ELECTRIC VEHICLE MARKET

Key drivers of market growth and considerations for EV-grid integration

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ABOUT ATLAS PUBLIC POLICY

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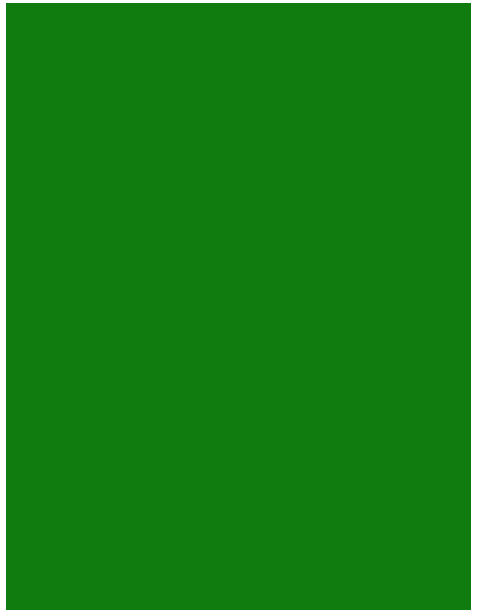
- DC-based policy tech firm started in 2015
- We equip businesses and policymakers to make strategic, informed decisions through the greater use of technology that aggregates publicly available information

Our Key Focus Areas

- **Access**: Collect and disseminate publicly available information for free.
- **Interpret**: Create technology to spur insights and conduct data-driven analyses.
- **Empower**: Strengthen policymakers, businesses, and non-profits' ability to meet emerging challenges and identify and seize opportunities.

OVERVIEW

- Why Electric Vehicles?
- Federal, State, and Local Policy
- EV Market State of Play
- EV-Grid Integration



EV AND CHARGING TERMINOLOGY

- Plug-in electric vehicle (EV)
  - Battery Electric Vehicle (BEV): all-electric car only powered by batteries
  - Plug-in Hybrid Electric Vehicle (PHEV) or Extended Range Electric Vehicle (EREV): vehicle that can be powered by either batteries, a gasoline engine, or both
- Charging Levels

Low – AC 120 V

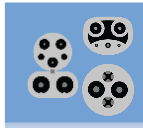
AC LEVEL 1

- Primarily residential (All EVs)
- Uses standard outlet
- Power requirements similar to a toaster
- Up to 1.4 kilowatts
- Can use existing power outlets resulting in no cost installation
- Charging rate: 3-5 miles per hour

Medium – AC 240 V

AC LEVEL 2

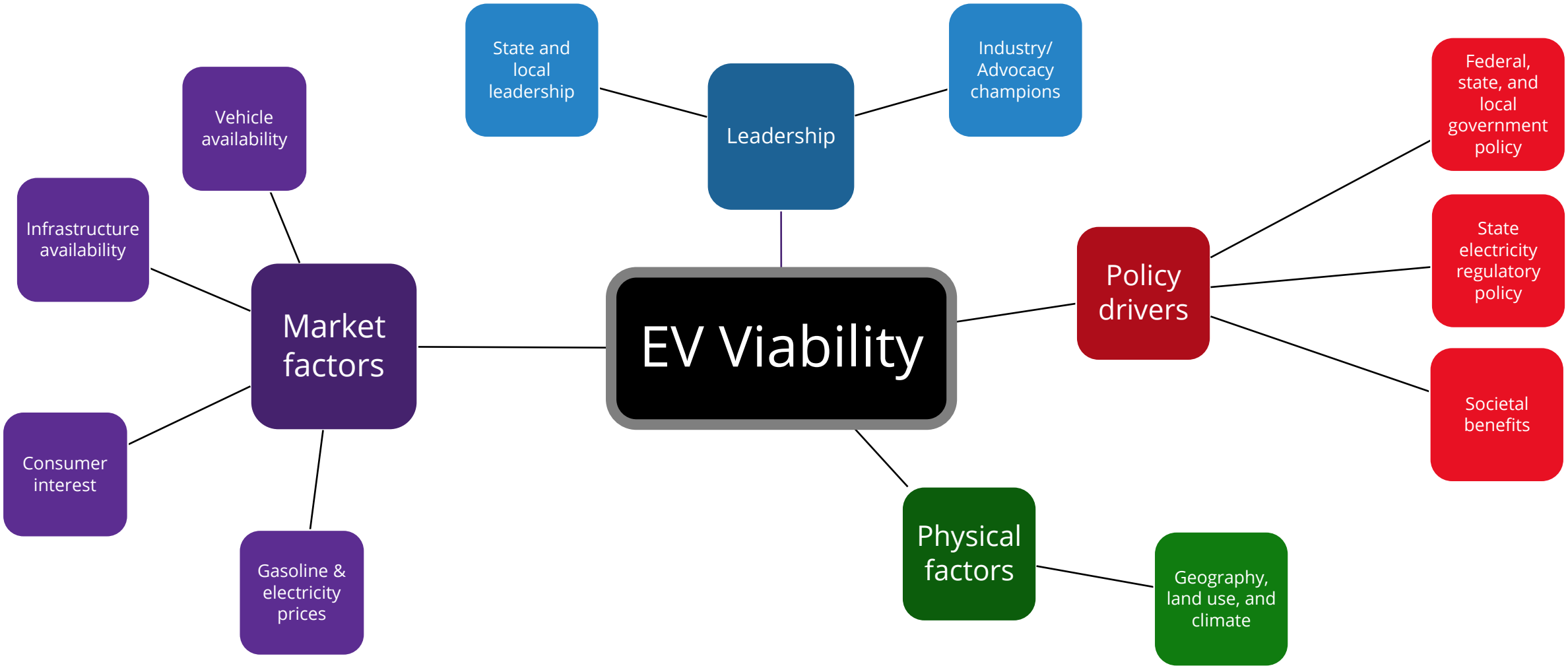
- Residential, Workplace and Commercial (All EVs)
- Requires high-voltage circuit
- Power requirements similar to an electric clothes dryer
- Up to 19.2 kilowatts
- Equipment & installation costs vary widely (~$6,500 in public and ~$2,000 at home)
- Charging rate: 12-75 miles per hour



High – DC Fast Charge

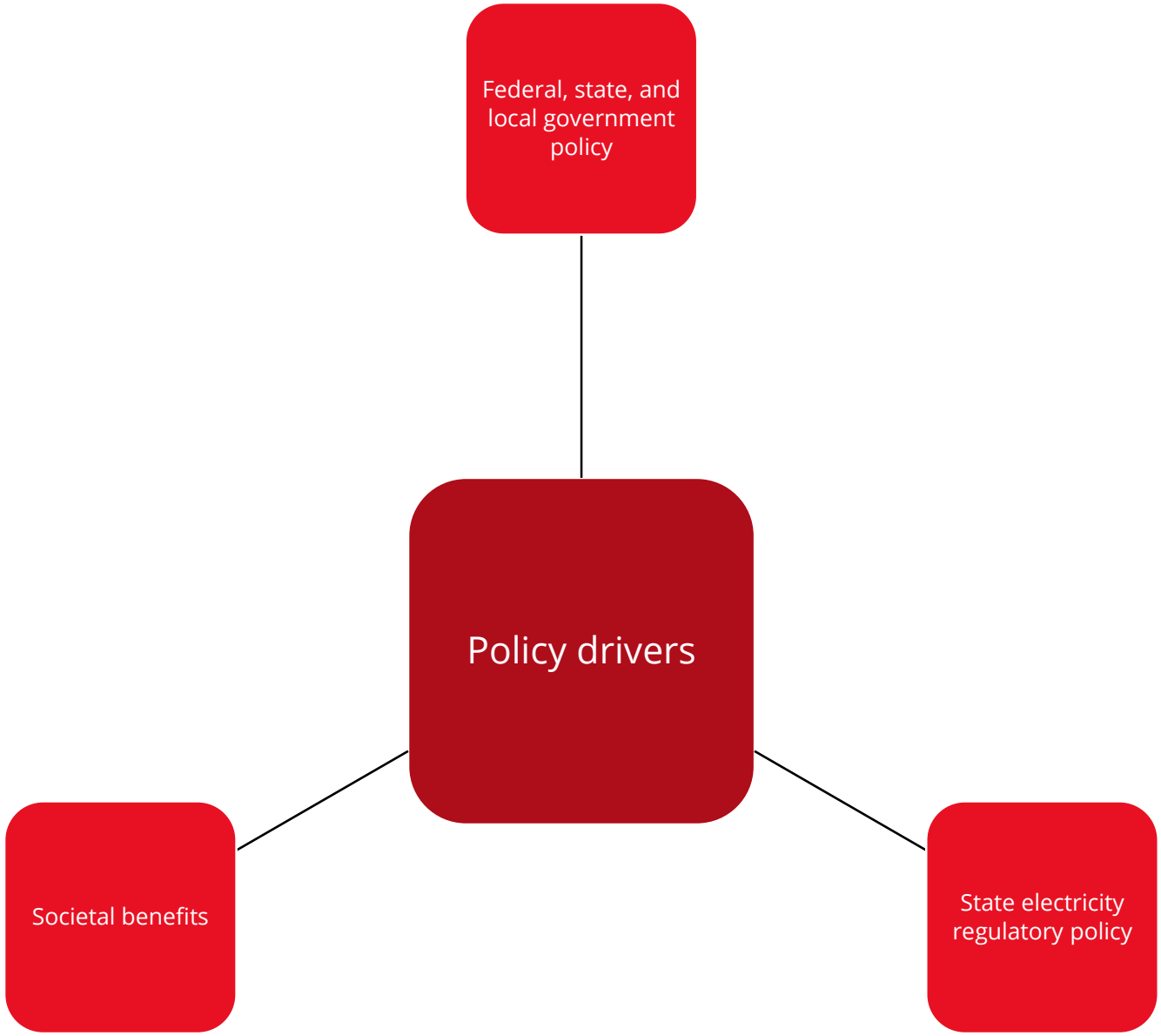
- Community/Metro and Highway Corridors (BEVs)
- Power requirements are up to max power for 15 homes
- Max power varies by system (CHAdeMO: 62.5 kW, SAE Combo: 100 kW, Tesla: 120kW)
- Can have very high equipment & installation costs (up to $90,000 per station)
- Charging rate: 100-300 miles per hour

REGIONAL FACTORS DRIVE EV MARKET SUCCESS



POLICY DRIVING THE EV MARKET

- Potential societal benefits helped drive initial interest in EVs
- Federal, state, and local government policy accelerating adoption in regional markets
- State electricity regulatory policy could lower EV-grid integration costs and realize benefits of EVs

