



Alternative Fuel Vehicle Infrastructure

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“The North Carolina Clean Energy Technology Center advances a sustainable energy economy by educating, demonstrating and providing support for clean energy technologies, practices, and policies.”

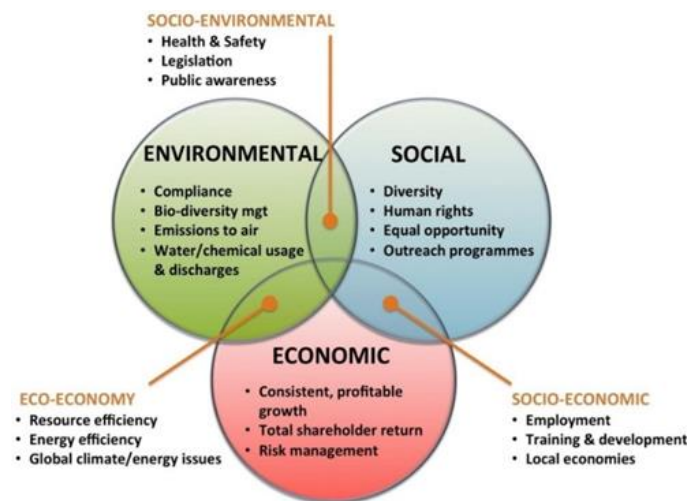


- Created in 1988
- Part of the College of Engineering at NC State University
- Clearinghouse for information, training, technical assistance, deployment, demonstration and applied research
- Example programs: solar, wind, industrial efficiency, CHP, renewable energy policy and ***clean transportation***

Why Alternative Fuel Vehicles?

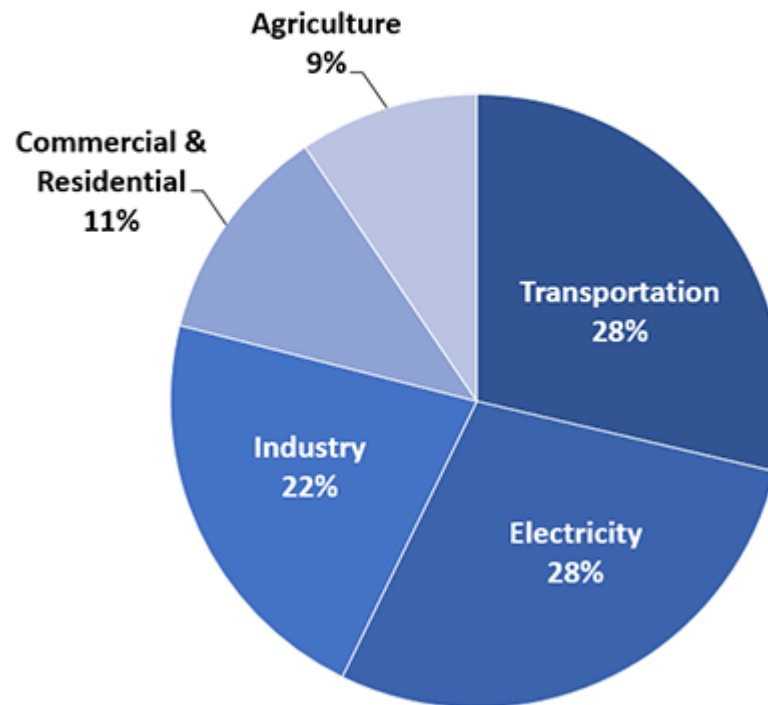
Today a business success measured by the triple bottom line:

- Willingness to do business—customers and suppliers
- Ability to recruit and retain top talent
- Energy security & fuel diversity
- Domestic economy
- Savings—reinvest or other areas
- Reduced emissions-environment/health
- Mandate or regulation



Significant Contributor to GHG Emissions

Total U.S. Greenhouse Gas Emissions
by Economic Sector in 2016



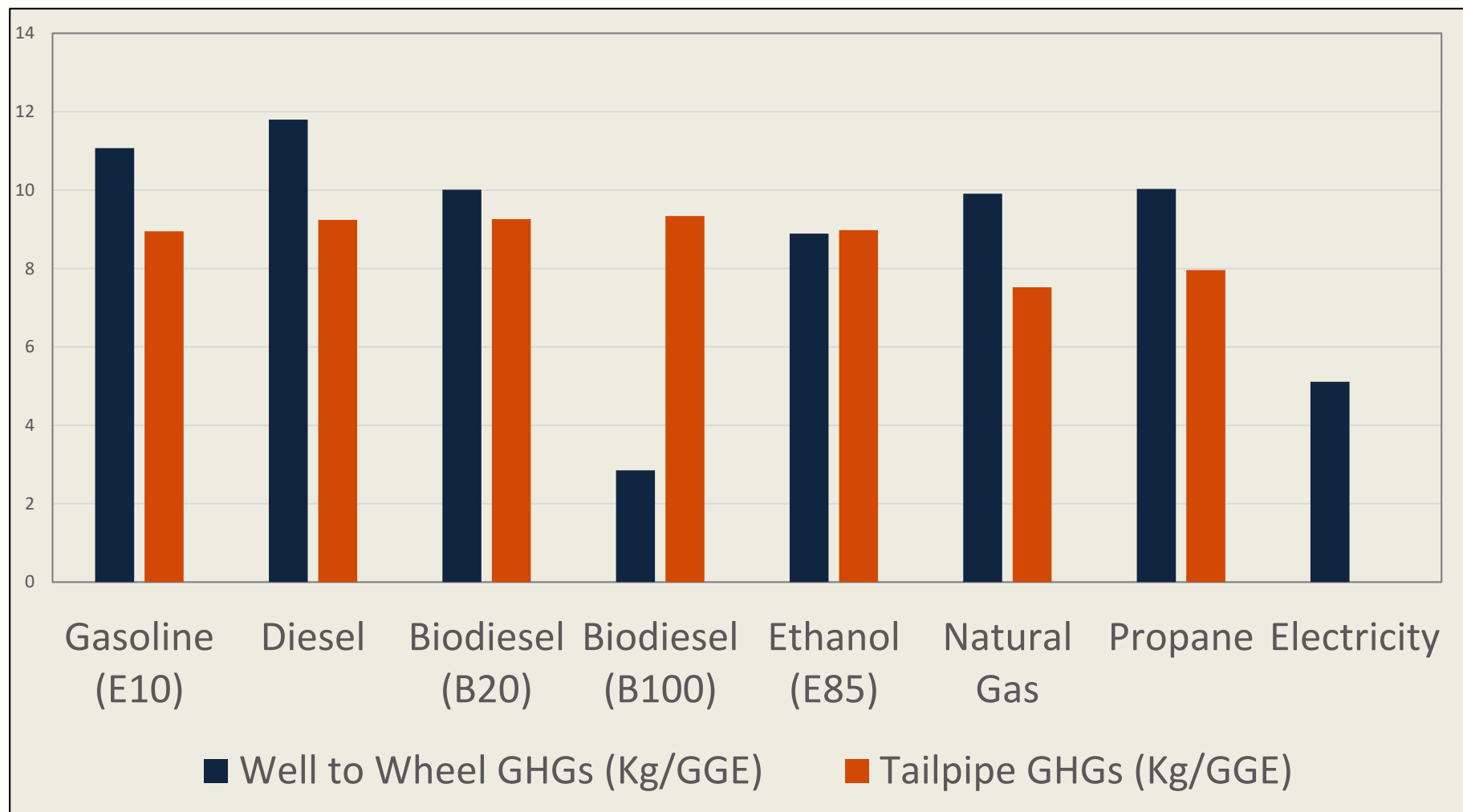
<https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions>



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GHG Emissions by Fuel Type



Snapshot of US Public AFV Infrastructure

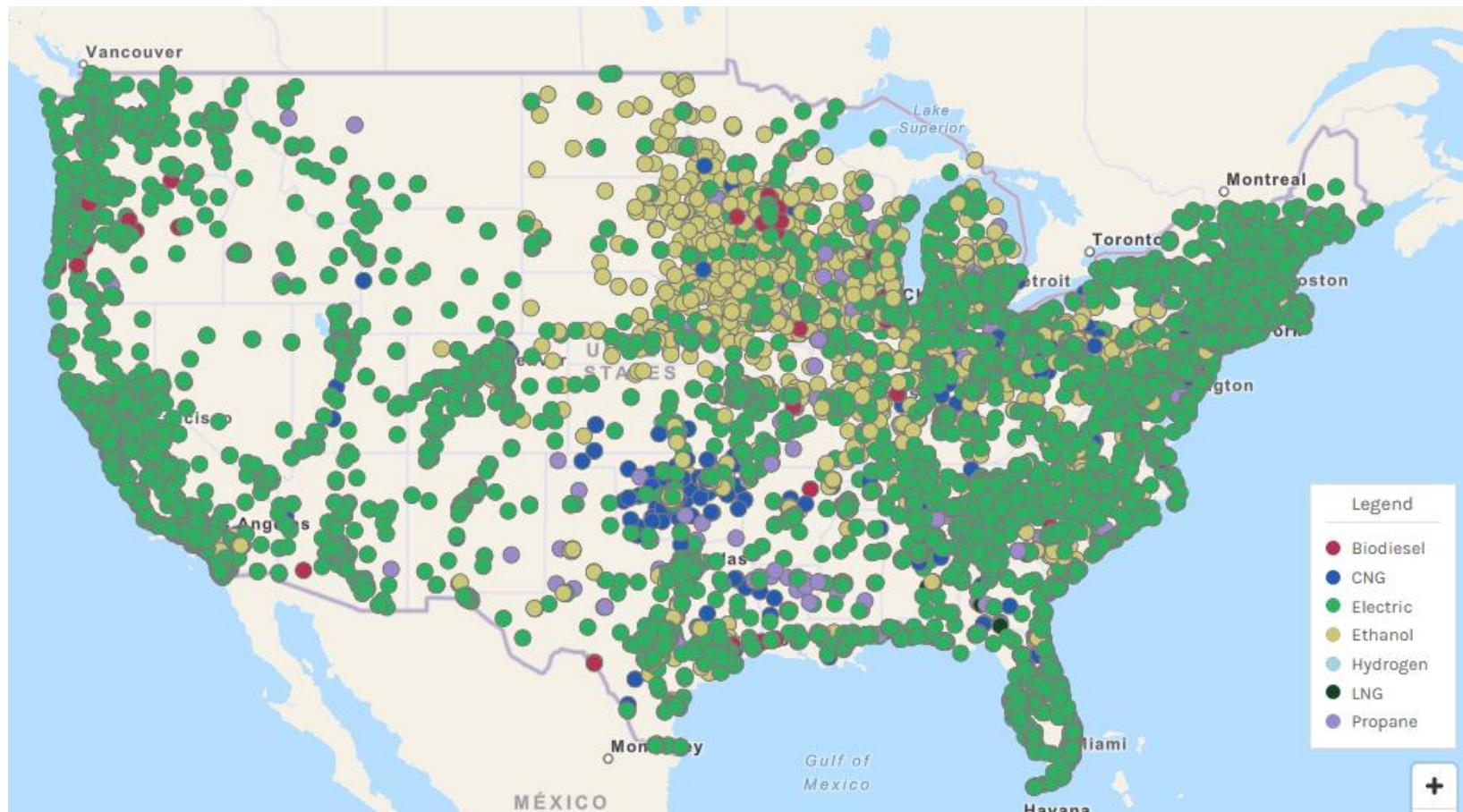
US Public Alternative Fuel Stations		
	Stations	Plugs
Propane	467	
CNG	921	
LNG	75	
EV L1	1,086	2,200
EV L2	17,948	45,177
EV DCFC	2,517	9,013
TOTAL EV	21,551	56,390
Ethanol	3,301	
Biodiesel (\geq B20)	197	

