ELECTRIC VEHICLE MARKET

Key drivers of market growth and considerations for EV-grid integration
ABOUT ATLAS PUBLIC POLICY
WWW.ATLASPOLICY.COM

• 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**

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<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>Details</th>
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<tbody>
<tr>
<td><strong>Low – AC 120 V</strong></td>
<td>Primarily residential (All EVs)</td>
<td>Uses standard outlet&lt;br&gt;Power requirements similar to a toaster&lt;br&gt;Up to 1.4 kilowatts&lt;br&gt;Can use existing power outlets resulting in no cost installation&lt;br&gt;Charging rate: 3-5 miles per hour</td>
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<td><strong>Medium – AC 240 V</strong></td>
<td>Residential, Workplace and Commercial (All EVs)</td>
<td>Requires high-voltage circuit&lt;br&gt;Power requirements similar to an electric clothes dryer&lt;br&gt;Up to 19.2 kilowatts&lt;br&gt;Equipment &amp; installation costs vary widely (~$6,500 in public and ~$2,000 at home)&lt;br&gt;Charging rate: 12-75 miles per hour</td>
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<tr>
<td><strong>High – DC Fast Charge</strong></td>
<td>Community/Metro and Highway Corridors (BEVs)</td>
<td>Power requirements are up to max power for 15 homes&lt;br&gt;Max power varies by system (CHAdeMO: 62.5 kW, SAE Combo: 100 kW, Tesla: 120kW)&lt;br&gt;Can have very high equipment &amp; installation costs (up to $90,000 per station)&lt;br&gt;Charging rate: 100-300 miles per hour</td>
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REGIONAL FACTORS DRIVE EV MARKET SUCCESS

**Ev Viability:**
- Market factors:
  - Vehicle availability
  - Infrastructure availability
  - Consumer interest
  - Gasoline & electricity prices
- Physical factors:
  - Geography, land use, and climate
- Policy drivers:
  - Federal, state, and local government policy
  - State electricity regulatory policy
  - Societal benefits
- Leadership:
  - State and local leadership
  - Industry/Advocacy champions

**Societal benefits**
• 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

- Electrical grid management
- Fuel diversity (petroleum dependence)
- Extreme weather & global climate change
- Local air quality
- Economic development

Opportunities with EVs

- Can increase utilization of electric power assets
- Electricity has numerous domestic feedstocks
- Lower lifecycle greenhouse gas emissions & resilient technology
- Lower or No tailpipe emissions
- 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
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 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

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>EV Sales</th>
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</thead>
<tbody>
<tr>
<td>General Motors Corp.</td>
<td>149,947</td>
</tr>
<tr>
<td>Tesla</td>
<td>140,243</td>
</tr>
<tr>
<td>Nissan North America Inc.</td>
<td>112,914</td>
</tr>
<tr>
<td>Ford Motor Company</td>
<td>97,492</td>
</tr>
</tbody>
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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)
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)*
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

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

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

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<th>2016</th>
<th>2017</th>
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<td><strong>Ford committed</strong> $4.5b with goal of 40% of its models having electric option by 2022 (January) <strong>GM invested</strong> $500m in Lyft, helping bring autonomous EVs to shared mobility (May) <strong>Tesla delivered</strong> first Model 3 and will rapidly advance EV investments (July)</td>
<td><strong>Mercedes will invest</strong> up to $11b in electric vehicles (February) <strong>Volkswagen plans</strong> to have 30 new all-electric models by 2025 (June) <strong>GM plans</strong> to add 20 new EV models by 2023 <strong>Tesla opened</strong> its $5b Gigafactory (July)</td>
</tr>
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</table>
BATTERY ADVANCES ARE MAKING ALL-ELECTRICS AFFORDABLE

Source: Bloomberg New Energy Finance (June, 2017)
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

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
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

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

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
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

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

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
APPENDIX

Backup slides
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

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

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)

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