



37.1 Major Developments in 2017

United States continues to rely on light-duty vehicles for personal transportation. November 2016 through November 2017 national vehicle miles traveled (latest data available) exceeded that for November 2015 through November 2016 by 1.2 %, reaching 3.20 trillion miles.¹⁰⁵ This presents a strong opportunity for reduced emissions and fuel use through vehicle electrification. HEV, PHEV, and full-electric or battery EV (BEV) sales all increased in 2017. There were 47 plug-in electric vehicle (PEV, including both PHEVs and BEVs) and 57 hybrid electric vehicle (HEV) models sold in the United States during 2017, reaching a total of 566,053 unit sales.¹⁰⁶

Some major market developments in the U.S. EV industry in 2017 include:

- Three new electric vehicles were released: Tesla started limited deliveries of its Model 3 BEV sedan¹⁰⁷. Hyundai released its IONIQ lineup, which has HEV, PHEV, and BEV iterations¹⁰⁸, and Honda released its Clarity lineup, also with HEV, PHEV, and BEV iterations (limited markets initially).¹⁰⁹
- Several manufacturers announced future electric vehicle plans¹¹⁰:
 - GM: 20 all-electric vehicles by 2023
 - Ford: 13 new electrified models by 2023
 - Toyota and Mazda are in partnership to develop basic EV technology for broad application across platforms and building a U.S. plant by 2021¹¹¹.

¹⁰⁵ U.S. Department of Transportation Office of Highway Policy Information, "Travel Monitoring," January 22, 2018. Accessed February 20, 2018

¹⁰⁶ Argonne National Laboratory, "Light Duty Electric Drive Vehicles Monthly Sales Updates. Data sourced from Hybrid Cars monthly sales dashboards.

¹⁰⁷ Engadget, "Tesla just delivered the first round of Model 3s," July 29, 2017. Accessed February 13, 2018.

¹⁰⁸ Motor Trend, "2018 Hyundai Ioniq Plug-In Starts At \$25,835," December 29, 2017. Accessed February 13, 2018.

¹⁰⁹ Forbes, "2018 Honda Clarity Plug-In Hybrid Charges In With \$33,400," November 16, 2017. Accessed February 13, 2018.

¹¹⁰ Mashable. "Here's how every major automaker plans to go electric." October 3, 2017. Accessed February 13, 2018.

- Daimler will be investing 1 billion USD in an Alabama plant to build all-electric SUVs, and investing 10 billion USD in overall EV development¹¹². Mercedes Benz plans to offer 50 electrified models by 2022¹¹³.
- Renault/Nissan/Mitsubishi plan 12 all-electric models by 2022¹¹⁴.
- Jaguar/Land Rover plan to electrify the entire line-up by 2020¹¹⁵.
- Volvo will be electrifying its entire line-up by 2019¹¹⁶.
- Volkswagen/Audi/Porsche: 84 billion USD in EV development; electrified versions of 300 vehicles by 2030¹¹⁷.
- Tesla announced the Tesla Semi, a fully electric Class 8 truck that aims to start at 150,000 USD for 300 miles of range. The company plans to produce 100,000 units of the truck per year within four years.¹¹⁸ Several large companies have already placed orders: Anheuser-Busch, DHL, J.B. Hunt, Pepsi, Ryder, Sysco, Walmart, UPS, and others.¹¹⁹
- Light trucks (SUVs, minivans, and pickup trucks) continue to pull market share from the passenger cars. This trend has carried into the electrified vehicle market. Light trucks now hold 27 % of the summed HEV, PHEV, and BEV market; whereas in 2015 and before they held less than 5 %. Most of electrified light trucks sales have been HEVs.

¹¹¹ Fortune, Toyota and Mazda to Build \$1.6Billion U.S. Plant, October 3, 2017, accessed February 22, 2018.

¹¹² The Wall Street Journal, Daimler to invest \$1Billion in Alabama Plant, September 21, 2017, accessed February 22, 2018.