156,000 Public Gas Stations in US



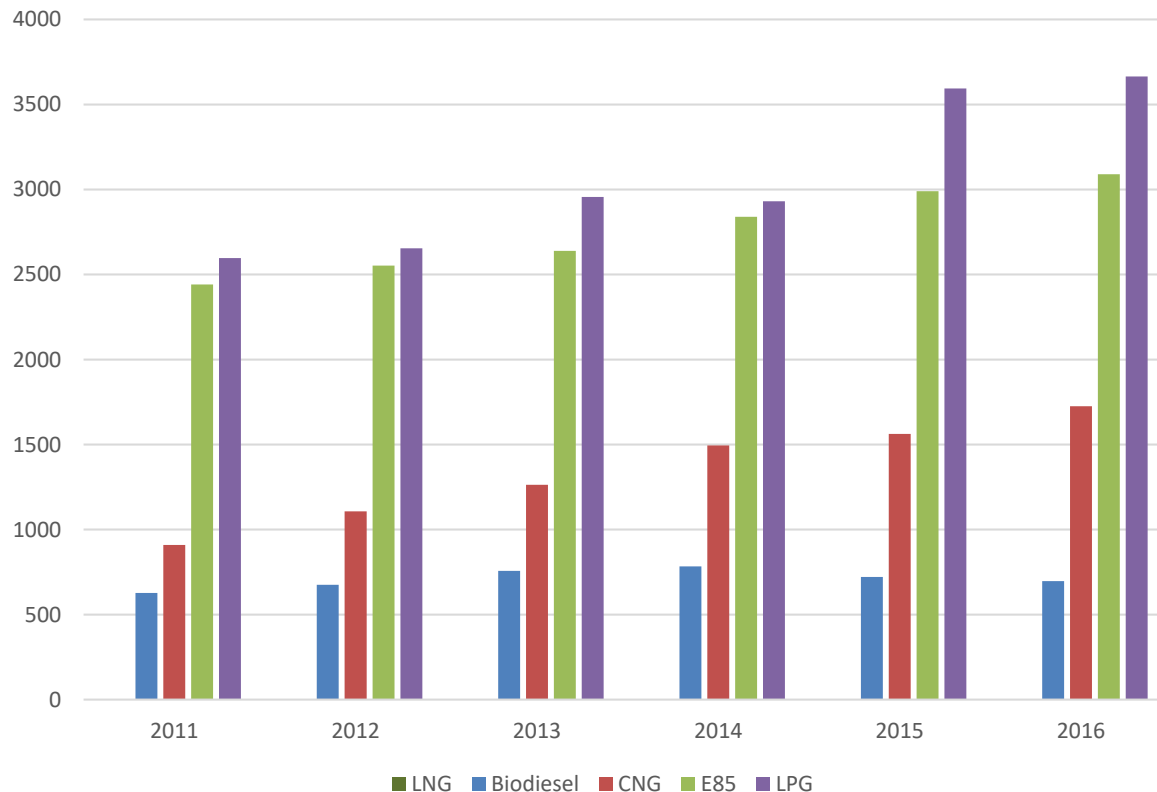
Source: <https://afdc.energy.gov/stations/#/find/nearest>

Snapshot of US AFV Infrastructure



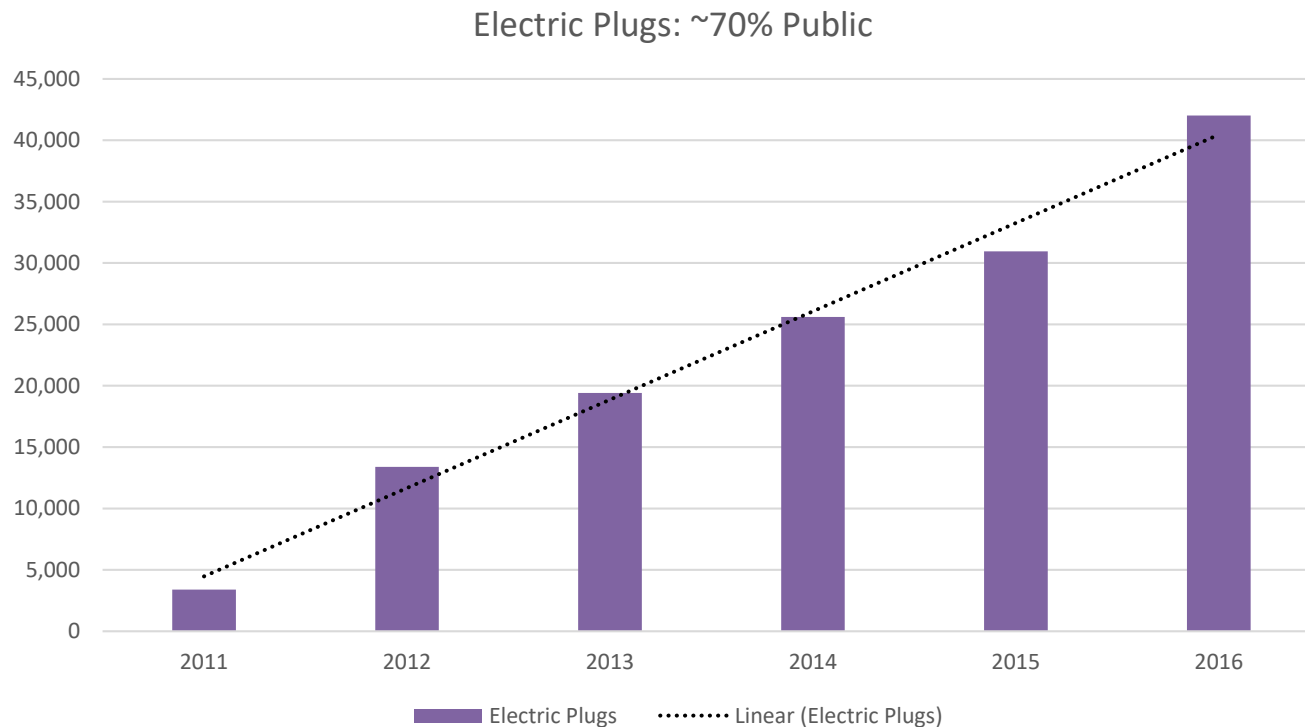
Source: <https://afdc.energy.gov/stations/#/find/nearest>

