Priorities	Provide utilities **guidance on near-term priorities** to accelerate approval while framework is finalized	• Leverage EVs for grid resilience • Target residents without access to home EV charging • Target MDV/HDV fleet infrastructure • Add infrastructure during new building construction • Accelerate deployment in disadvantaged communities

CA utilities are concerned the time required to finalize the framework will delay near-term efforts to roll out EV infrastructure; expect CPUC decision in 2020

Source: CPUC, Transportation Electrification Framework, Energy Division Staff Proposal, February 2020.

New York is targeting $900 million in EV charging infrastructure funding through 2025



NYPA and the IOUs received $121 million primarily to overcome "range anxiety" by installing DCFCs along highways

EV funding likely will significantly increase going forward. DPS Staff proposed for utilities to build make-ready infrastructure; NYPA proposed Phased II of EVolve NY program

Source: Brattle analysis of PSC EV-related orders and Make-Ready Program whitepaper, and NYPA Evolve funding.

Other states have taken different approaches to approving EV infrastructure investments

MASSACHUSETTS

Utilities are allowed to recover costs for EVSE if doing so advances EV deployment and does not interfere with the competitive market

Alternative incentive is allowed for EVSE deployment (performance-based incentive in the case of National Grid)

OREGON

Regulators allow utilities to **own charging stations** in the state's pilot programs because of the state's high needs for more charging infrastructure

Utilities can budget for **outreach and education programs**

MARYLAND

Cost-benefit analysis was used to inform design decisions and investment decisions

The Public Service Commission eventually approved smaller pilot-scale projects (less than the proposed $104 million budget)

MINNESOTA

Buildout targets were set based on expectations of future EV ownership. Utility investment is meant to **spur competitive private buildout**

Utilities must submit annual **Transportation Electrification Plans** to Commission

Recommendations for Industry Planners and Policymakers

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Electricity industry should take a three-pronged approach to planning for a world with significantly greater EVs

Proactively develop an EV roadmap to maximize opportunities and limit challenges of EV adoption

- Develop location-specific **EV adoption forecasts** that identify the impact of key local drivers
- Incorporate forecasts into **resource, grid, and EV infrastructure planning and investments**
- Design tailored EV adoption programs and mechanisms, including **EV-specific rates** to maximize cost savings to EV owners and limit peak load impacts

Craft EV regulatory policies that articulate societal and non-energy benefits of EV adoption

- Propose framework for cost-effectiveness assessment that takes into account societal benefits of electrification and for prioritization of infrastructure investments; **Total Value Test** by EPRI/Brattle offers such a framework
- Propose a **phased approach to infrastructure investment** that would allow balancing risks associated with an emerging technology and customer benefits resulting from the technology

Facilitate collaboration across the supply chain to identify win-win-win solutions that address barriers

- **Identify under-served markets** which are not prioritized by private investment and channel a share of investments into these markets (i.e. multi-unit buildings, low income areas, and low-traffic areas)
- Ensure best use of ratepayer funds by **leveraging strengths of different market participants**
- Make **customer outreach** a centerpiece of EV efforts and advance equitable access to infrastructure for all customers

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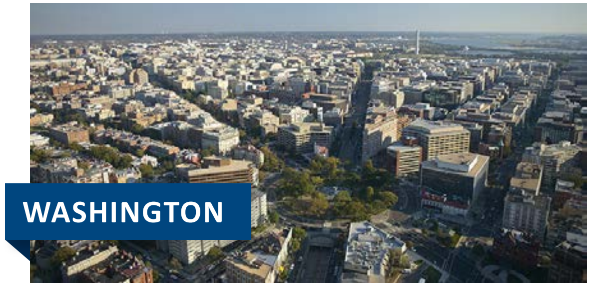
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