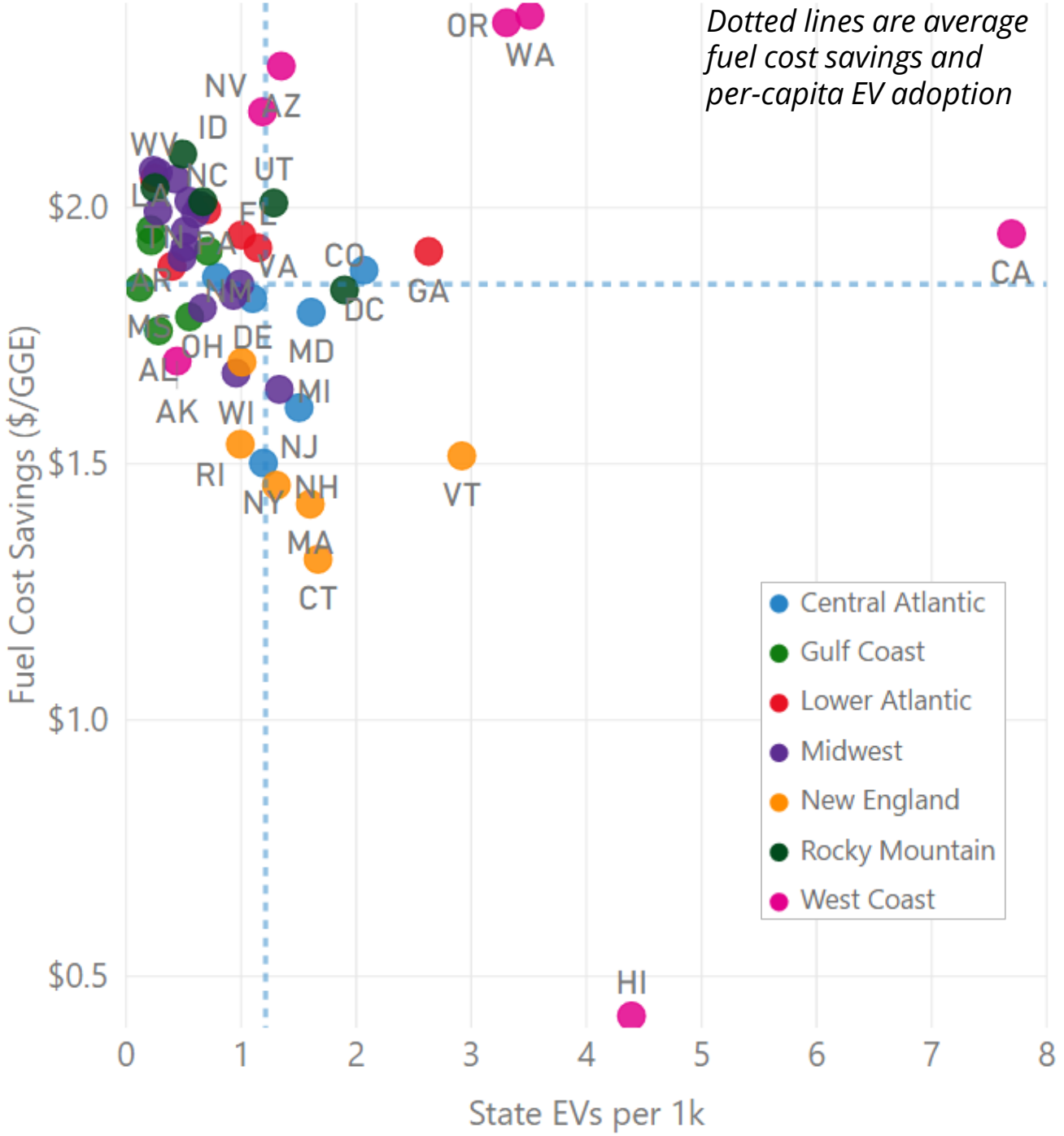


WHY ELECTRIC VEHICLES?

System Level Challenges	Opportunities with EVs
Electrical grid management	Can increase utilization of electric power assets
Fuel diversity (petroleum dependence)	Electricity has numerous domestic feedstocks
Extreme weather & global climate change	Lower lifecycle greenhouse gas emissions & resilient technology
Local air quality	Lower or No tailpipe emissions
Economic development	Cutting edge technological innovation

EVS HAVE CONSIDERABLE FUEL SAVINGS OVER GASOLINE VEHICLES

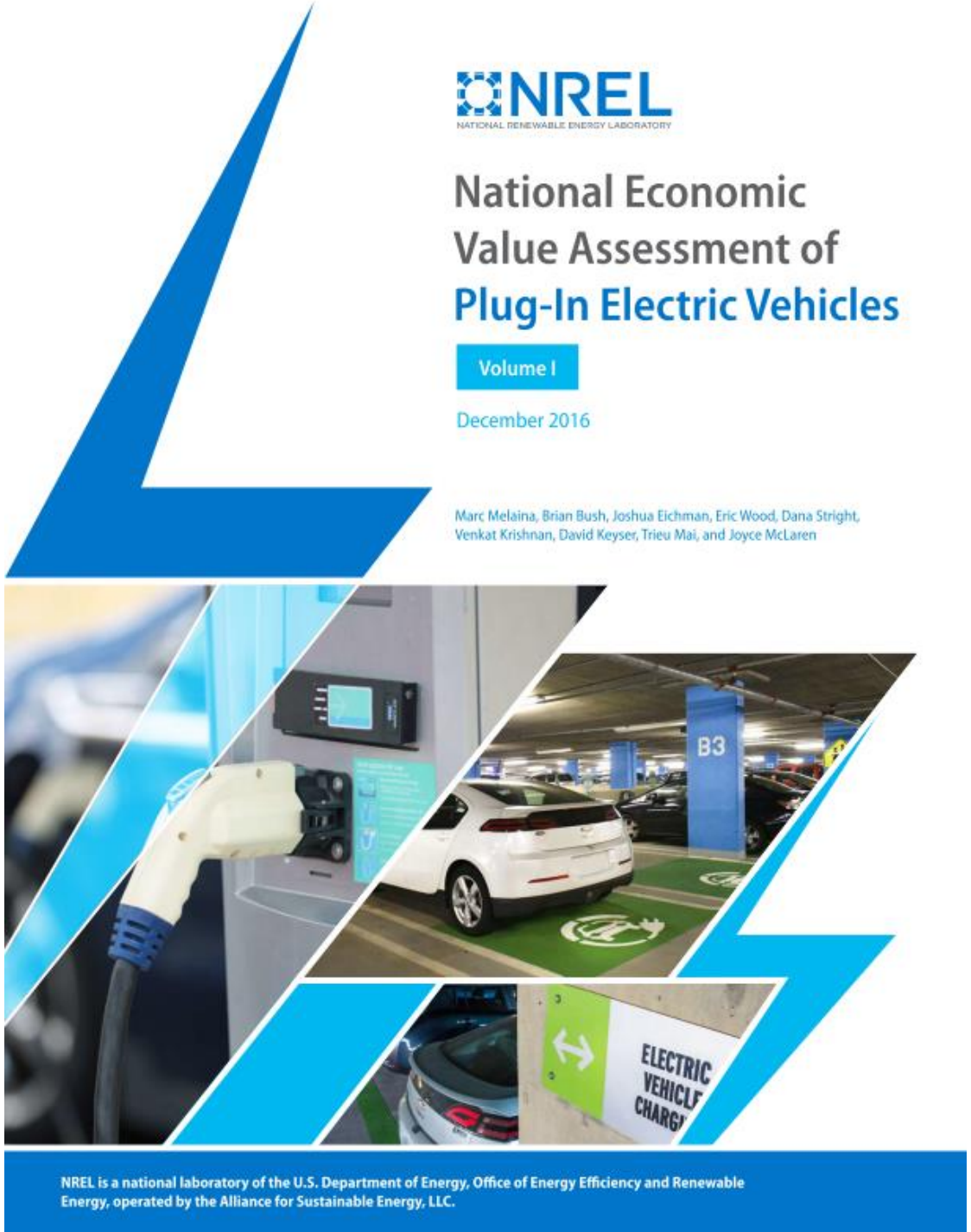
- Gas and electricity price differential can affect consumer and policymaker interest in EVs
  - Electricity prices are predictable and stable, but vary greatly nationwide
  - Gasoline prices fluctuate considerably and vary greatly nationwide
- U.S. average savings still greater than $1/gallon after oil price fall in 2014
  - Fuel cost savings is difference of electricity and gasoline prices on energy-equivalent basis



Source: Atlas Public Policy analysis of data from U.S. EIA (Electricity & Gasoline Prices) from 2011 to 2016

SIGNIFICANT SOCIETAL BENEFIT FROM GREATER EV DEPLOYMENT

- 2016 NREL study found significant social economic value from greater EV deployment
  - *Primary private benefit from fuel savings*
- Private costs and benefits
  - Vehicle and charging costs
  - Benefits: Household fuel savings
- Public costs and benefits
  - Workplace and publicly available charging costs
  - Benefits: Emission reductions, petroleum savings, increased jobs, and increased GDP
- Net societal benefit ranging from $4.7b to $83.7b depending on assumptions



FEDERAL, STATE, AND LOCAL GOVERNMENT POLICY

FEDERAL INCENTIVE

- Federal EV tax credit maximum value per vehicle is $7,500
  - Value is $2,500, plus $417 for vehicles with battery capacity of 5 kilowatt hours (kWh) and $417 for each additional kWh in battery capacity
- Tax credit phases out when auto manufacturer has sold 200,000 qualifying EVs
  - Phases out for that manufacturer over a one-year period
  - Vehicle purchasers from that manufacturer can receive reduced credits depending on when they are purchased during the phase-out period

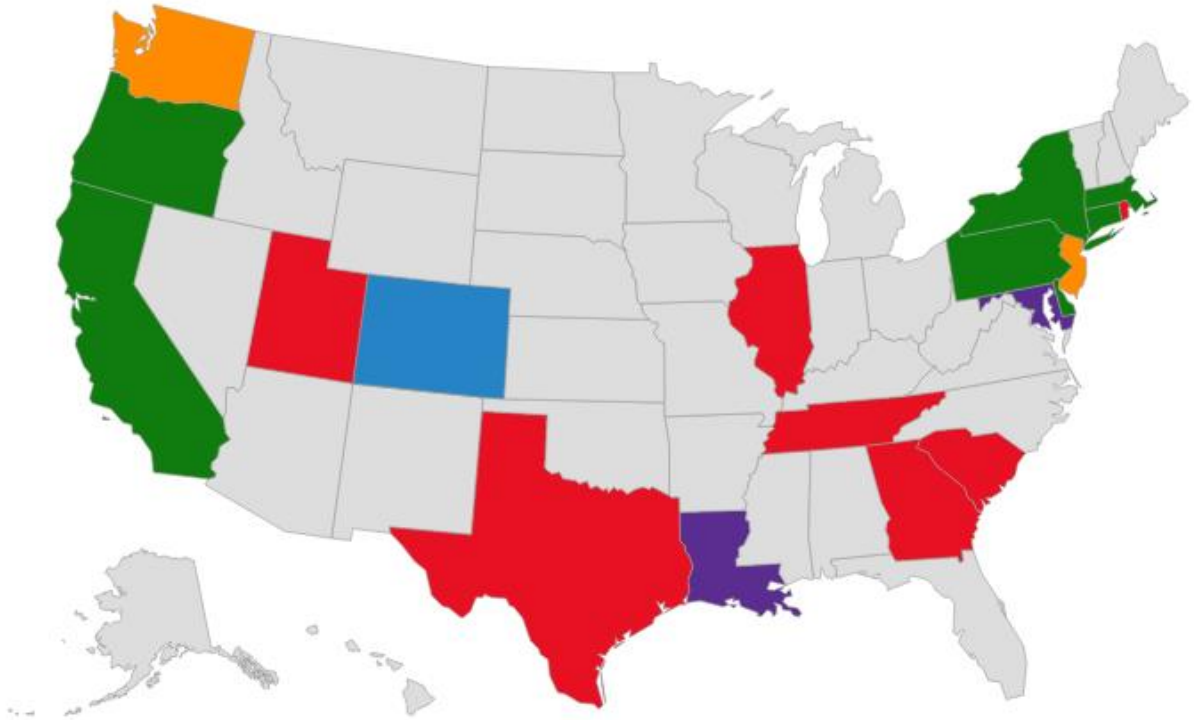
Total EV Sales by Manufacturer through August 2017

Manufacturer	EV Sales
General Motors Corp.	149,947
Tesla	140,243
Nissan North America Inc.	112,914
Ford Motor Company	97,492

Source: Atlas Public Policy Analysis of data from hybridcars.com (2017)