Recent Trend AFV Stations: Public and Private



Source: <http://www.afdc.energy.gov/data/10332>

Recent Trend AFV Stations: Public and Private Electric Plugs



Source: <http://www.afdc.energy.gov/data/10332>

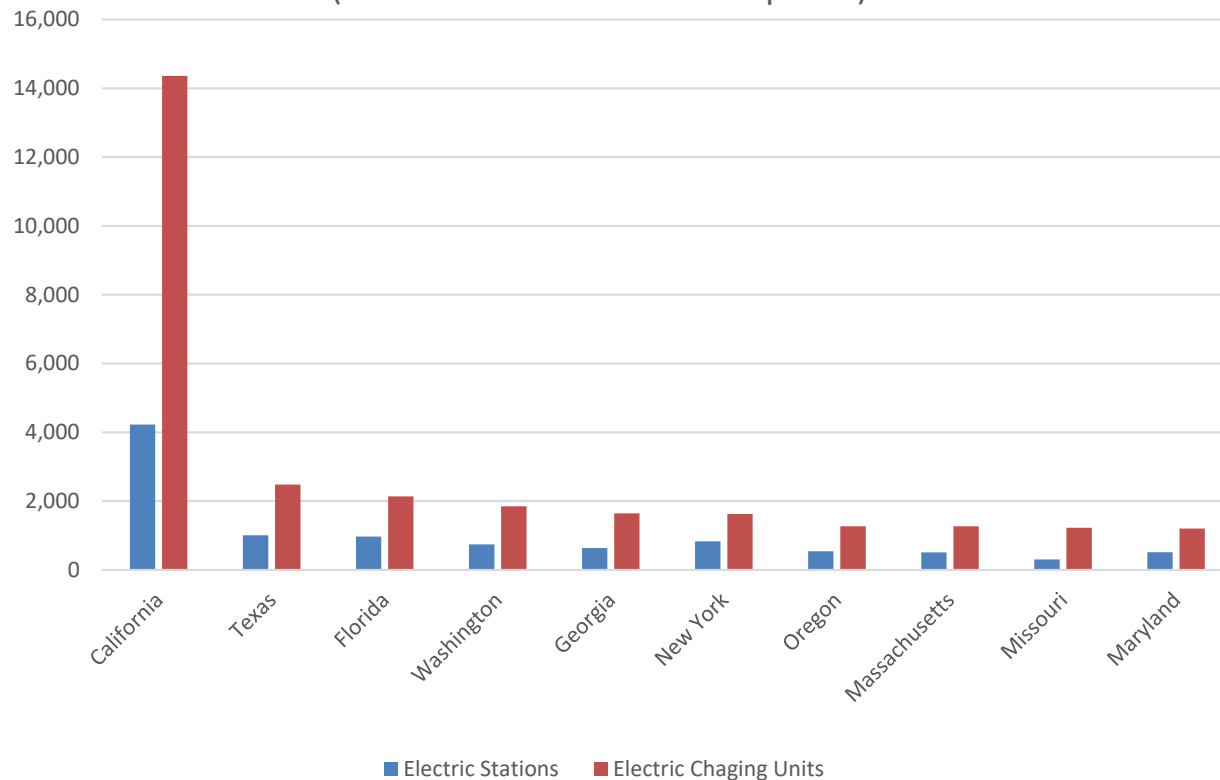


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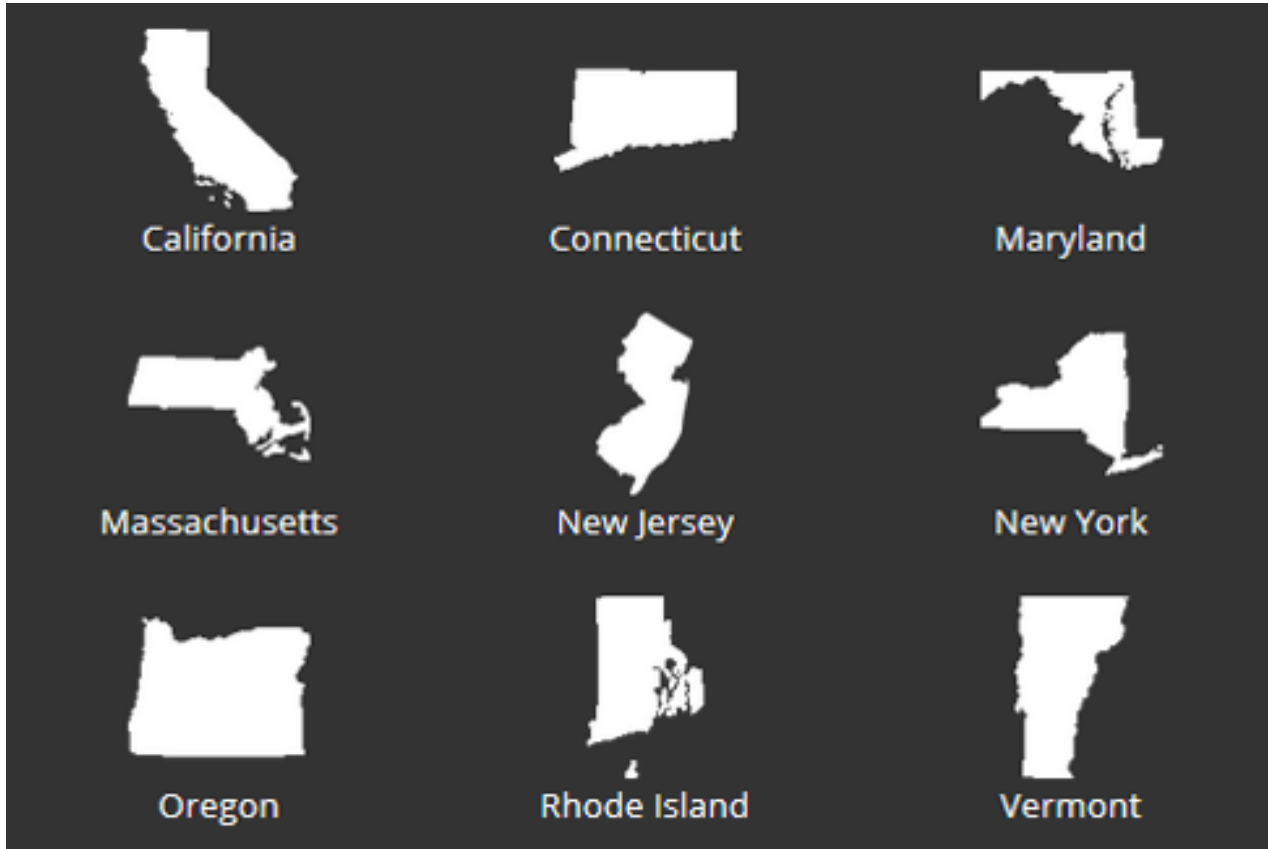
Top States for EVSE

Top 10 States for Charging Infrastructure
(2017 Public & Private ~70% public)



Source: http://www.afdc.energy.gov/afdc/fuels/stations_counts.html

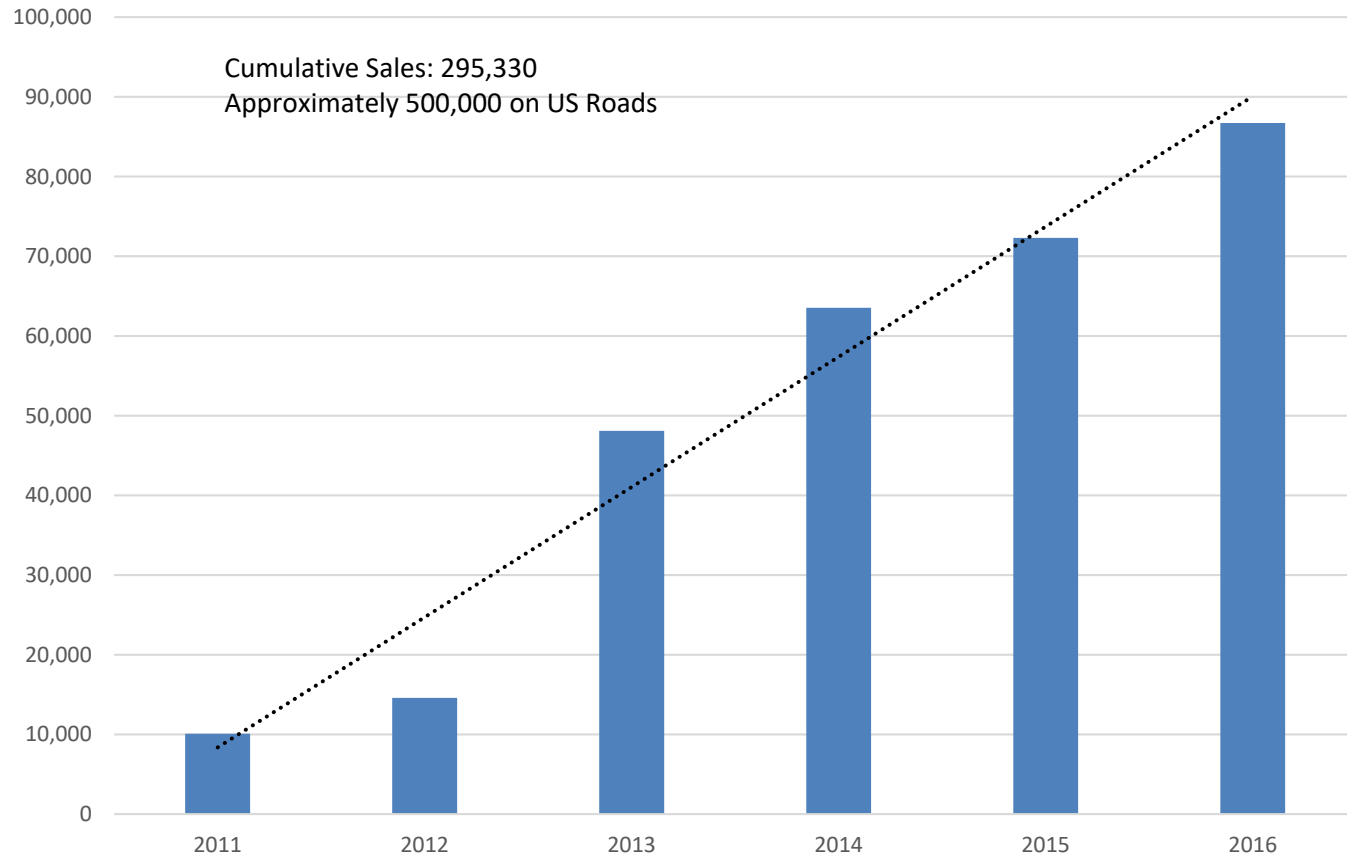
Multi-State ZEV Task Force



Source: <https://www.zevstates.us/>

PEV Sales 2011-2016

All Electric Vehicle Sales 2011-2016



Source: <http://www.anl.gov/energy-systems/project/light-duty-electric-drive-vehicles-monthly-sales-updates>