¹¹³ Reuters, Mercedes Benz to offer electric option for every car by 2022, September 11, 2017, accessed February 22, 2018.

¹¹⁴ Green Car Reports, Nissan, Mitsubishi, Renault to launch 12 new electric cars by 2022, September 15, 2017, accessed February 22, 2018.

¹¹⁵ Consumer Reports, Jaguar Land Rover to Electrify Its Entire Lineup by 2020, September 8, 2017, accessed February 22, 2018.

¹¹⁶ J.D.Power, Volvo Announces Its Entire Lineup to go Electric Starting in 2019, July 5, 2017, accessed February 22, 2018.

¹¹⁷ Bloomberg Pursuits, VW to Build Electric Versions of All 300 Models by 2030, September 11, 2017, accessed February 22, 2018.

¹¹⁸ FleetOwner, "Tesla can produce 100,000 electric Class 8 trucks a year, Musk says," February 12, 2018. Accessed February 13, 2018.

¹¹⁹ Business Insider, "Tesla is now taking Semi orders in some European countries — here are all the companies buying the electric truck," January 10, 2018. Accessed February 13, 2018.

37.1.1 Continued Research and Development

Several different electric vehicle research and development (R&D) funding opportunities were released in 2017, from both federal and state sources. Selected prominent funding initiatives from 2017 are briefly summarized below:

- The U.S. Department of Energy Vehicle Technologies Office (VTO) funded a technology gap assessment of extreme fast charging (i.e., charging at a rate of 400 kW, which could provide for 200 miles of range addition in as little as 10 minutes). The technology gap assessment report explores impacts on vehicles, batteries, infrastructure, and operating costs and identifies technical barriers that must be overcome through R&D in order for extreme fast-charging to be widely adopted.¹²⁰
- VTO announced up to 15 million USD for research projects on batteries and vehicle electrification technologies to enable extreme fast charging. Advanced battery projects will focus on early-stage research on battery cells that can enable extreme fast charging, while electrification projects will support the development and verification of electric drive systems and infrastructure for extreme fast charging (400 kW).¹²¹
- VTO announced 19.4 million USD for 22 new cost-shared projects to accelerate the research of advanced battery, lightweight materials, engine technologies, and energy efficient mobility systems, including 15 “Battery Seedling” Phase 1 projects for Battery500 Consortium research to more than double the specific energy (to 500 watt-hours per kilogram) of lithium battery technologies. After 18 months, promising Phase 1 awardees will be competitively awarded a Phase 2 research opportunity.
- California Energy Commission (CEC) awarded over 24 million USD in grants for clean energy freight transportation projects. The three grantees (Long Beach Harbor Department, South Coast Air Quality Management District, and Los Angeles Harbor Department) are building, deploying, and/or demonstrating battery electric trucks and charging infrastructure.¹²²
- California’s *Clean Vehicle Rebate Project*, which has issued rebates over 480 million USD for more than 218,000 EVs (over 2010-2017), recently

¹²⁰ U.S. DOE, “Enabling Fast Charging: A Technology Gap Assessment,” October 2017. Accessed February 13, 2018.

¹²¹ U.S. DOE, “Energy Department Announces \$15 Million for Batteries and Electrification to Enable Extreme Fast Charging,” October 23, 2017. Accessed February 13, 2018.

¹²² CEC, “Energy Commission Awards More Than 36 Million USD for Clean Transportation,” May 10, 2017. Accessed February 13, 2018.

announced that its *Rebate Now* program would allow car shoppers to apply online for pre-approval to expedite the rebate process.¹²³

37.2 HEVs, PHEVs and EVs on the Road

This section provides information on the number of hybrid and electric vehicles on the road in the United States at the end of 2017, by powertrain technology. It also includes an overview of the prices of the most popular-selling hybrid and electric vehicles. Figure 1 shows the overall sales of electrified vehicles by manufacturer in 2017. Figure 2 shows the overall cumulative 2017 sales by type. It is seen that the top two market shareholders (Toyota and Ford) are primarily HEV-focused, while the 3rd and 4th largest (Tesla and Chevrolet) are PEV-focused.