STATE VEHICLE INCENTIVES

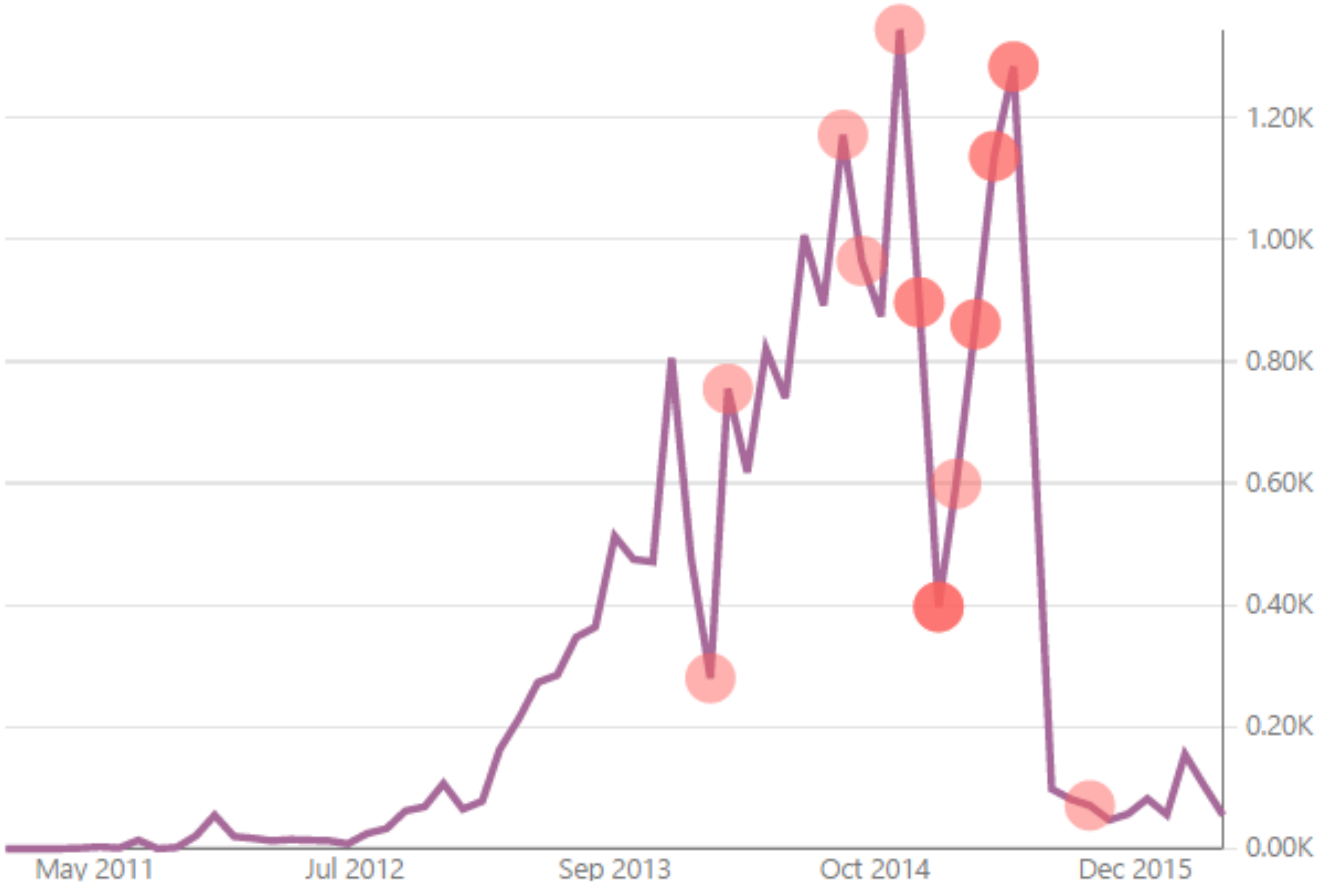
- 12 states with active vehicle incentives
  - Varied approaches
  - Most are non-ZEV states
  - 70% of total EV sales (80% including expired states)
- Rebates or assignable tax credits are preferred
  - “Cash on the hood”
- Georgia exemplifies importance of predictable and sustained policy



Source: Atlas Public Policy analysis of data from Alternative Fuel Data Center (2017)

POLICY MUST BE PREDICTABLE AND SUSTAINED: GEORGIA CASE STUDY

- Georgia had 2nd largest EV market in 2014
  - Innovative auto dealers (Nissan) made BEV purchase compelling
  - Georgia had highest per capita BEV adoption
  - Growing awareness of EV market success led to increased media coverage
- Legislature abruptly ended tax credit in July 2015
  - Sales immediately collapsed and have not recovered despite strong utility, HOV incentive, & other positive factors for EVs



Monthly BEV sales in Georgia. Red dots are news stories on Georgia EV market leading up to BEV tax credit ending.

Source: Atlas Public Policy analysis

POLICY DRIVES EV DEPLOYMENT IN LEADING CITIES

- Of 8 EV-cities with above average EV adoption, 6 had consumer incentives and 5 adopted California's ZEV program
- Best practices for driving EV Sales
  - Consumer incentives, charging infrastructure, model availability, and city-level actions to promote EV awareness
  - "Ecosystem approach" requires state, local, public and private stakeholder engagement

Source: *Assessment of Leading Electric Vehicle Promotion Activities in United States Cities (ICCT, 2015)*

Seattle
- Incentives, utility action, charging infrastructure
- EV sales more than 3x U.S. average

Atlanta
- Expired BEV incentive, carpool lane access
- BEV sales with incentives more than 8x U.S. average

Portland
- Most extensive charging network and outreach
- BEV sales more than 3x U.S. average

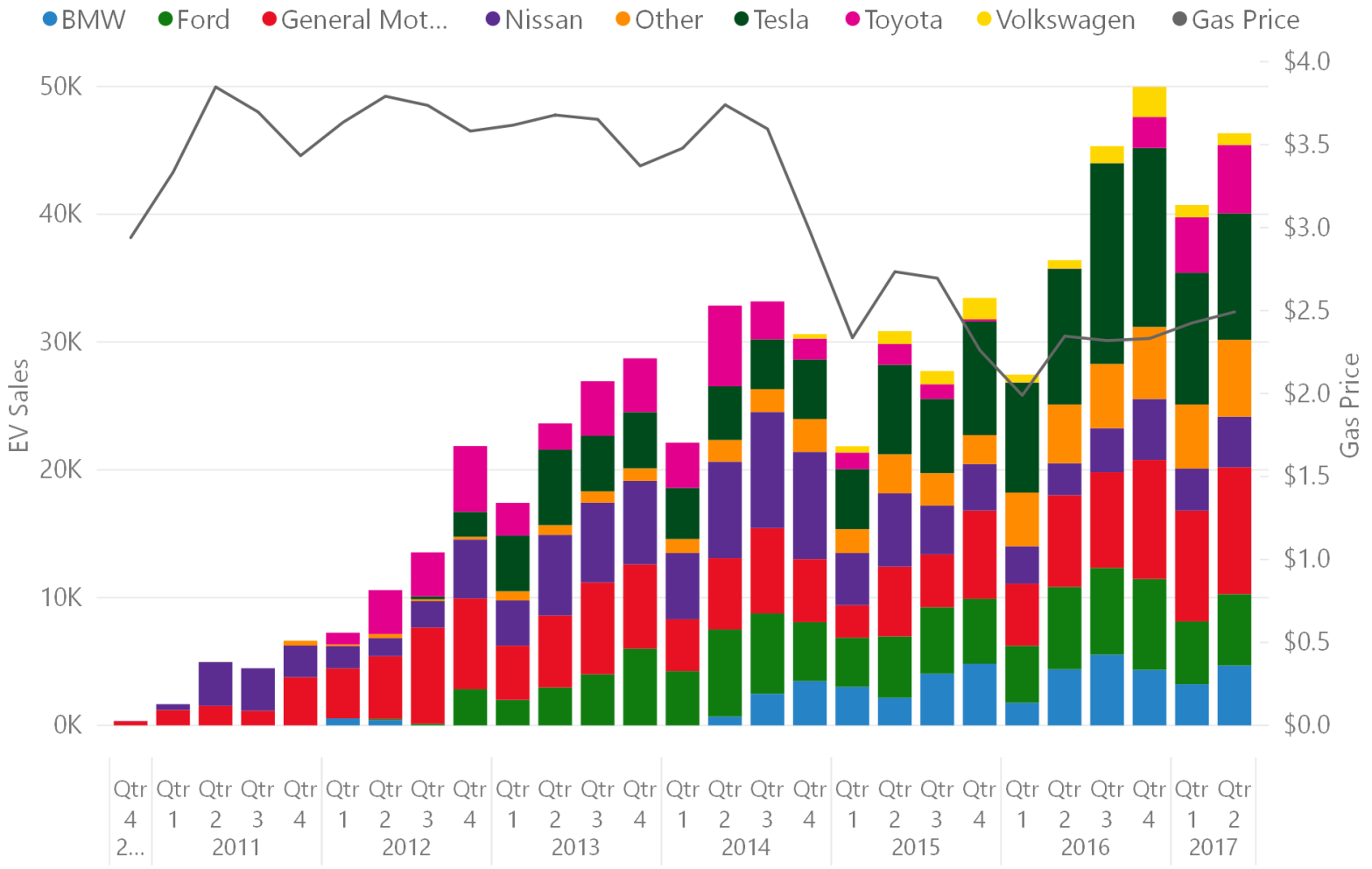
4 California Cities
- Strong environmental policy, long-term commitment to incentives and city-level promotion
- EV uptake is consistently higher than national average
- Riverside, San Diego, Los Angeles, and San Francisco

EV MARKET STATE OF PLAY

A growing market in a period of low gas prices

U.S. EV SALES RESILIENT DESPITE LOW GAS PRICES

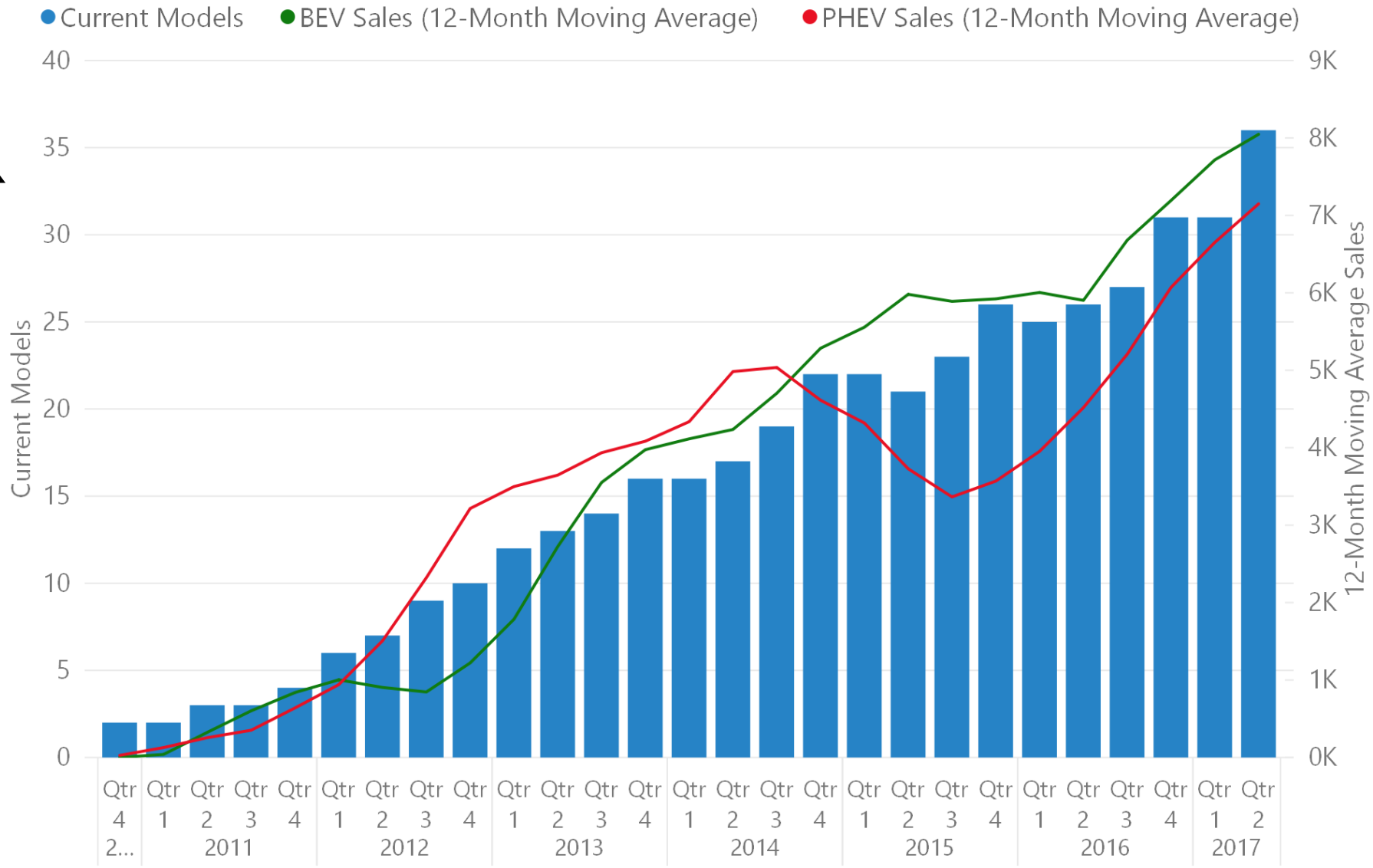
- Gas prices plummeted in summer of 2014
  - Expected to stay below $2.50 through 2018
- 650k EV sales since 2010
  - Could hit 1m EVs by next year
- Continuous quarterly sales records since Q4 of 2015
  - 2016 sales up 30% YOY
  - 2017 sales expected to be up 25% YOY
  - Tesla Model 3 wildcard