>60 PEV options 2018/2019

INSIDE

EVs

Plug-In Vehicle Comparisons - US

Updated 2018-09-07

Estimated

Brand	Model	Base Price (MSRP)	Dest. Charge	Tax Credit	Price After Tax Credit	Battery Size (kWh)	EPA EV Range (mi)	Total Range (mi)	Top Speed (mph)	Peak Power EV (kW)	Peak Power ICE (hp)	0-60 mph (sec)	Weight (lbs)	Price per kWh	
Audi	A3 Sportback e-tron (2018)	\$ 35,500	\$ 915	\$ 4,502	\$ 35,913	8.8	15	400	150	75	150	7.5	3,610	\$4,088	
BMW	530e iPerformance (2018)	\$ 45,000	\$ 995	\$ 4,001	\$ 42,684	7.6	14	350	140	65	180	5.9	3,900	\$6,000	
BMW	530e iPerformance (2018)	\$ 53,400	\$ 995	\$ 4,001	\$ 49,394	9.4	16	370	167	70	184	6.0	4,266	\$5,501	
BMW	530e iPerformance (2018)	\$ 55,700	\$ 995	\$ 4,001	\$ 52,694	9.4	14	300	167	70	184	5.8	4,305	\$5,920	
BMW	740e xDrive iPerformance (2018)	\$ 91,250	\$ 995	\$ 4,001	\$ 87,244	9.2	14	340	155	80	255	5.1	4,609	\$9,910	
BMW	i3 (33.2 kWh) (2018)	\$ 44,450	\$ 995	\$ 7,500	\$ 37,945	33.2	114	114	93	125	---	7.2	2,961	\$1,338	
BMW	i3 REx (33.2 kWh) (2018)	\$ 48,300	\$ 995	\$ 7,500	\$ 41,795	33.2	97	180	93	125	34	8.0	3,234	\$1,451	
BMW	i3s (33.2 kWh) (2018)	\$ 47,650	\$ 995	\$ 7,500	\$ 41,145	33.2	103	107	100	135	---	6.8	---	\$1,432	
BMW	i3s REx (33.2 kWh) (2018)	\$ 51,500	\$ 995	\$ 7,500	\$ 44,999	33.2	97	180	100	135	34	7.6	---	\$1,551	
BMW	i8 Coupe (2018)	\$ 147,500	\$ 995	\$ 5,000	\$ 142,505	11.6	17	320	155	105	228	4.2	3,501	\$12,716	
BMW	i8 Roadster (2018)	\$ 163,500	\$ 995	\$ 5,000	\$ 158,505	11.6	17	320	155	105	228	4.4	3,671	\$14,075	
BMW	X5 iPerformance (2018)	\$ 63,750	\$ 995	\$ 4,001	\$ 60,674	9.2	13	240	130	80	240	6.5	5,220	\$6,926	
Cadillac	CUE PHEV (2018)	\$ 75,285	\$ 995	\$ 7,500	\$ 68,985	18.4	31	430	150	149	335	5.2	4,400	\$4,001	
Chrysler	Bolt EV (2018)	\$ 36,600	\$ 875	\$ 7,500	\$ 29,995	60	238	238	90	150	---	6.5	3,580	\$9,999	
Chrysler	Soul (2018)	\$ 33,225	\$ 875	\$ 7,500	\$ 26,685	18.4	53	420	98	111	101	8.4	3,543	\$1,908	
Chrysler	Pacifica Hybrid (2018)	\$ 38,995	\$ 1,295	\$ 7,500	\$ 32,695	16	33	529	---	---	248	---	---	\$2,500	
Fiat	500e (2018)	\$ 32,995	\$ 1,295	\$ 7,500	\$ 26,795	24	64	84	85	83	---	8.9	2,980	\$1,371	
Ford	Focus Electric (2018)	\$ 29,125	\$ 875	\$ 7,500	\$ 22,495	33.5	115	115	107	---	---	---	---	\$6,400	
Ford	Fusion Energy (2018)	\$ 31,400	\$ 875	\$ 4,007	\$ 28,288	7.6	21	610	104	88	141	8.8	3,984	\$4,132	
Ford	Fusion Energy - Titanium (2018)	\$ 34,595	\$ 875	\$ 4,007	\$ 30,883	9.0	21	---	---	88	141	---	---	\$3,984	
Honda	Clarity Electric (2018)	lease only	---	\$ 7,500	---	25.5	89	89	---	120	---	---	---	\$4,024	
Honda	Clarity Plug-in Hybrid (2018)	\$ 33,400	\$ 895	\$ 7,500	\$ 26,795	17	47	340	135	100	---	---	---	\$4,052	
Hyundai	KONA Electric (2018)	\$ 29,500	\$ 895	\$ 7,500	\$ 22,885	28	124	124	102	88	---	9.9	3,164	\$1,054	
Hyundai	KONA Electric (2018)	\$ 29,515	\$ 895	\$ 7,500	\$ 22,900	28	124	124	102	88	---	9.9	3,164	\$1,050	
Hyundai	KONA Plug-in Hybrid (2018)	\$ 24,650	\$ 895	\$ 4,543	\$ 21,392	8.9	29	630	104	45	104	---	---	\$2,800	
Hyundai	KONA Plug-in Hybrid (2018)	\$ 25,200	\$ 895	\$ 4,543	\$ 21,592	8.9	29	630	104	45	104	---	---	\$2,848	
Hyundai	Kona Electric (2019)	\$ 30,000	\$ 895	\$ 7,500	\$ 22,600	44.0	258	258	104	150	---	7.6	---	---	
Hyundai	Sonata PHEV (2018)	\$ 33,250	\$ 895	\$ 4,919	\$ 29,216	9.8	28	600	75	50	154	---	3,787	\$3,380	
Karma	Revero (2018)	\$ 130,000	\$ 1,400	\$ 7,500	\$ 123,900	21.4	37	240	125	301	260	5.8	5,400	\$6,075	
Kia	Niro PHEV (2018)	\$ 27,900	\$ 940	\$ 4,543	\$ 24,297	8.9	26	580	---	---	104	---	---	\$3,391	
Kia	Optima PHEV (2018)	\$ 35,210	\$ 895	\$ 4,919	\$ 31,186	8.8	29	670	75	50	154	9.1	3,788	\$3,500	
Kia	Soul EV (2018)	\$ 31,950	\$ 895	\$ 7,500	\$ 27,345	30	111	111	111	81.4	---	---	---	\$4,321	
Land Rover	Range Rover P400e (2018)	\$ 95,150	\$ 995	---	\$ 96,145	13.1	10	---	137	85	296	6.4	5,532	\$7,261	
Land Rover	Range Rover Sport P400e (2018)	\$ 79,300	\$ 995	---	\$ 79,295	13.1	10	---	137	85	296	6.3	5,448	\$5,917	
Mercedes	C-Class (2018)	\$ 47,800	\$ 995	\$ 3,501	\$ 44,284	8.2	8	495	---	---	80	241	5.8	4,057	\$7,224
Mercedes	GLC 300e (2018)	\$ 49,900	\$ 995	\$ 4,400	\$ 46,395	8.7	9	390	---	---	120	6.2	---	\$5,748	
Mercedes	GLC 300e (2018)	\$ 46,700	\$ 995	\$ 4,400	\$ 43,225	8.8	9	480	---	---	85	5.3	---	\$7,504	
MINI	Cooper SE Countryman ALL4 (2018)	\$ 36,900	\$ 850	\$ 4,001	\$ 33,749	7.6	12	270	78	65	136	6.7	---	\$4,691	
Mitsubishi	Outlander PHEV (2018)	\$ 34,595	\$ 995	\$ 5,836	\$ 29,744	12.0	22	370	120	117	---	---	---	\$2,683	
Nissan	LEAF (40 kWh) (2018)	\$ 29,990	\$ 895	\$ 7,500	\$ 22,375	40	151	151	90	110	---	7.9	3,433	\$7,541	
Porsche	Cayenne S E-Hybrid (2018)	\$ 79,900	\$ 1,050	\$ 5,326	\$ 75,614	10.8	14	480	151	70	333	5.8	5,181	\$7,388	
Porsche	Cayenne E-Hybrid (2018)	\$ 79,900	\$ 1,050	\$ 5,326	\$ 75,614	14.1	16	480	157	100	340	4.7	---	\$5,665	
Porsche	Panamera 4 E-Hybrid (2018)	\$ 99,600	\$ 1,050	\$ 6,670	\$ 93,980	14.1	16	480	172	100	330	4.6	4,784	\$7,064	
Porsche	Panamera Turbo S E-Hybrid (2018)	\$ 184,400	\$ 1,050	\$ 6,670	\$ 178,780	14.1	14	470	192	100	500	3.2	5,093	\$13,078	
smart	fortwo ED Cabrio (2018)	\$ 28,100	\$ 750	\$ 7,500	\$ 21,350	17.6	57	57	81	60	---	11.7	---	\$1,287	
smart	fortwo ED Cabrio (2018)	\$ 21,300	\$ 750	\$ 7,500	\$ 17,150	17.6	56	56	81	60	---	11.4	2,363	\$1,238	
Tesla	Model 3 Standard	\$ 35,000	\$ 1,200	\$ 7,500	\$ 28,790	---	250	250	130	---	---	5.5	3,549	\$6,000	
Tesla	Model 3 Long Range (2018)	\$ 49,000	\$ 1,200	\$ 7,500	\$ 42,790	---	310	310	140	---	---	---	5.1	3,814	\$6,000
Tesla	Model 3 Performance (2018)	\$ 54,000	\$ 1,200	\$ 7,500	\$ 47,790	---	310	310	140	---	---	---	---	---	\$6,000
Tesla	Model 3 Performance (2018)	\$ 64,000	\$ 1,200	\$ 7,500	\$ 57,790	---	310	310	140	---	---	---	---	---	\$7,999
Tesla	Model S 75D (2018)	\$ 77,000	\$ 1,200	\$ 7,500	\$ 70,790	75	259	259	140	---	---	---	4.2	4,709	\$1,075
Tesla	Model S 100D (2018)	\$ 96,500	\$ 1,200	\$ 7,500	\$ 90,290	100	305	305	155	---	---	---	4.1	4,883	\$9,999
Tesla	Model S P100D (2018)	\$ 135,000	\$ 1,200	\$ 7,500	\$ 128,790	100	315	315	155	---	---	---	2.5	4,941	\$1,700
Tesla	Model X 75D (2018)	\$ 83,000	\$ 1,200	\$ 7,500	\$ 76,790	75	238	238	130	---	---	---	4.9	5,307	\$1,107
Tesla	Model X 100D (2018)	\$ 99,500	\$ 1,200	\$ 7,500	\$ 93,290	100	295	295	155	---	---	---	4.7	5,421	\$9,999
Tesla	Model X P100D (2018)	\$ 140,000	\$ 1,200	\$ 7,500	\$ 133,790	100	280	280	155	---	---	---	2.9	5,531	\$1,400
Toyota	Prox PHEV (2018)	\$ 27,300	\$ 920	\$ 4,502	\$ 23,718	8.8	25	640	---	68	---	---	---	3,305	\$3,102
Volkswagen	e-Golf (2018)	\$ 30,495	\$ 895	\$ 7,500	\$ 23,890	36.8	125	125	93	100	---	9.0	---	\$6,500	
Volvo	S90 T8 Twin Engine (2018)	\$ 63,400	\$ 995	\$ 5,002	\$ 60,393	18.4	21	410	---	64	313	---	---	---	\$6,126
Volvo	S90 T8 Twin Engine (2018)	\$ 63,400	\$ 995	\$ 5,002	\$ 60,393	18.4	21	410	---	64	313	4.7	4,578	\$6,126	
Volvo	XC90 T8 Twin Engine (2018)	\$ 72,900	\$ 995	\$ 5,002	\$ 69,893	18.4	21	370	---	64	313	4.9	---	\$5,085	
Volvo	XC90 T8 Twin Engine (2018)	\$ 84,900	\$ 995	\$ 5,002	\$ 80,893	18.4	21	370	---	64	313	5.9	5,099	\$6,247	