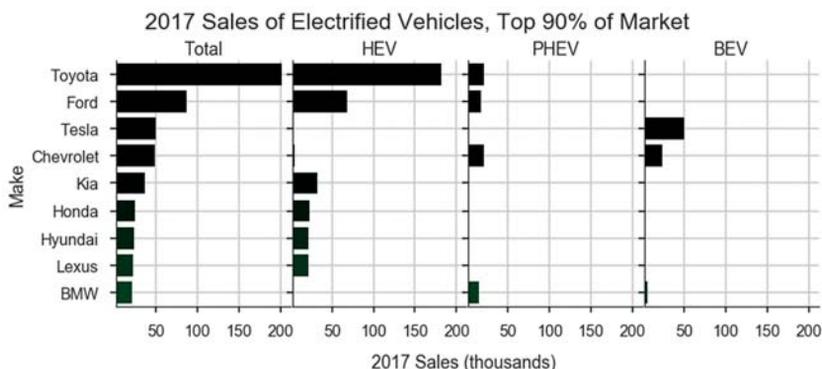


Figure 1: 2017 sales of electrified vehicles for market leaders (90 % of U.S. electrified vehicle sales; data source: Argonne National Laboratory, “Light Duty Electric Drive Vehicles Monthly Sales Updates, which utilizes Hybrid Cars monthly sales dashboards)

¹²³ Center for Sustainable Energy, “Clean Vehicle Rebate Project Initiates Rebate Now In San Diego County,” February 6, 2018. Accessed February 13, 2018.

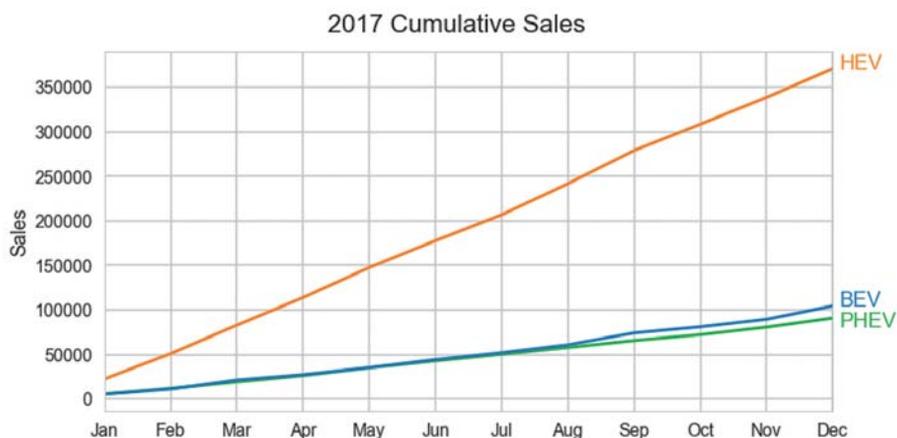


Figure 2: Cumulative sales of PEVs in 2017, not including FCEVs (Data source: Argonne National Laboratory, "Light Duty Electric Drive Vehicles Monthly Sales Updates, which utilizes Hybrid Cars monthly sales dashboards")

The 2017 HEV sales reached 370,685 units, in a reversal of the prior sales decline (which occurred between 2013 and 2016). There were 40 different models sold across 18 manufacturers, with 23 models that accumulated annual sales over 1,000 units. The highest selling models were the Toyota Prius Liftback, Ford Fusion, and Toyota RAV4, which accounted for 47 % of the U.S. hybrid vehicle market. The Toyota Prius line-up controlled a considerably smaller share of the market (24 %) compared to its share in 2016 (38 %), possibly due to the increasing adoption of hybrid technologies across manufacturers. This shift in the market is evident in Figure, which shows annual HEV sales for the top 6 manufacturers (from those with over 2 % of the HEV market). Toyota's overall share shrank further in 2017 as newer players (e.g., Kia) and Ford offered competitive HEVs.¹²⁴ Out of the remaining 12 OEMs, four held 1-2 % of the market and eight held less than 1 % each.