Source: Atlas Public Policy Analysis of data from hybridcars.com & U.S. Energy Information Administration (2017)

INCREASED CHOICES FOR CONSUMERS

- Steady increase in plug-in hybrid availability in 2016,
  - Compact car, midsize car, and full-size all-wheel-drive SUV
- +75% plug-in hybrid sales in 2016
  - 2nd Generation Chevy Volt compact
  - Ford Fusion and CMAX midsize
  - BMW X5 AWD SUV



Source: Atlas Public Policy Analysis of data from hybridcars.com & U.S. Energy Information Administration (2017)

AUTOMAKERS ARE DOUBLING DOWN ON EVS

- Affordable long-range EVs arriving much faster than expected
  - 200-mile Chevy Bolt on sale for $37,500
  - 200-mile Tesla Model 3 on sale for $35,000
- More, improved options for plug-in hybrids
  - 2nd Generation Chevy Volt increased electric range by 40%
  - 2017 Chrysler Pacifica is first plug-in hybrid minivan

Major EV investments by automakers

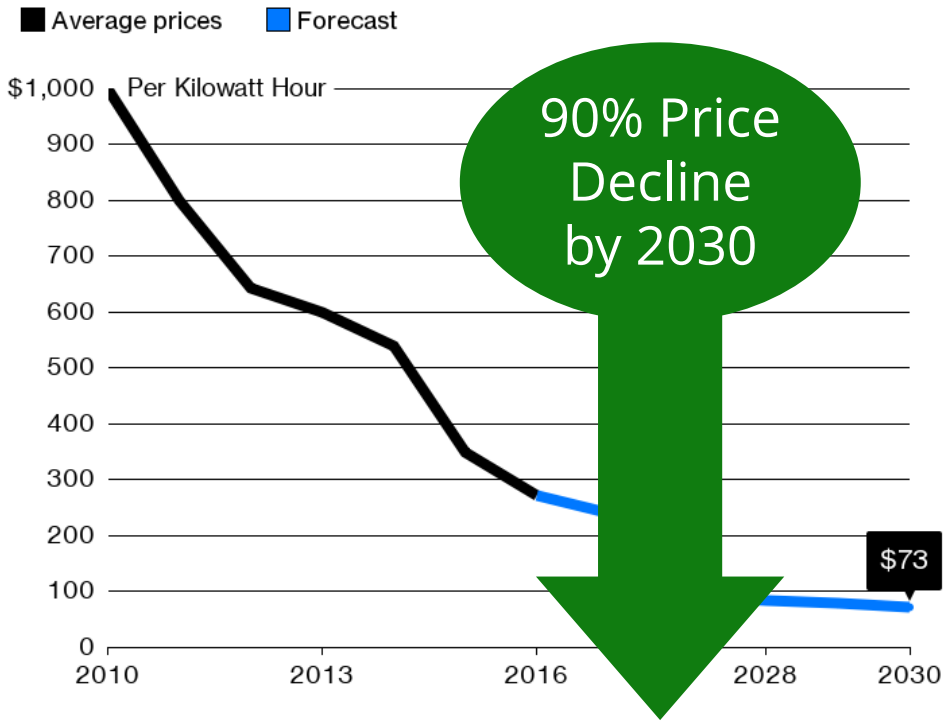
2016

- Ford committed **$4.5b** with goal of 40% of its models having electric option by 2022 (January)
- GM invested **$500m** in Lyft, helping bring autonomous EVs to shared mobility (May)
- Volkswagen plans to have **30** new all-electric models by 2025 (June)
- Tesla opened its **$5b** Gigafactory (July)

2017

- Mercedes will invest up to **$11b** in electric vehicles (February)
- Tesla delivers first Model 3 and will rapidly advance EV investments (July)
- GM plans to add 20 new EV models by 2023

BATTERY ADVANCES ARE MAKING ALL-ELECTRICS AFFORDABLE



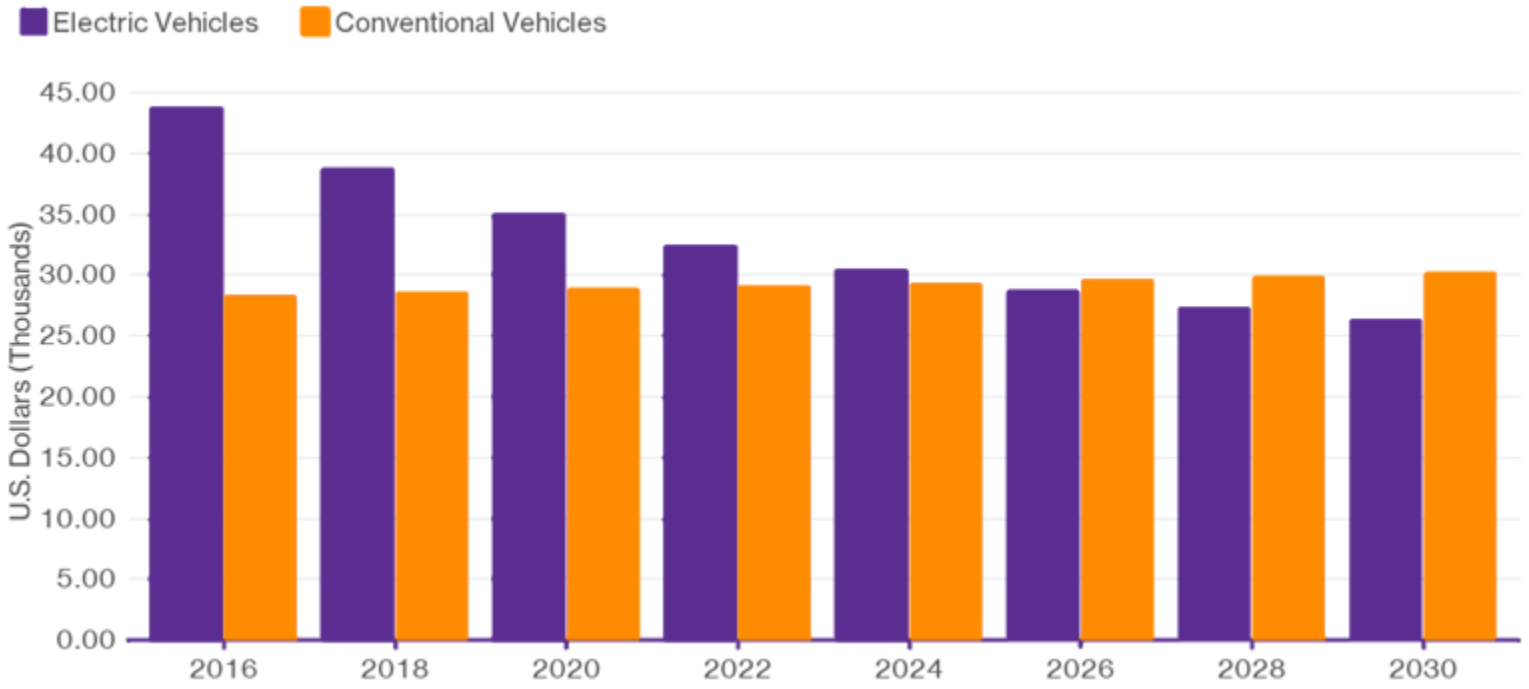
Source: [Bloomberg New Energy Finance (June, 2017)]

Vehicle cost per mile of battery range		Range in miles	MSRP
2017 Chevy Bolt	$157	238	$37,500
2017 Tesla Model 3	$163	215	$35,000
2016 Tesla Model S	$307	259	$79,500
2017 Nissan LEAF	$345	84	$29,010
2016 Tesla Model X	$349	238	$83,000
2017 BMW i3	$382	114	$43,600
2016 Ford Focus Electric	$384	76	$29,170
2011 Nissan LEAF	$443	74	$32,780
2014 BMW i3	$510	81	$41,350
2012 Ford Focus Electric	$516	76	$39,200

EVS WILL COST LESS THAN GAS CARS WITHIN 7 YEARS

- Upfront costs of EVs to be lower than gasoline cars by 2025
- Battery costs will fall 77% from 2016 to 2030
- Conventional cars will cost more due to emissions regulations