***UPDATED SEPTEMBER 2018



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Source: <https://insideevs.com/compare-plug-ins/>



Miles per Charging Time

Charging Types Summary		
	Charging Rates	
Level 1	4 to 5	miles per hour
Level 2	11 to 60	miles per hour
DC Fast		
25kW	22.5	miles per 15 minutes
50kW	45	miles per 15 minutes
120kW	108	miles per 15 minutes
150kW	135	miles per 15 minutes
350kW	315	miles per 15 minutes
400kW	360	miles per 15 minutes

Sources: <https://www.fleetcarma.com/electric-vehicle-charging-guide/>
<https://evobsession.com/electric-car-charging-101-types-of-charging-apps-more/>
<https://insideevs.com/what-are-the-power-limits-of-available-dc-quick-charging-standards/>
<https://www.caranddriver.com/news/1800-miles-per-hour-ultrafast-charging-tech-moving-far-faster-than-anticipated>
<https://plugincars.com/first-150-kw-fast-charging-station-opens-tesla%E2%80%99s-backyard-132652.html>
<https://www.firstenergycorp.com/content/dam/customer/get-help/files/PEV/guide-to-ev-charging.pdf>



DOT FHWA Alternative Fuel Corridors

Objectives:

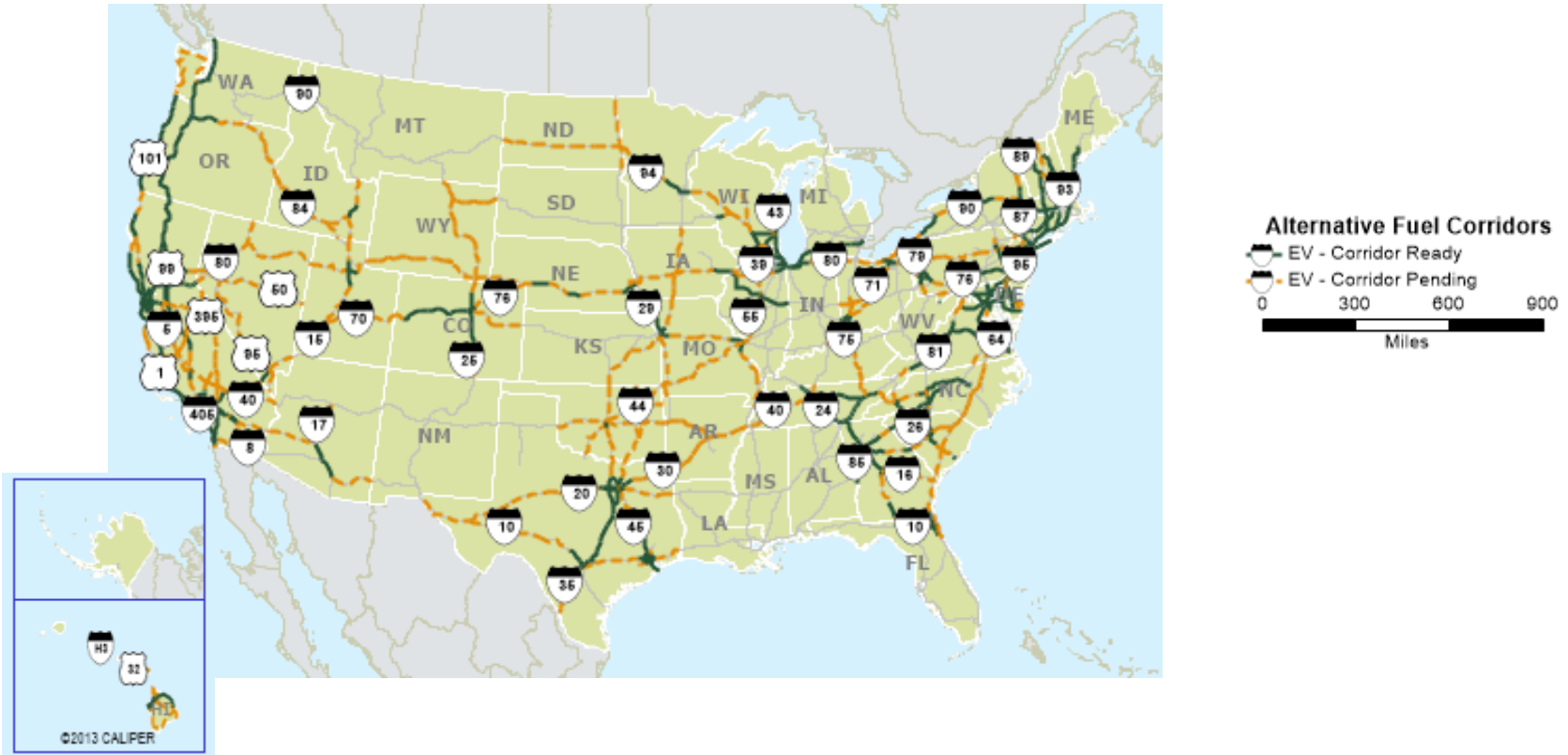
- National network of alternative fueling and charging infrastructure along national highway system corridors
- Promote build out of national network
- Develop national signage and branding to help catalyze applicant and public interest
- Encourage multi-State and regional cooperation and collaboration

To date results:

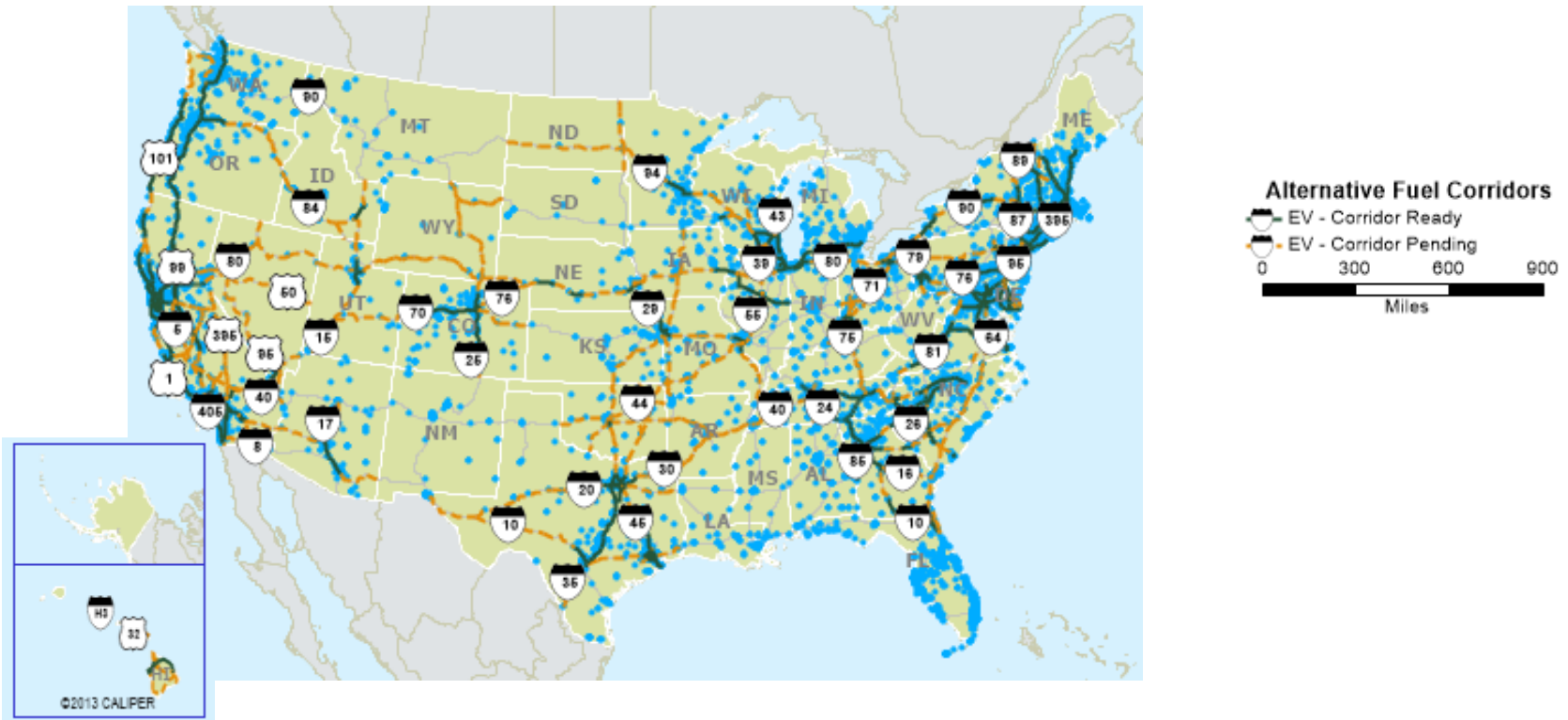
- 58 Nominations
- Portions/segments of 84 Interstates & 43 US highways/state roads
- 44 states & D.C.
- Over 100,000 miles of the [National Highway System](https://www.fhwa.dot.gov/environment/alternative_fuel_corridors/) (all fuels combined).