¹²⁴ Argonne National Laboratory, "Light Duty Electric Drive Vehicles Monthly Sales Updates, Data sourced from Hybrid Cars monthly sales dashboards.

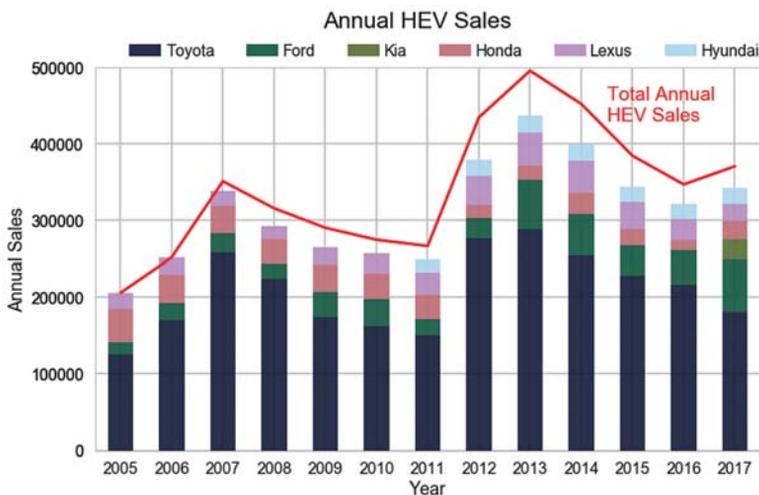


Figure 3: Evolution of the U.S. HEV market over time starting in 2005. Only OEMs with over 2 % of the HEV market are shown in detail (Data source: Argonne National Laboratory, “Light Duty Electric Drive Vehicles Monthly Sales Updates, which utilizes Hybrid Cars monthly sales dashboards)

In 2017, there were 30 PEV models sold in the United States, including 18 all-electric EV models across 13 manufacturers and 27 plug-in hybrid EV (PHEV) models across 14 manufacturers. As mentioned previously, three new PEV models were released in 2017: Honda’s Clarity PHEV and BEV (announced late 2017), Hyundai’s IONIQ PHEV and BEV (announced spring 2017), and Tesla’s Model 3 (announced mid-2017).

Total 2017 PEV sales reached 195,368 units (non-Tesla: 145,398). A total of 25 PEV models sold over 1,000 units in 2017, including 12 BEVs and 13 PHEVs. The highest-selling 2017 models included Tesla Model S, Tesla Model X, Toyota Prius Prime, Chevrolet Volt, Chevrolet Bolt, and Nissan LEAF. Chevrolet, Tesla, Nissan, Ford, Toyota, and BMW cover 80 % of the complete 2017 U.S. PEV market. (It should be noted that monthly Tesla sales are *estimates*, since Tesla only publishes quarterly sales.) Figure shows the evolution of the U.S. PEV market over time. 2017 continued the upward trend in total annual sales and saw increased OEM diversity in the market – 21 different OEMs now offer a PEV model, compared to 17 in 2016 and 2015. The top six OEMs (among those with over 2 % of the PEV market), cover 90 % of the total historical PEV market, but held an 85 % share in 2017. Of the remaining 15 OEMs, nine held between 1-2 % of the PEV market and six held less than 1 %. Chrysler, Mini, and Volvo sold their first U.S. PEVs in 2017. Table 1 provides estimated total stock and sales numbers for the electrified fleet.