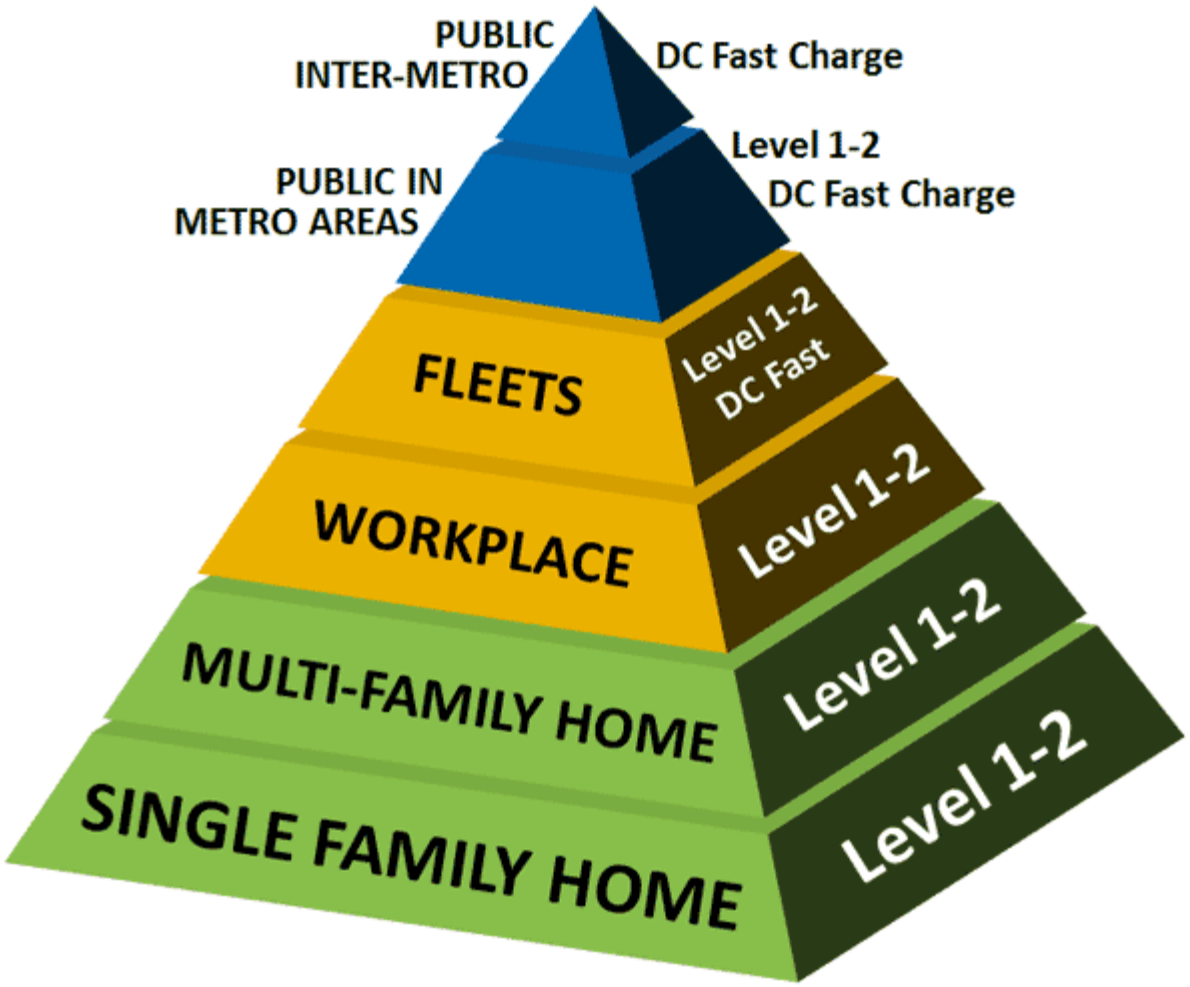
Upfront Cost of Vehicle



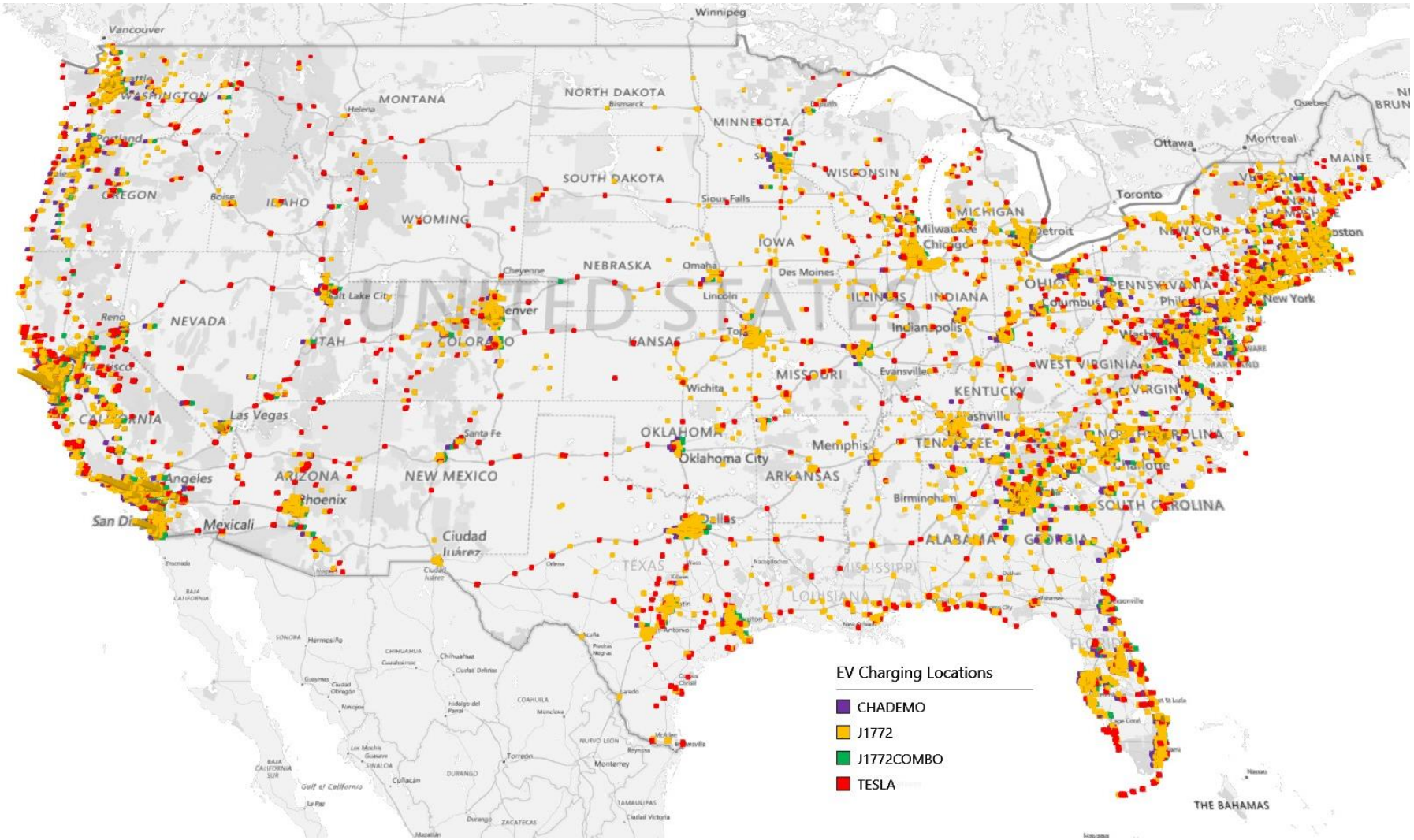
Source: Bloomberg New Energy Finance (May 2017)

CHARGING INFRASTRUCTURE OVERVIEW

- Charging pyramid reflects current and near-term vehicle technology demand
  - Over 80% of charging is likely to occur at home when available
  - Deployment costs almost inverse of charging pyramid
  - Top of pyramid (DC fast charge) mostly relevant for BEVs
- Workplace and public used much less frequently
  - Extended daily travel for BEVs
  - Interregional travel increasingly important
  - Increases electric mile share for PHEVs
  - Substitute when home charging is unavailable
- Business case for public charging is complex
  - Public quick charging needed for long distance BEV travel



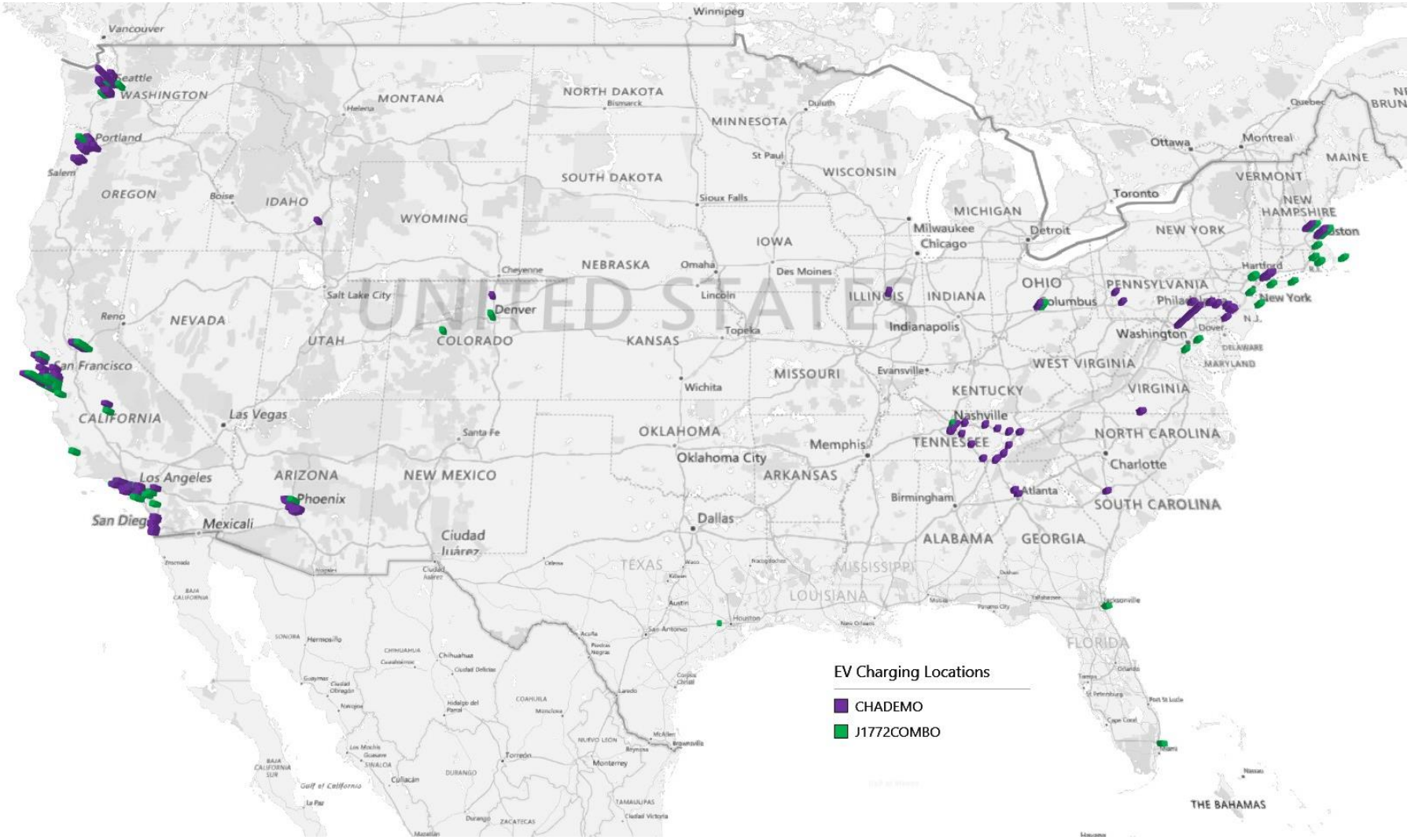
PUBLIC CHARGING AVAILABILITY GROWING, BUT LIMITED



- Charging access at Level 2 and DC fast charging levels
  - Level 1 connector typically comes with an EV
- PHEVs currently do not support DC fast charging and some BEVs are not equipped with DC fast charging connectors
- 3 major DC fast charging connectors are not interoperable

Source: Atlas Public Policy Analysis of data from U.S. Department of Energy (2017)

DC FAST CHARGING COMPLEXES NEEDED FOR NEW BEVS



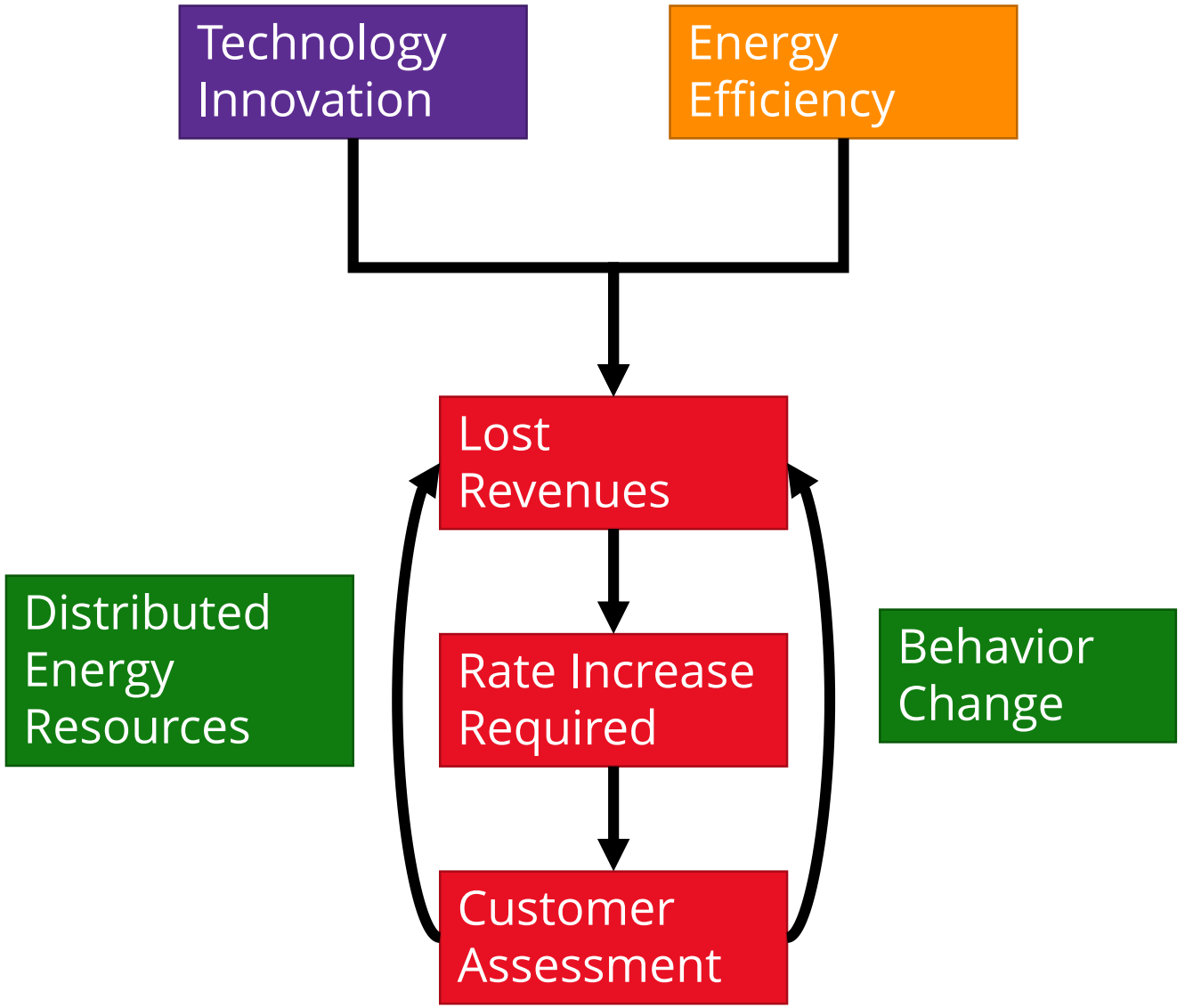
- Very few DC fast charging locations with more than one charging port of the same connector
  - Drivers need reliable access
- Automakers launching 200+ mile BEVs
  - Sales could be stymied due to limited fast charging access