Source: https://www.fhwa.dot.gov/environment/alternative_fuel_corridors/

FHWA Alternative Fuel Corridors: EVSE



FHWA Alternative Fuel Corridors: EVSE



Summary of State EV Actions

Type of Action	# of Actions	% by Type	# of States
Financial Incentives	56	27%	11 + DC
Studies and Investigations	34	16%	23 + DC
Deployment	32	15%	16 + DC
Regulation	31	15%	12
Market Development	30	14%	7 + DC
Rate Design	28	13%	18 + DC
Total	211	100%	32 States + DC

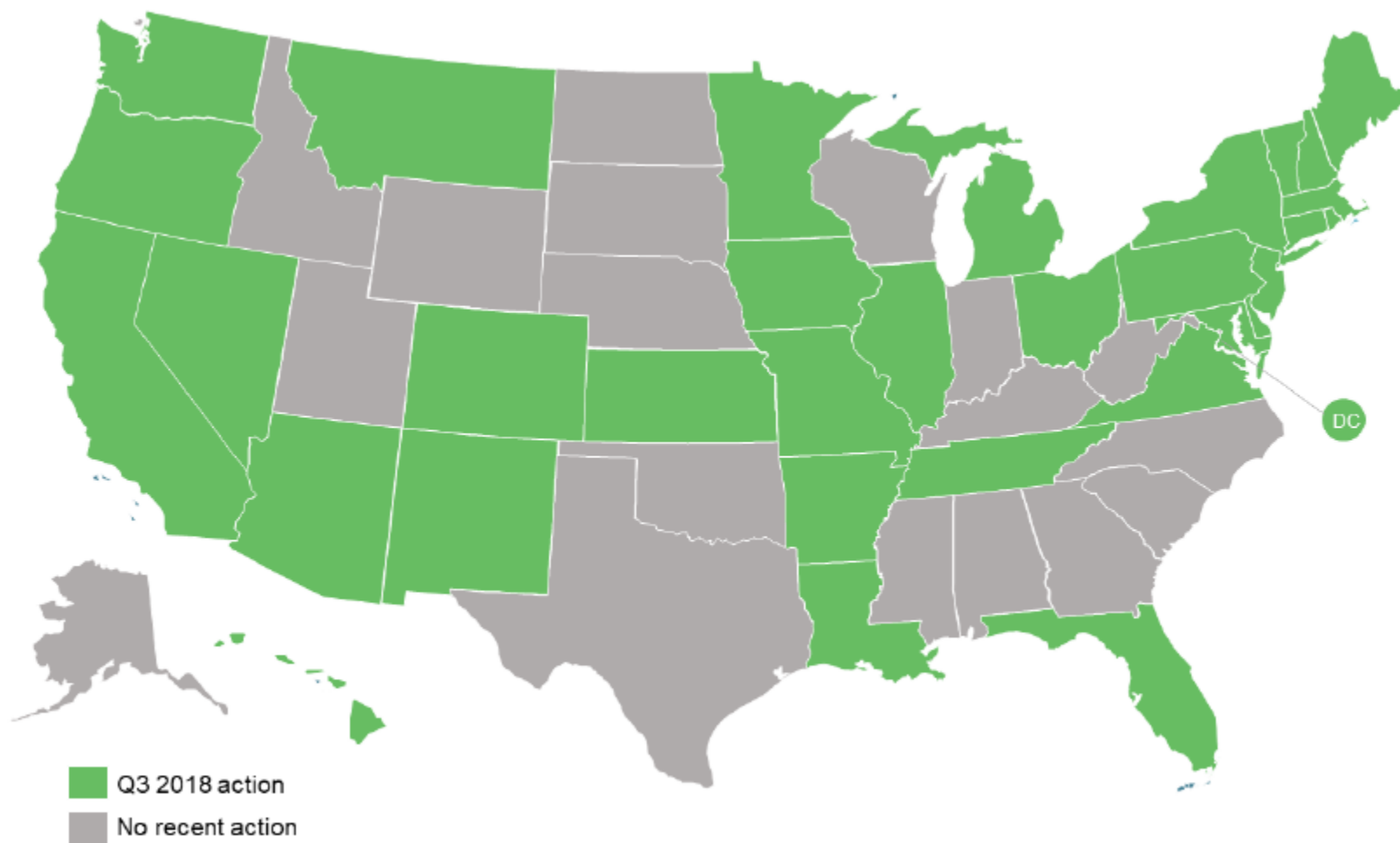
Note: The "# of States/ Districts" total is not the sum of the rows because some states have multiple actions. Percentages are rounded and may not add up to 100%.

Common actions:

- Level 2 charging station deployment
- Electric vehicle rate tariffs
- Fast charging station deployment
- Rebate programs

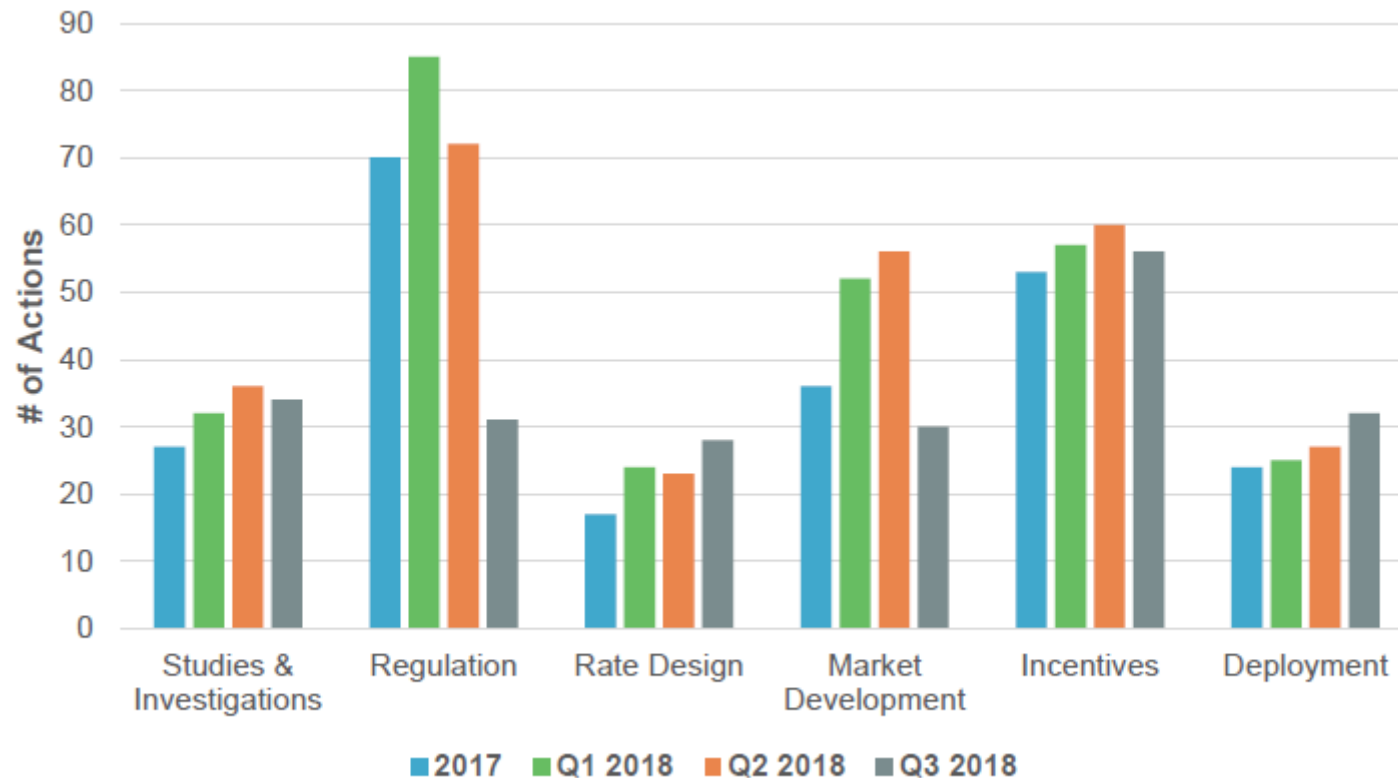
Source: 50 States of EV Quarterly Report: Q3 2018, NC Clean Energy Technology Center

Summary of State EV Actions



Source: 50 States of EV Quarterly Report: Q3 2018, NC Clean Energy Technology Center

Number of Actions by Category



Source: 50 States of EV Quarterly Report: Q3 2018, NC Clean Energy Technology Center