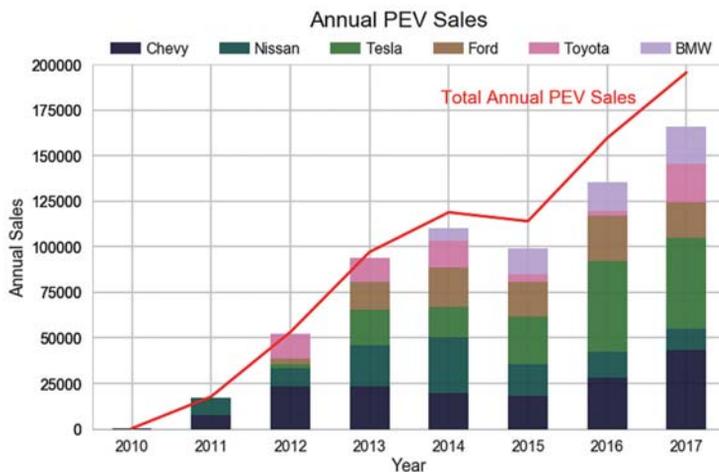


Figure 4: Evolution of the U.S. PEV market over time. Only OEMs with over 2 % of the PEV market are shown in detail (Data source: Argonne National Laboratory, “Light Duty Electric Drive Vehicles Monthly Sales Updates, which uses HybridCars monthly sales dashboards)

A list of available vehicles and their respective prices appears in Table 2 and Table 3. It is seen that in 2017, seven of the 16 PEV models listed in table 2 (i.e., nearly half the models) sell for a price below the average of prices for all light-duty passenger vehicles (which was 36,113 USD as published by Kelly Blue Book¹²⁵).

¹²⁵ Kelly Blue Book news release, January 3, 2018, accessed March 12, 2018.

2018 HEV TCP ANNUAL REPORT

Table 1: Distribution and sales of all-electric EVs, PHEVs and HEVs in 2017

Fleet Totals on 31 December 2017					
Vehicle Type	EVs	PHEVs	HEVs	FCVs	Total
Passenger Vehicles ^a	350,000 ¹²⁶	400,000 ¹²⁶	4,430,000 ¹²⁶	3,500 ¹²⁷	116,740,000 ¹²⁶
Light trucks ^b					6
Medium and Heavy Weight Trucks ^c	n.a.	n.a.	n.a.	n.a.	11,203,000 ¹²⁸
Total Sales during 2017					
Vehicle Type	EVs	PHEVs	HEVs	FCVs	Total
Electric Bicycles	260,000 ¹²⁹	n.a.	n.a.	n.a.	n.a.
Passenger Vehicles ^a	80,505 ¹³⁰	77,949 ¹³⁰	253,871 ¹³⁰	2,298 ¹³⁰	6,873,000 ¹²⁸
Light trucks ^b	23,857 ¹³⁰	12,782 ¹³⁰	116,794 ¹³⁰	n.a.	10,296,000 ¹²⁸
Medium and Heavy Weight Trucks ^c	n.a.	n.a.	n.a.	n.a.	697,000 ¹³¹
Totals without bicycles	104,362	90,731	370,665	2,298	17,866,000

n.a. = not available

^a U.S. Cars

^b U.S. Class 1-2 Trucks (<10,000 lbs. GVWR)

^c U.S. Class 3-8 Trucks

¹²⁶ Estimates from U.S. Energy Information Administration Annual Energy Outlook 2018.

¹²⁷ Information not available; based on 2-year cumulative sales (2016-2017)

¹²⁸ Data from Oak Ridge National Laboratory Transportation Energy Data Book: Edition 36, "Quick Facts", December 2017. Note: This is 2016 data (latest available).

¹²⁹ Estimate from the Light Electric Vehicle Association.

¹³⁰ Argonne National Laboratory Light Duty Electric Drive Vehicles Monthly Sales Updates, as sourced from HybridCars.com monthly sales dashboards

¹³¹ ORNL Transportation Energy Data Book: Edition 36, Table 5.3, December 2017. Note: This is 2016 data (latest available).