Source: Atlas Public Policy Analysis of data from U.S. Department of Energy (2017)

EV-GRID INTEGRATION

MAJOR TRENDS IN ELECTRIC POWER DRIVING INTEREST IN EV MARKET

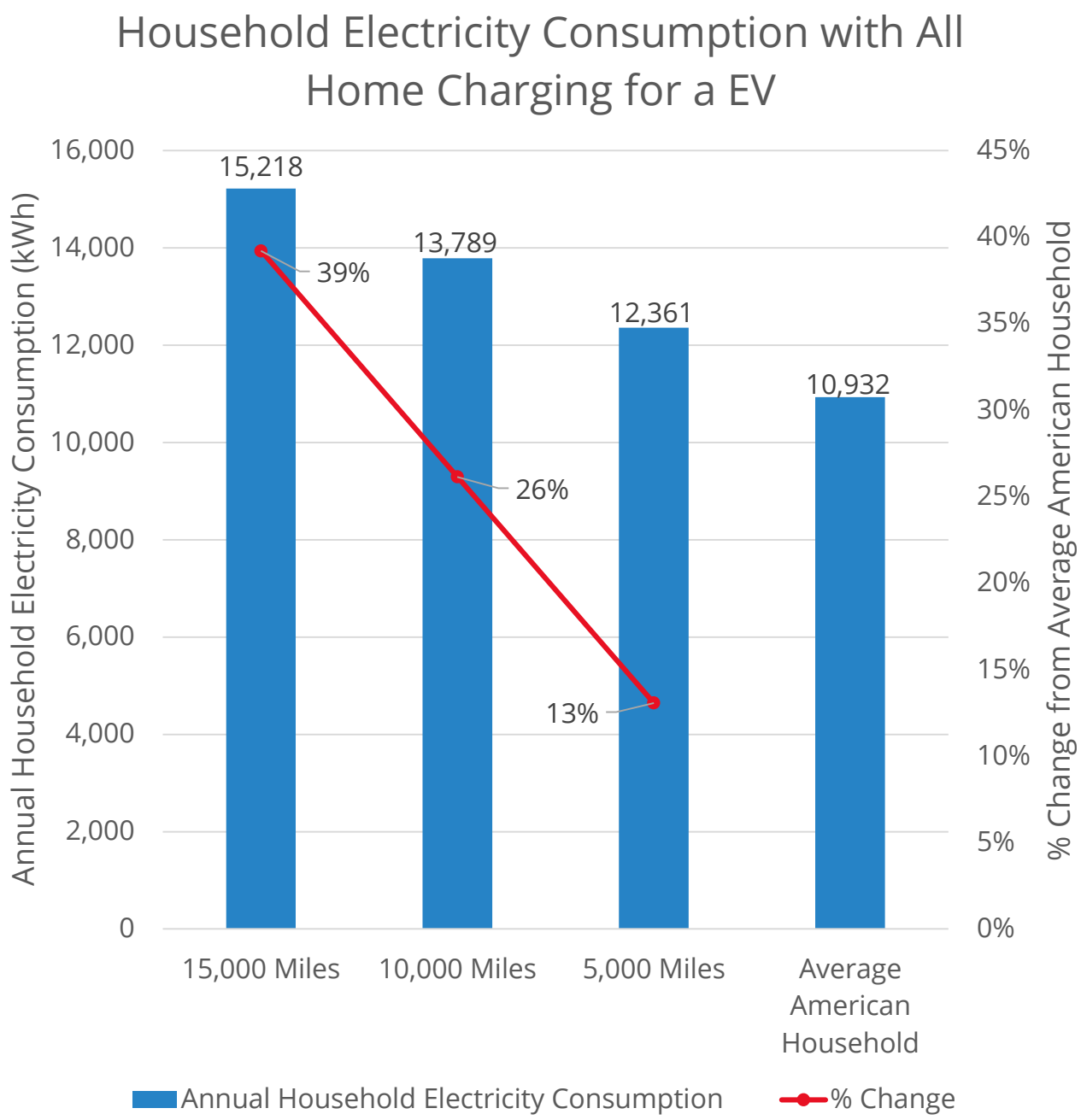
- **Reduced Demand**: Public policy driving energy efficiency and reducing electricity demand
  - Building codes
  - Appliance efficiency standards
  - Utility decoupling
- **Increased Investment**: Record $42 billion invested in electrical grid in 2014 (Source: EEI, 2016)
- **Lower Emissions**: Electric power carbon dioxide emissions in 2015 were over 20% below 2005 levels (Source: EIA, 2016)



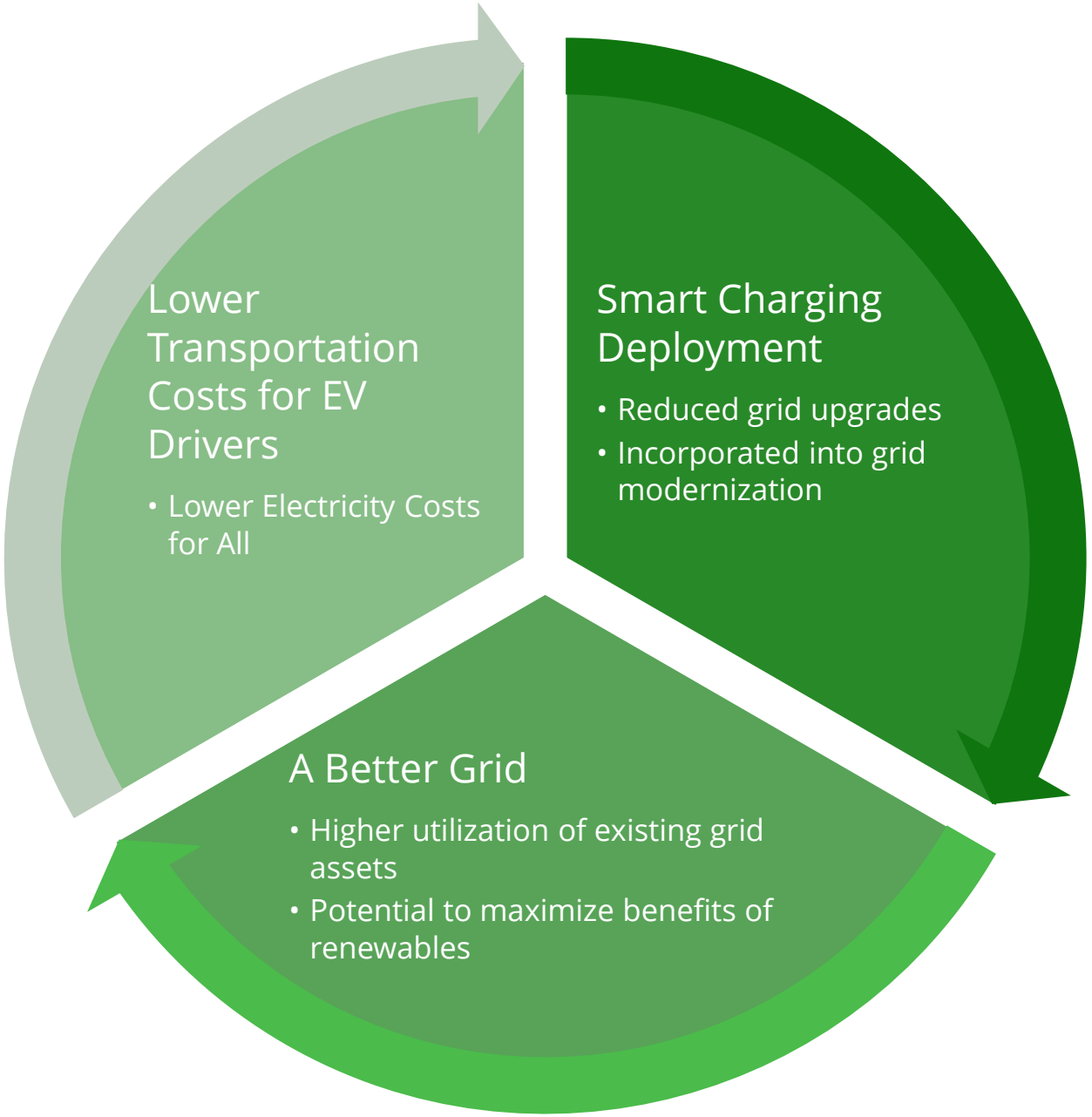
Source: Edison Electric Institute

EVS ARE A PROMISING SOLUTION

- Transportation electrification at scale can offset declining system utilization and rising cost-of-service
- Managed charging at home and work can result in more overnight, off-peak charging
  - Better system utilization
  - Reduced peak load



Source: Atlas Public Policy Analysis



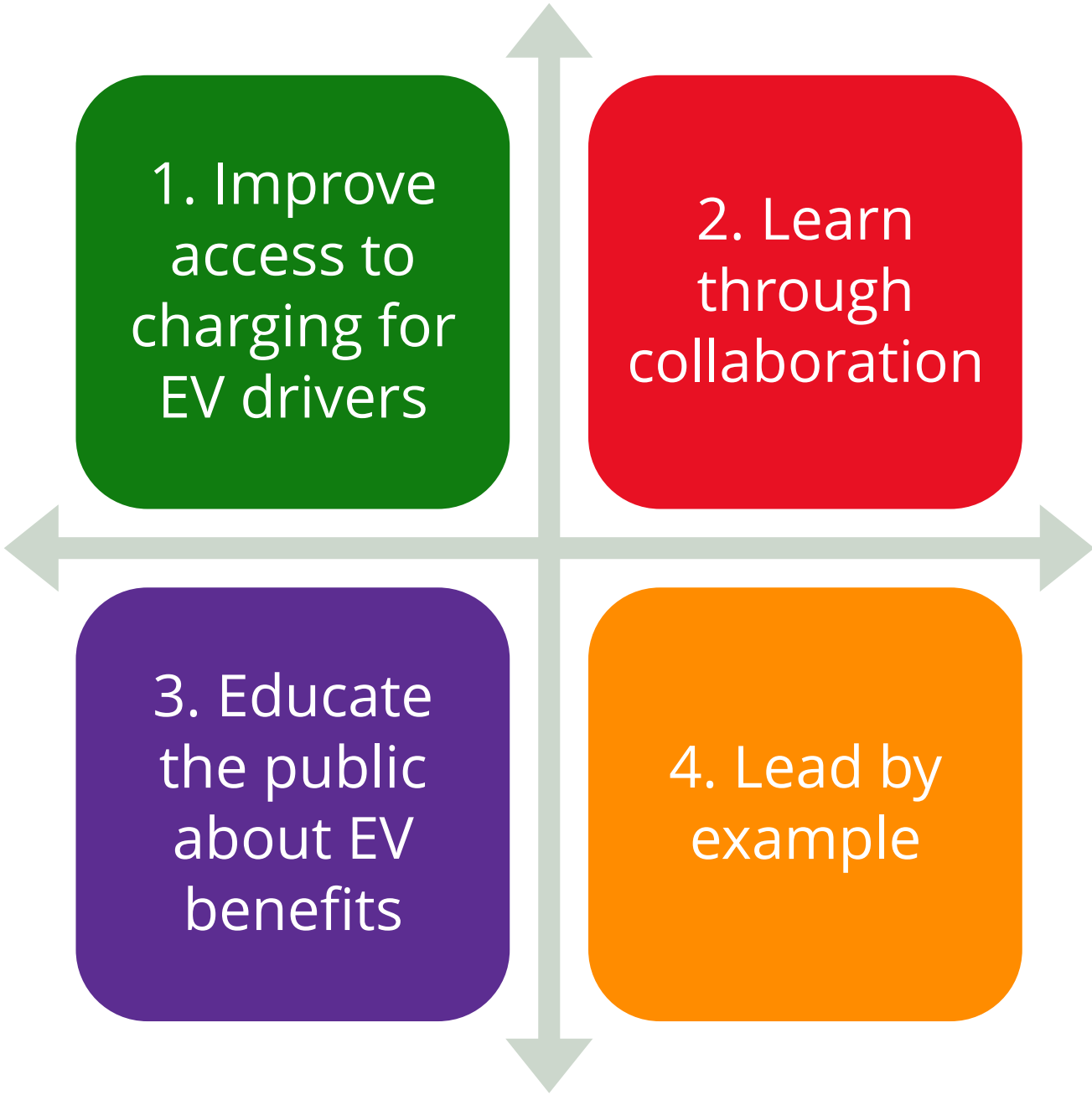
Source: [Advancing Industry Collaboration in the EV Market (Atlas Public Policy, 2016)]