National Plug-In Infrastructure Analysis

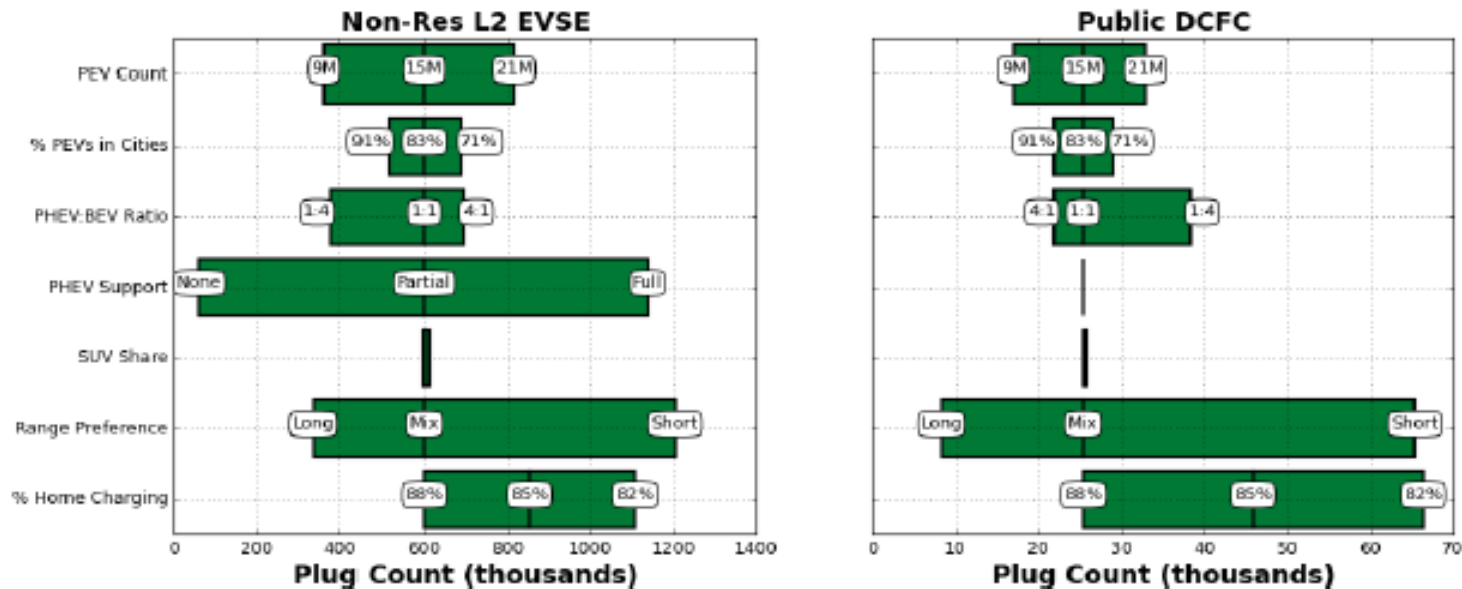
- DOE EERE Vehicle Technology Office September 2017
- How much EVSE is needed in the United States to support both plug-in hybrid electric vehicles (PHEVs) & battery electric vehicles (BEVs)—plug-in vehicles (PEVs)
- Looked at 2-pieces--Community non-residential and national network
- Four areas of deployment focus:
 - Cities >50,000 (71% of population)
 - Towns 2,500 to 50,000 (10% of US population)
 - Rural areas (19% of US population)
 - Interstate highway corridors (28,530 miles)

Source: <https://www.nrel.gov/docs/fy17osti/69031.pdf>

National Plug-In Infrastructure Analysis: Study Area



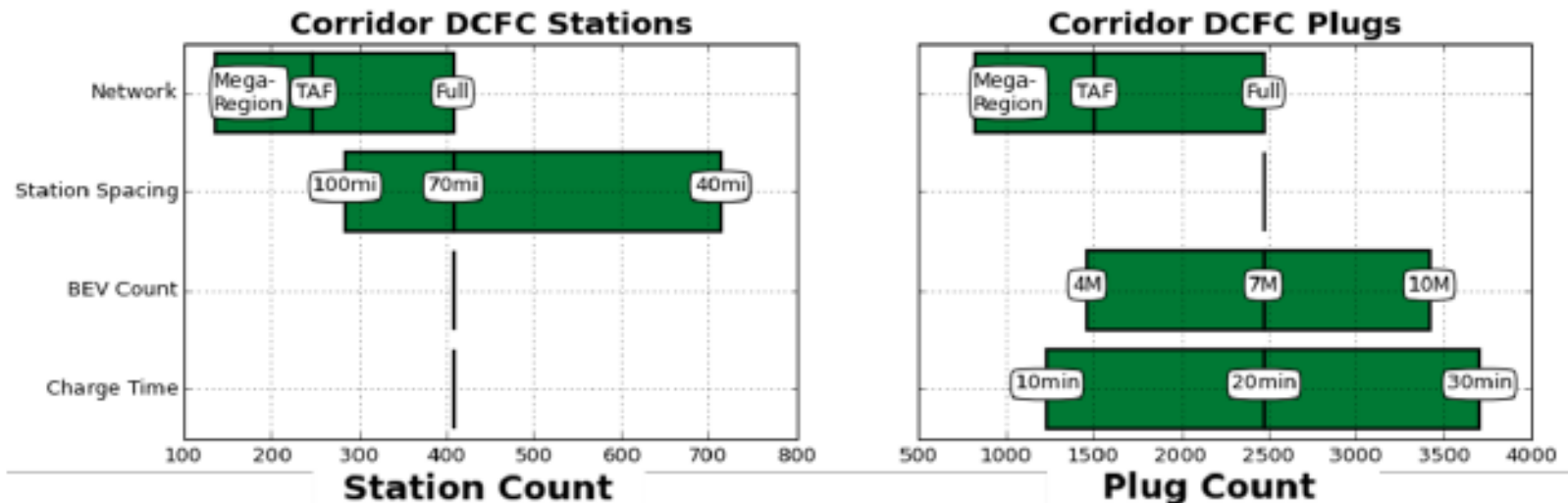
National Plug-In Infrastructure Analysis: Community Non-Residential Estimates



- Level 2 plug count 63,000 to 1,100,000—central case 600,000
- DCFC 8,400 to 65,000—central case 25,000