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Table 2: Select available PHEVs and prices in the U.S. (Data source: manufacturer websites)

Available Passenger Vehicles	Untaxed, Unsubsidized Sale Price (in USD)
Audi A3 Sportback e-tron	39,500
BMW i3 (BMW i3 w/ Range Extender)	48,850
BMW X5 xDrive40e	63,750
BMW 330e	45,600
BMW 530e	52,650
BMW 740e xDrive	90,700
Chevy Volt	34,095
Chrysler Pacifica	39,995
Ford C-Max Energi	27,120
Ford Fusion Energi	31,120
Honda Clarity PHEV	33,400
Hyundai Sonata	32,600
Kia Optima	35,210
Mercedes C350We Plug-in Hybrid	47,900
Porsche Cayenne S E-Hybrid	79,900
Toyota Prius Prime	27,100
Average light-duty passenger vehicle price in 2017¹³²	36,113
BMW i3 (BMW i3 w/ Range Extender)	44,450
Chevy Bolt	37,495
Fiat 500e	32,995
Ford Focus	29,120
Hyundai Ioniq Electric	29,500
Kia Soul	33,950
Nissan Leaf	30,875
Smart Fortwo Electric Drive	24,250
Tesla Model S 75D AWD (standard)	74,500
Tesla Model X 75D AWD (standard)	79,500
Tesla Model 3	35,000

¹³² Kelly Blue Book news release, January 3, 2018, accessed March 12, 2018.

37.3 Electric Vehicle Charging Infrastructure

In 2017, EV charging infrastructure availability in the United States grew considerably. The number of available (public) stations grew by 25 %, including those for Level 2 and DC Fast Charging station count increases of 13 % and 9 % respectively, while Level 1 charging availability decreased about 13 % (a possible explanation for the drop could be the increased availability of Level 2 and Fast-chargers, which reduce the charging time substantially). The average number of plugs at each station increased considerably for Level 2 chargers (42 %) and was nearly constant for Level 1 and DC Fast Charge installations compared to 2016.

Table 3 provides an overview of the number of public charging stations in the United States by type including Levels 1 and 2, Fast Chargers, and Tesla Superchargers, while Figure 5 and Figure 6 show the state-level distribution of charging stations in the U.S. California leads the other states by an order of magnitude with over 23 % of the total stations and 30 % of the total available plugs. This information is all continuously collected by the U.S. DOE's Alternative Fuels Data Center (AFDC), and placed on their website.¹³³

Table 3: Information on charging infrastructure in 2017; excluding non-public charging stations. Numbers represent the total installed stations, while those in parentheses indicate the total number of available plugs (Data source: U.S. DOE AFDC, accessed February 13, 2018)

Number of Charging Stations			
Chargers	2016	2017	Change
AC Level 1 Chargers	1,515 (2,983)	1,300 (2,604)	-14% (-13%)
AC Level 2 Chargers	13,841 (23,996)	15,639 (38,264)	+13% (+59%)
Fast Chargers	2,039 (5,527)	2,232 (6,267)	+10% (+13%)
Superchargers (incl. in Fast Chargers)	357 (2,452)	394 (2,831)	+10% (+16%)
Totals	13,730 (30,245)	17,219 (47,135)	25% (56%)

¹³³ U.S. DOE Alternative Fuels Data Center. Accessed February 13, 2018.

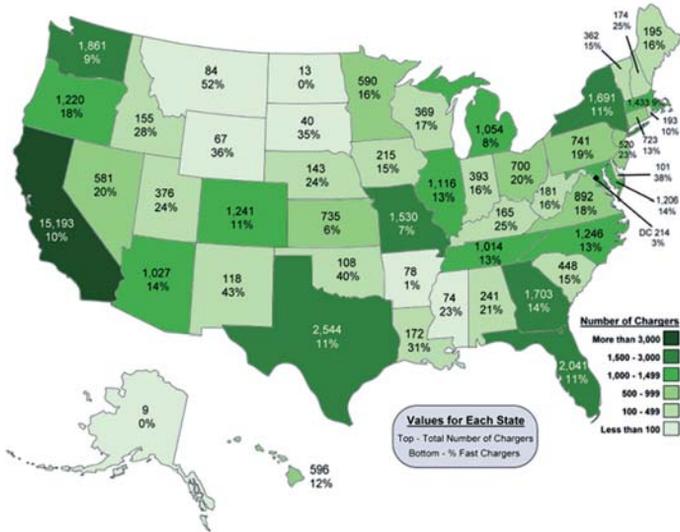


Figure 5: Level 2 and DC fast charge electric vehicle charging stations in the United States (Source: U.S. DOE)