UTILITY ENGAGEMENT IN EVS CAN CREATE VIRTUOUS CYCLE

- Utility leverages grid experience to capture EV benefits
- EV deployment can complement utility's main objective for grid
  - Safe and reliable
  - Environmentally sustainable
  - Efficient and affordable
- EVs primarily charge overnight
  - Can increase utilization of existing assets putting downward pressure on rates

GREATER INDUSTRY COLLABORATION CAN ACCELERATE EV ADOPTION

- Automakers, electric utilities, and charging service providers collaboration can:
  - Optimize private investments
  - Leverage experience
  - Reduce deployment costs
- Greater utility engagement is key ingredient
  - Lower vehicle ownership costs by capturing EV benefits to ratepayer
  - New approaches to electricity rates
  - Greater and more rapid charging infrastructure deployment
  - Developing synergism with existing capacity and required new capacity



Source: Advancing Industry Collaboration in the EV Market (Atlas Public Policy, 2016)

STRATEGIES TO LOWER EV-GRID INTEGRATION COSTS

- Off peak rates for residential charging and workplace lower total cost of ownership of EVs
- Residential metering and rate strategies need creative thinking
  - Evaluations needed on whole house meter vs. household and EV meters
- Whole house off peak rates can:
  - Assist load management by encouraging off-peak demand
  - Discourage peak usage with higher peak rates or demand charges while offering attractive off-peak benefit

- *Source: Effects of Utility Outreach on Plug-in Electric Vehicle Market Success (Argonne National Laboratory, 2016)*

Principles of EV-Grid Integration

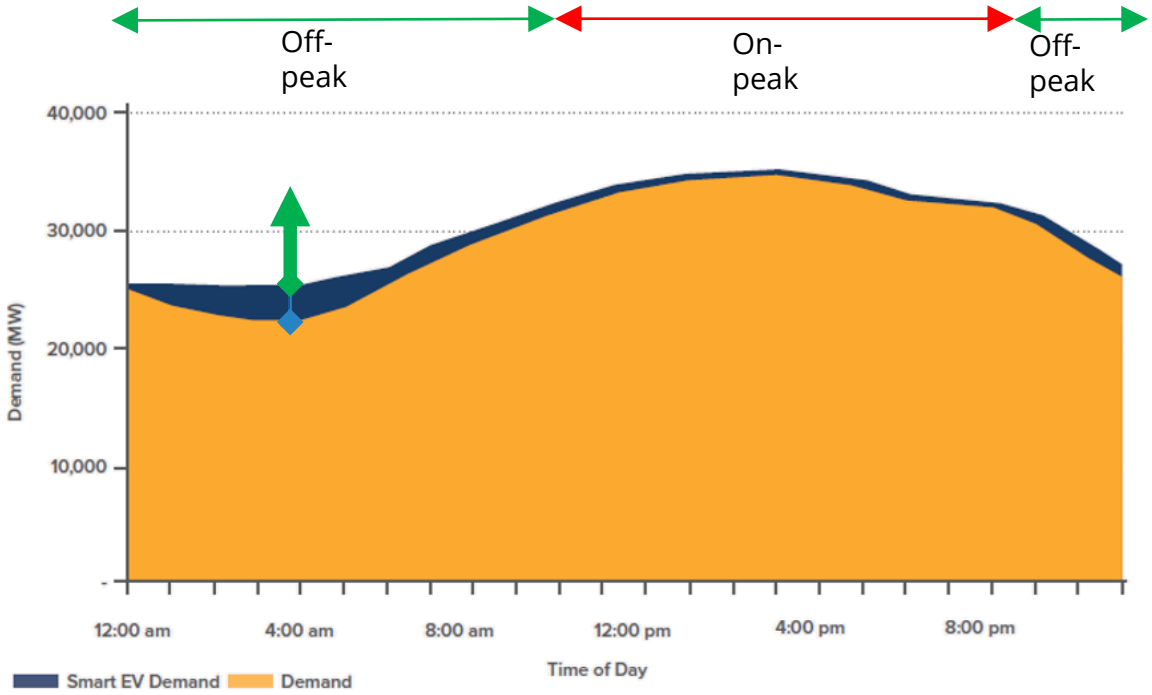
- Protect the reliability of the grid
- Minimize cost to the electricity distribution system
- Encourage transportation electrification
- Provide consistent treatment of EVs with comparable loads

Source: An Action Plan to Integrate Plug-in Electric Vehicles with the U.S. Electrical Grid (C2ES, 2012)

LOAD MANAGEMENT STRATEGIES FOR EV CHARGING

- Smart EV integration should fill in system utilization gaps
  - Limit need for new capacity in near term
  - Utilities can help manage load effectively, especially with smart residential charging
- More aggressive residential and workplace managed charging can improve integration further
  - Charging rates could be lower before peak demand period
  - Consider seasonal and work-week load variations
- Time variant electricity rates should consider environmental and economic goals
  - Low-cost charging at night can sometimes lead to higher emissions
  - Whole-house rates can lead to less savings in areas with high air conditioning usage

Opportunity to increase grid utilization with additional 'Smart EV Demand' during off-peak periods



Source: Electric Vehicles as a Distributed Energy Resource (Rocky Mountain Institute, 2017)

KEY TAKEAWAYS

- Growing EV market requires engagement from utilities and regulators
- Benefits of EV-Grid integration vary by location and require local assessments of utility role in grid management and infrastructure deployment
  - Utilities engagement can help all ratepayers benefit from EVs
  - Utility role in support of charging infrastructure depends on market needs
- If properly managed, EVs can benefit consumers, the environment, and state economies

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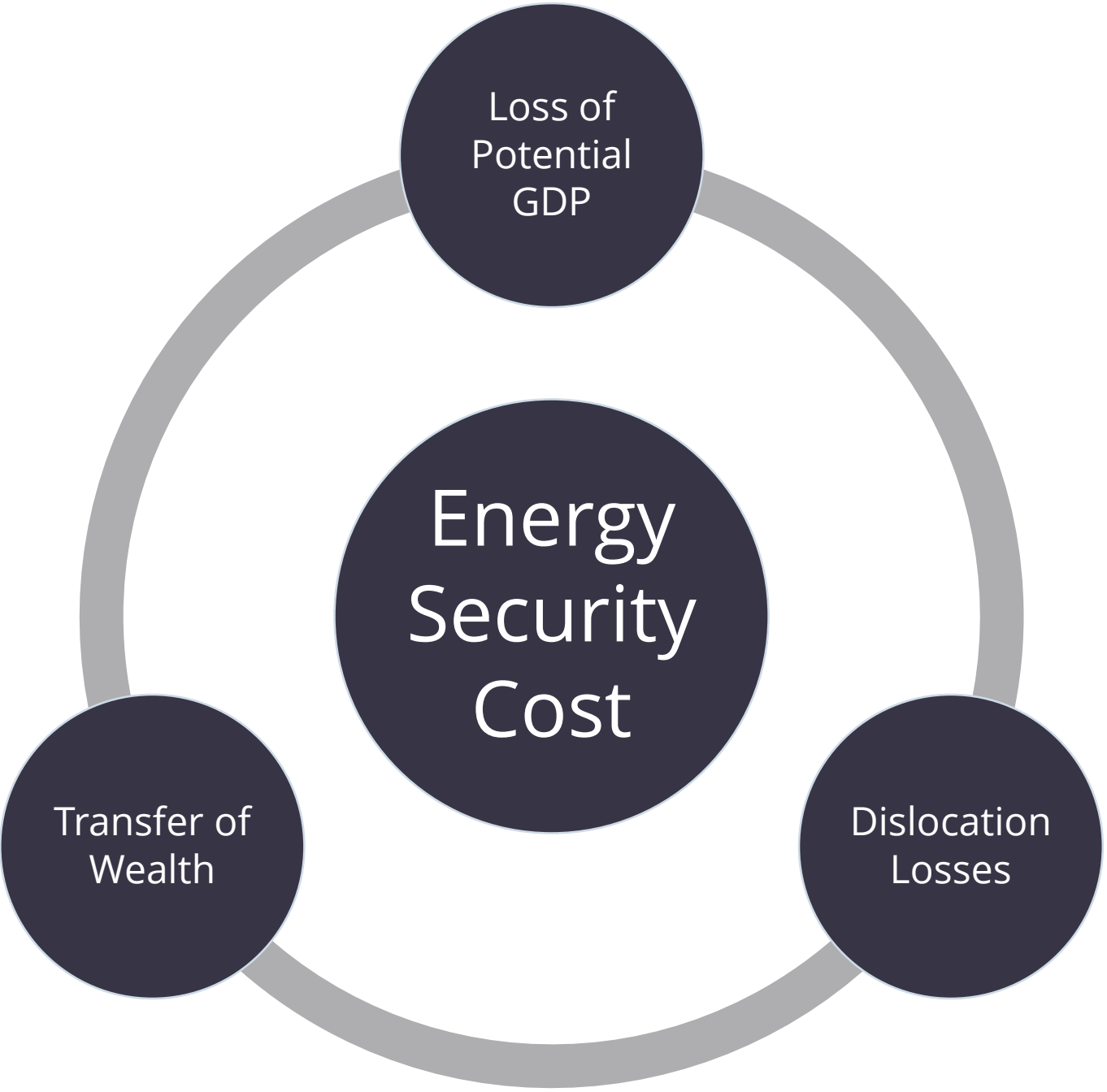
APPENDIX

Backup slides



ENERGY SECURITY BENEFITS OF EVS

- 2009 RAND Corporation study found that the United States spends $83 billion per year to secure global supply and transit of oil
- 2014 Oak Ridge National Laboratory study estimated that all-electric vehicle could provide over $2,000 per vehicle in energy security benefits in 2025
- 2015 IEA report found low prices increase concentration of low-cost suppliers in oil market
  - Increases dependence on Middle East oil
  - Leads to increase in vulnerability to supply disruptions and potential price shocks
- Consumers can be locked-in to decisions made when prices are low
  - Oil is not easily substitutable as a transportation fuel
  - Creates inelastic demand causing significant economic losses when prices spike