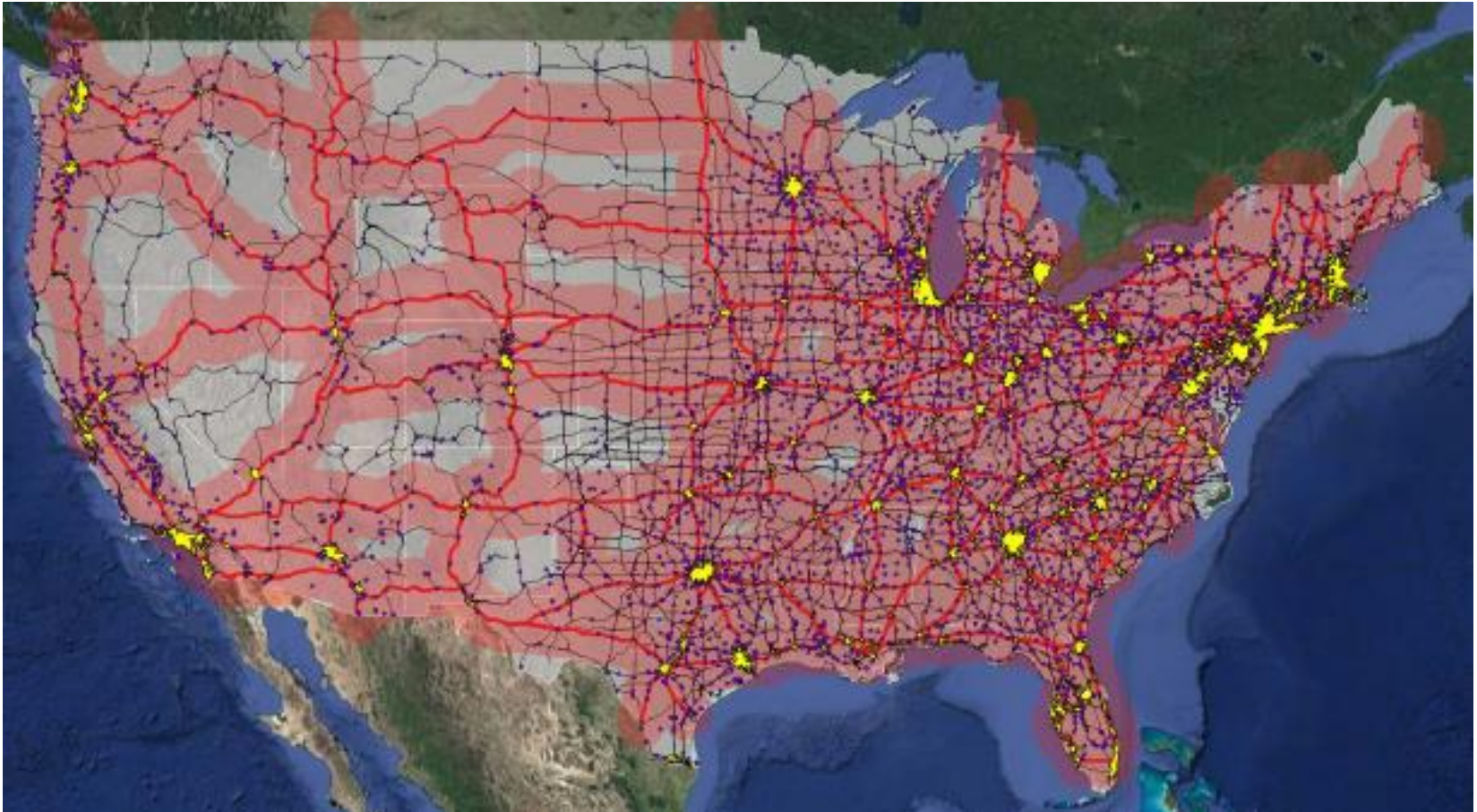


National Plug-In Infrastructure Analysis: DCFC National Network

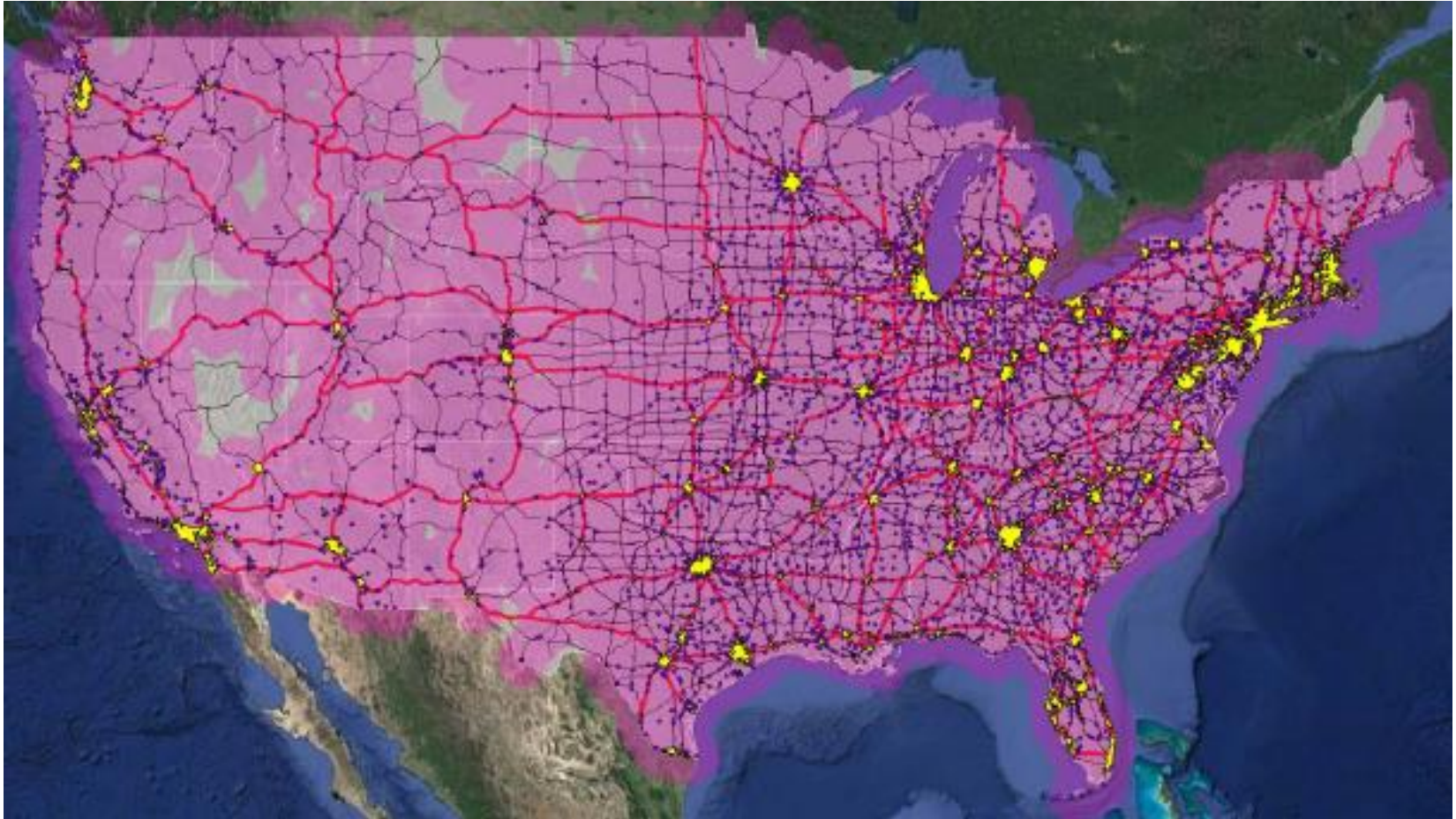


- Station count 137 to 713—central case 408
- Plug count 824 to 3,709—central case 2,472

National Plug-In Infrastructure Analysis: DCFC National Network Coverage Area



National Plug-In Infrastructure Analysis: DCFC Combined Coverage Area



How to Fund/Accomplish

- Private companies: ChargePoint, ABB, Clipper Creek, Electrify America, . . .
- VW Settlement Mitigation Funds 15% of \$3B
- CMAQ funding
- State funding and tax credits (currently 31 states)
- Public private partnerships—Northeast EV Network, the West Coast Electric Highway, Washington State EV Action Plan, . . .
- Cooperatives—Sourcewell, National Cooperative Buying Alliance, Fleets for the Future

General Comments

- PEVs are real and a viable transportation option
- EVSE network is critical for wide scale adoption
- “Perceived range anxiety” is an obstacle
- Rate and time of growth is uncertain
- Going to take a combination of awareness and motivation generation through education, policy, incentives and collaboration
- Moving target with rapid technology changes
- Largest obstacle to overcome is human nature to resist change
- Level 1 charging has its place

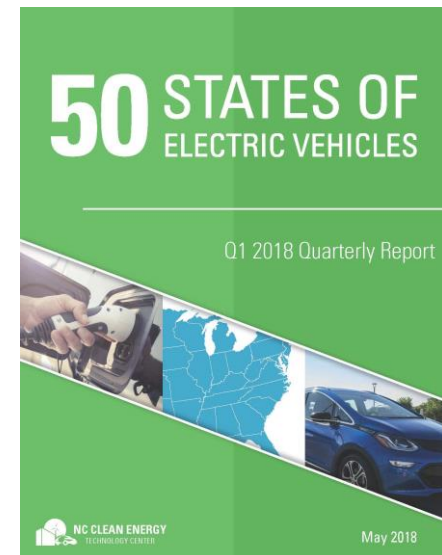
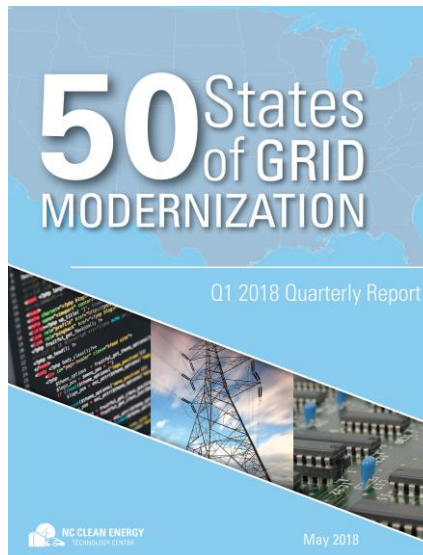
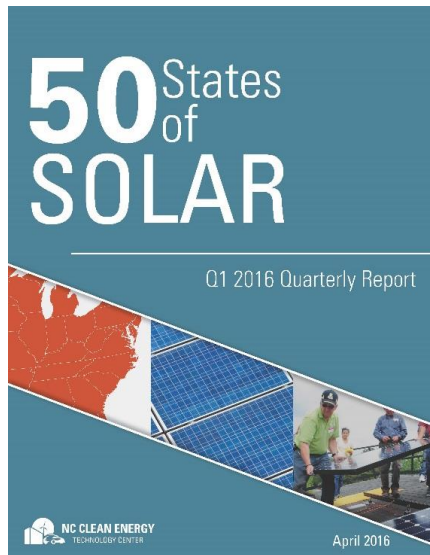
Some Interesting Statistics to Consider

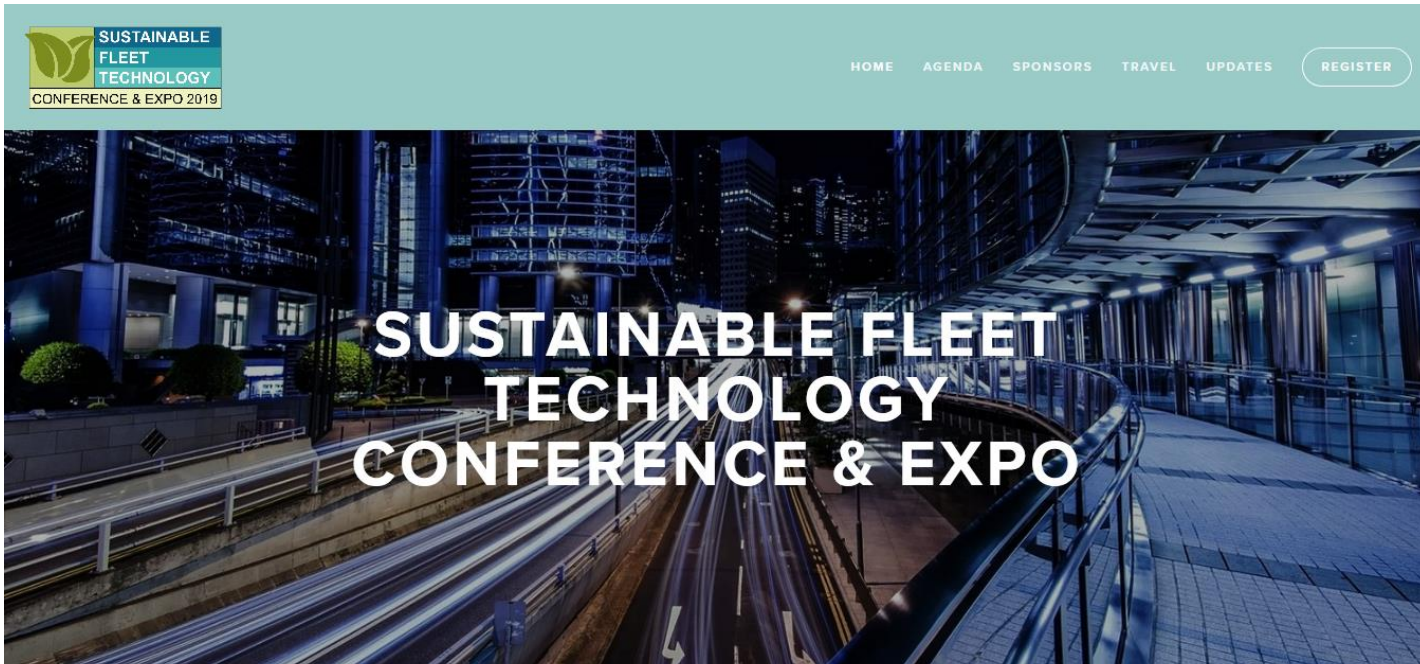
- 73% of Tesla buyers supercharger network influenced purchase (Tesla)
- 95% to 98% of charging occurs at home or at work (DOE)
- 85%-95% of charging occurs at home (DOE)
- Person is 20 times more likely to purchase a plug-in vehicle, if they have access to charging at work (DOE)
- 70% of daily driving is <40 miles and 95% is <100 miles (DOE)
- US drivers use personal vehicle for trips >100 miles 6 days/year (DOE)
- 80% of consumer vehicles are owned by multi-vehicle households (DOE)
- 91% of PEV registrations where 71% of population lives—cities (DOE)

About the 50 States Report Series

Quarterly publications detailing state and utility activity related to: (1) distributed solar policy & rate design, (2) grid modernization and energy storage, and (3) electric vehicles

<https://nccleantech.ncsu.edu/our-work/policy/the-50-states-reports/>





SAVE THE DATE: August 6-8, 2019
Durham Convention Center, Durham NC
SUSTAINABLEFLEETEXPO.COM



<https://lucidmotors.com/stories/lucid-air-hits-235-mph>

**North Carolina State University
NC Clean Energy Technology Center
Clean Transportation Program**
www.cleantransportation.org

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