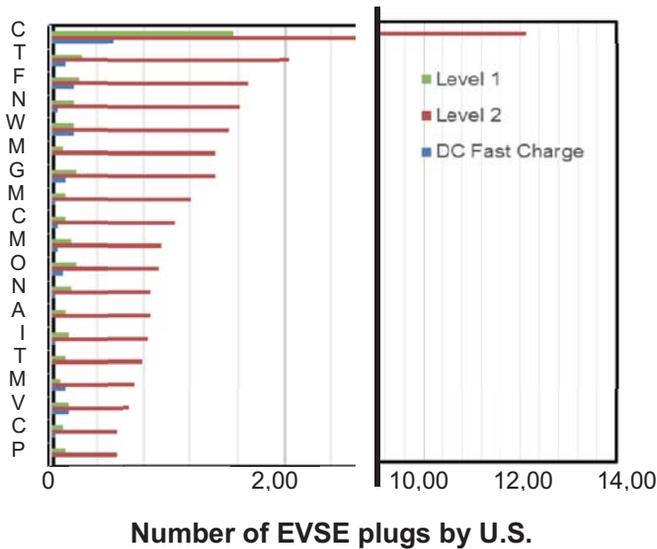


Figure 6: Number of EVSE plugs per U.S. State for 20 States with the most chargers, grouped by charging level (Data source: U.S. DOE AFDC, accessed February 13, 2018)

Due to the terms of their settlement with U.S. and California governments, Volkswagen will be spending a total of 2 billion USD over the next 10 years to install additional EV infrastructure across the U.S. The company created a subsidiary called *Electrify America* to facilitate station siting and installation and started the station rollout with 50 dual-standard DC fast chargers (50 kW) in 10 major metro markets. In December 2017, they announced plans to install 2,800 charging stations in 17 of the largest U.S. cities by 2019.¹³⁴

In 2017, the U.S. DOE published its *Public PEV Charging Infrastructure Guiding Principles*¹³⁵ document. This was the collaboration among the PEV community to guide DOE VTO's research efforts and to support stakeholder decisions regarding PEV infrastructure deployment.

37.4 Outlook

Global sales of light, medium, and heavy duty PEVs are estimated to continue growing, according to revised forecasts from Bloomberg New Energy Finance (BNEF).¹³⁶ BNEF suggests that electric vehicles will reach cost parity with gasoline vehicles by 2025 due to the quickening pace of lithium ion battery cost reduction. OPEC and several oil producers, including Exxon, BP, and Statoil, also drastically increased their EV market penetration forecasts mid-year.¹³⁷ As noted earlier in this section, there is a broad industry consensus to increase electrification in the passenger vehicle market over the next 10 years.

Electrification also appears to be an integral feature of self-driving cars according to Ford (testing on the Fusion Hybrid), GM (testing on the Bolt EV), Uber (testing on Volvo's XC90 PHEV), Waymo (testing on Chrysler's Pacifica PHEV), and others. If this technology achieves the performance and cost claimed by its advocates and continues to use EVs, the share of electrified vehicle miles traveled could increase dramatically.

¹³⁴ Reuters, "Volkswagen to install 2,800 U.S. electric vehicle charging stations," December 18, 2017. Accessed February 13, 2018.

¹³⁵ U.S. DOE, "Public Plug-In Electric Vehicle Infrastructure Guiding Principles," January 2017. Accessed February 13, 2018.

¹³⁶ Bloomberg, "The Electric Car Revolution is Accelerating," July 6, 2017. Accessed February 14, 2018.

¹³⁷ <https://www.bloomberg.com/news/articles/2017-07-14/big-oil-just-woke-up-to-the-threat-of-rising-electric-car-demand>, July 14, 2017. Accessed February 22, 2018.