FUTURE/ADAPTED EVS CAN SUPPORT EMERGENCY RESPONSE SERVICES

- EVs that can send power out of their batteries can be mobile power sources in case of emergency
- Electricity can go out in a disaster but is usually restored quickly
  - Conventional fuel supplies can take longer
- Technology is still emerging and sending power out of the vehicle is a non-standard use

iREV
Initiative for Resiliency in Energy through Vehicles

Electric Vehicles and Emergency Response

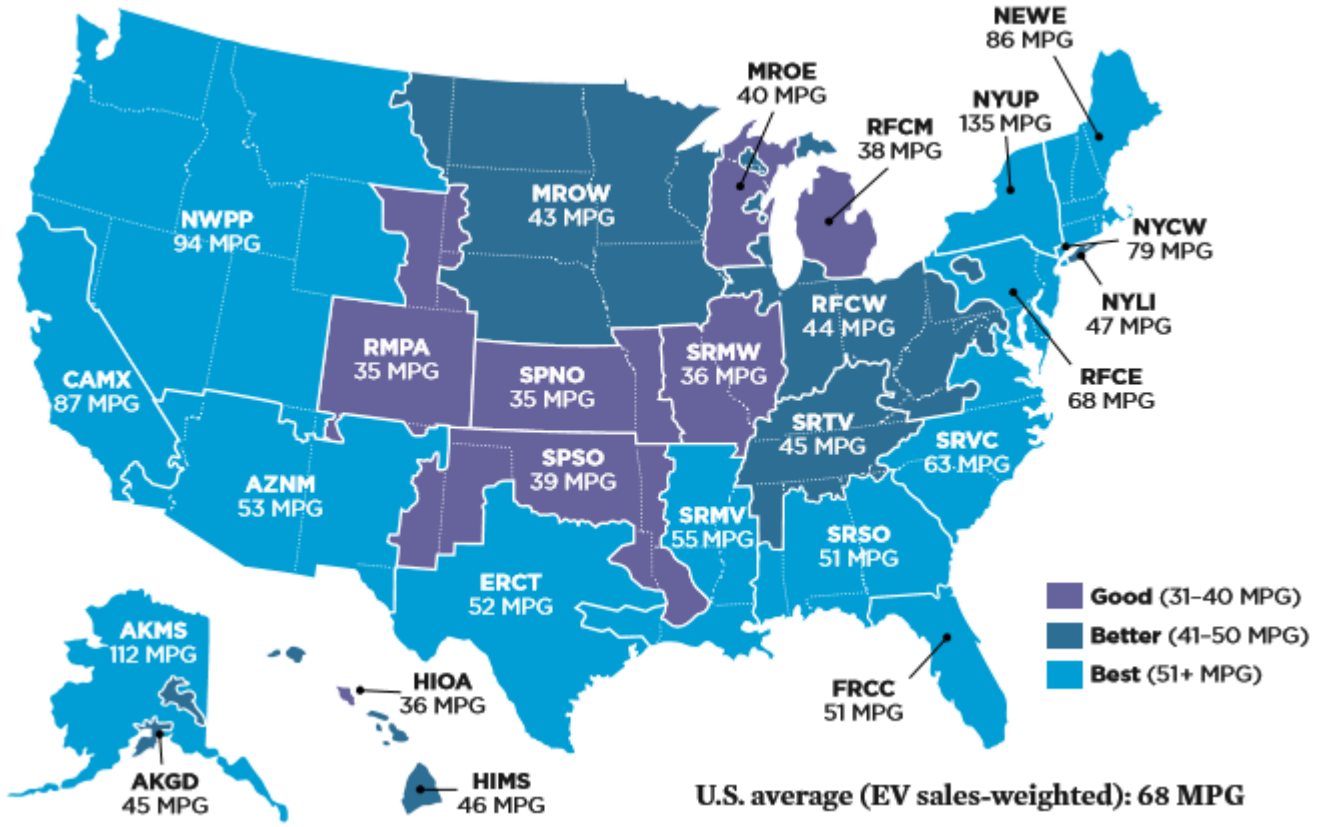
LAPD purchased 100 BMW i3 electric cars.

June 2016

Source: NASEO, 2016

ENVIRONMENTAL BENEFITS OF EVS ARE INCREASING

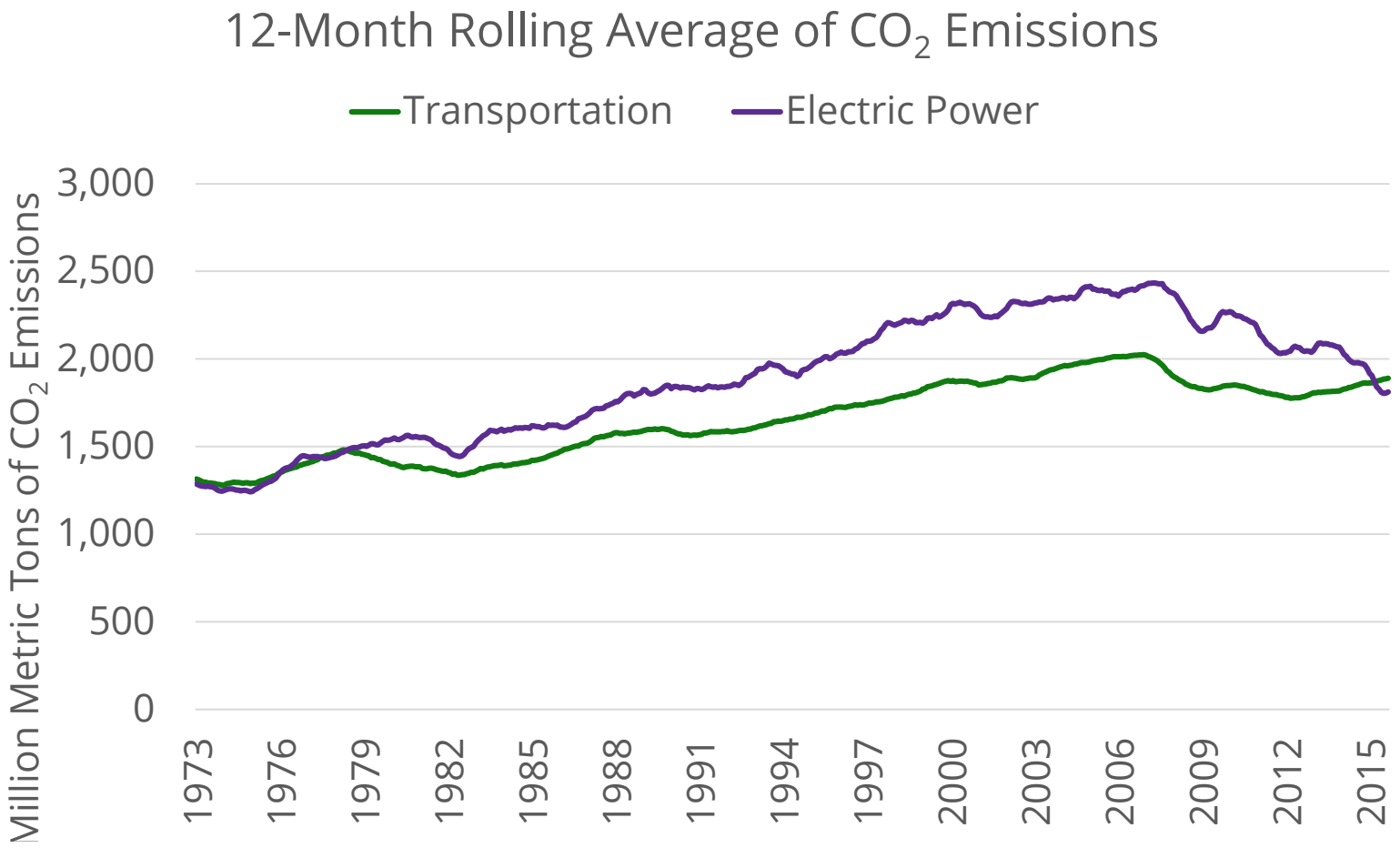
- Research shows EVs today have lower lifecycle greenhouse gas emissions than most conventional vehicles
  - Average fuel economy of EVs is 2x current gasoline vehicles
- Atlas study for Connecticut showed EVs are only viable near-term pathway to significantly reduce emissions from passenger vehicles



Source: Cleaner Cars from Cradle to Grave (UCS, 2015)

EVS CAN HELP INTEGRATE MORE RENEWABLES

- U.S. transportation CO2 emissions surpassed electric power emissions in March 2016 for first time since 1979
- Argonne National Lab study found managed EV charging can lower the cost of adding renewables, potentially lowering grid emissions further
- Pacific Northwest National Laboratory study found great potential for EVs to address load balancing from wind power



Source: U.S. Energy Information Administration Monthly Energy Review (2016)

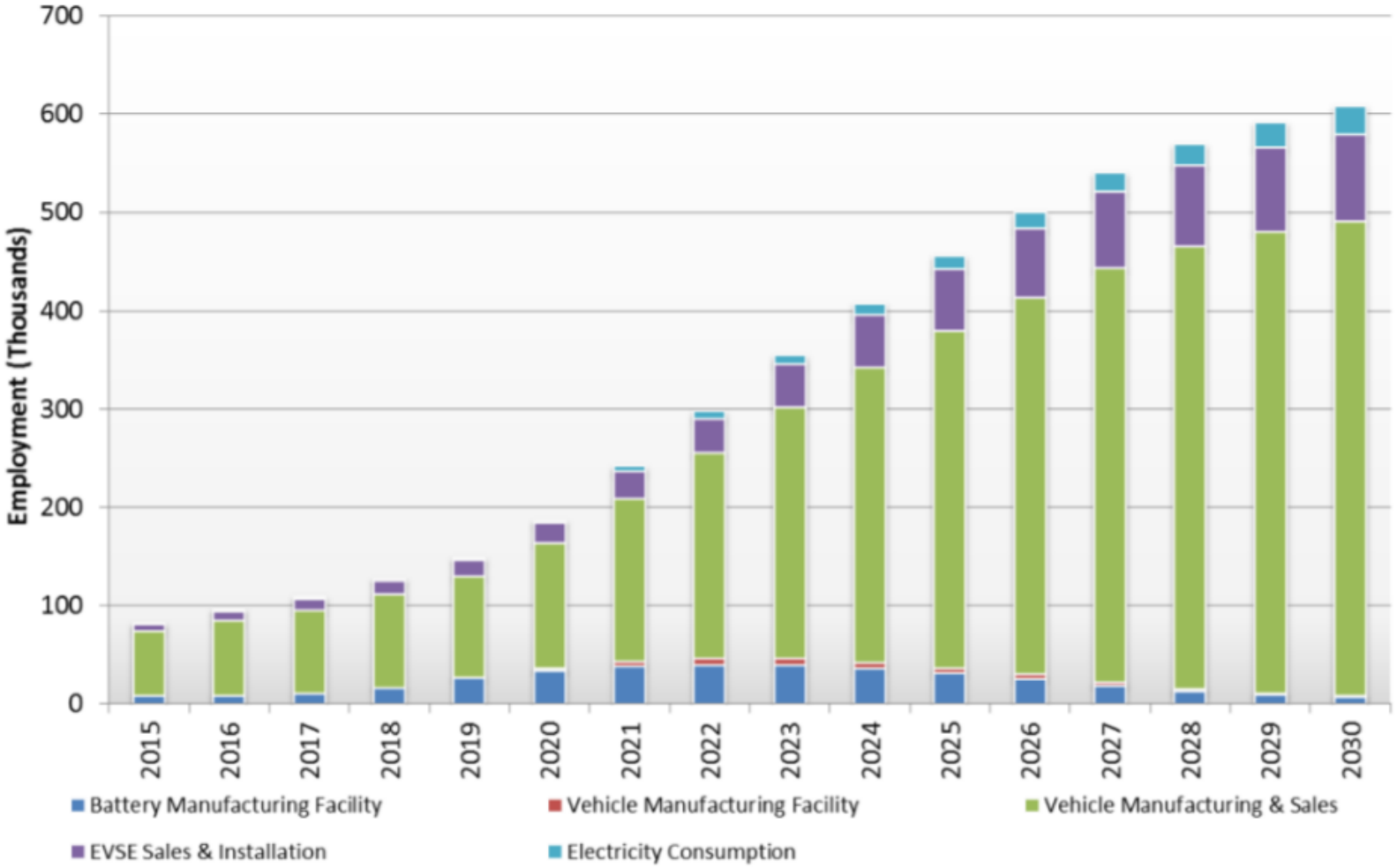
LOCAL AIR ENVIRONMENTAL BENEFITS OF EVS

- EVs in electric mode have zero tailpipe emissions
  - Lifecycle emissions are not zero and include upstream emissions from electrical grid and vehicle manufacturing and disposal
- Electrical grid rapidly reducing emissions through market forces and regulations
- 2016 National Academy of Sciences study found EVs powered with natural gas or renewables can reduce health impacts by 50% or more
  - Relied on electrical grid from 2007, which has since become far cleaner
- 2016 American Lung Association study found significant human health benefits with greater zero emission vehicle deployment in California

EVS CAN BENEFIT LOCAL/STATE ECONOMIES

- 2016 Argonne National Lab report finds EVs can lead to significant job growth
  - Add 450k jobs with 5% EV penetration in 2025
  - Over 10% of jobs in battery industry
- Study measures effects from:
  - EV manufacturing and sales
  - Charging sales and installation
  - Electricity consumption
  - Construction of battery and vehicle manufacturing facilities (as needed)

Job Gains from Increased EV Deployment (ZEV Scenario)



Source: Economic Impact Assessment of E-mobility (IEA, 2016)