
INTRODUCTION TO ELECTRIC VEHICLES



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Senior Research Program Manager (retired)

Medtronic Corporate
Minneapolis, Minnesota

36 YEARS

Hardware/software product development in multiple industries

24 YEARS

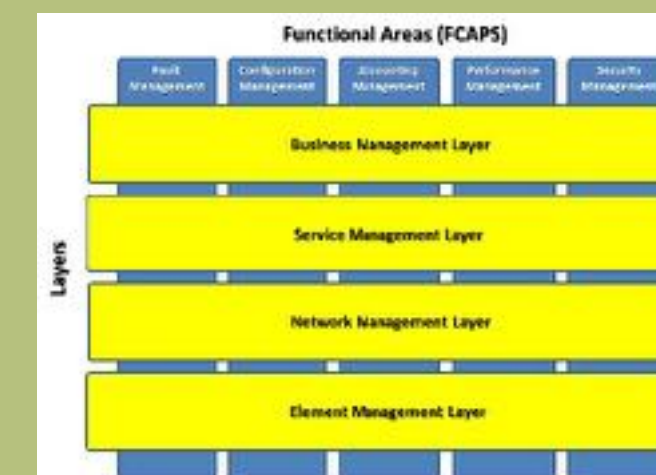
Medical device software development and quality

About Me

- ❖ Hometown: Portage, Wisconsin
- ❖ Current Residence: Plymouth, MN
- ❖ Family: Wife Karen, Son Tor (28), Daughter Louise (21)
- ❖ EV driver since Oct 2015
- ❖ Home powered by solar since Sep 2015

Professional Experience

- ❖ RF Design - 2-way radios & power amps
- ❖ Automotive Diagnostic Software
- ❖ Telecommunications Systems and Software
- ❖ Medical Device Systems and Software



Fun Facts

- ❖ At Argonne National Labs outside Chicago, my father experimented using CP-5. This sparked my interest in science and engineering.
- ❖ Of the 18 countries I have visited, 5 begin with the letter 'I' (there are only 9 in total).
- ❖ I love to talk to people about electric vehicles and renewable energy. One year, my Tesla Model 3 was on display at the State Fair for several days.

Hobbies

- ❖ Camping /Hiking
- ❖ Cycling
- ❖ Tree Care Advisor
- ❖ Music
- ❖ Travel
- ❖ Electric vehicle & Renewable Energy advocacy

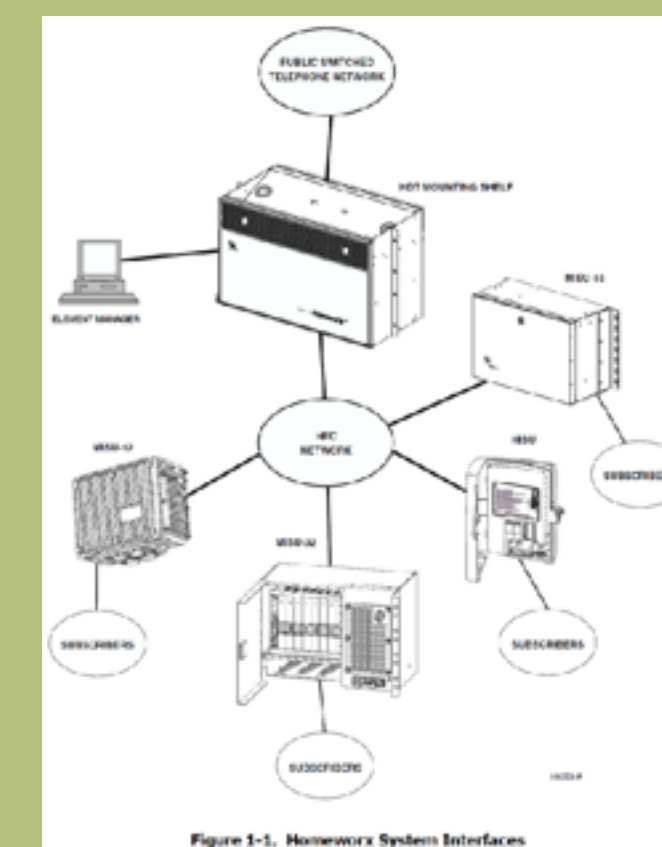
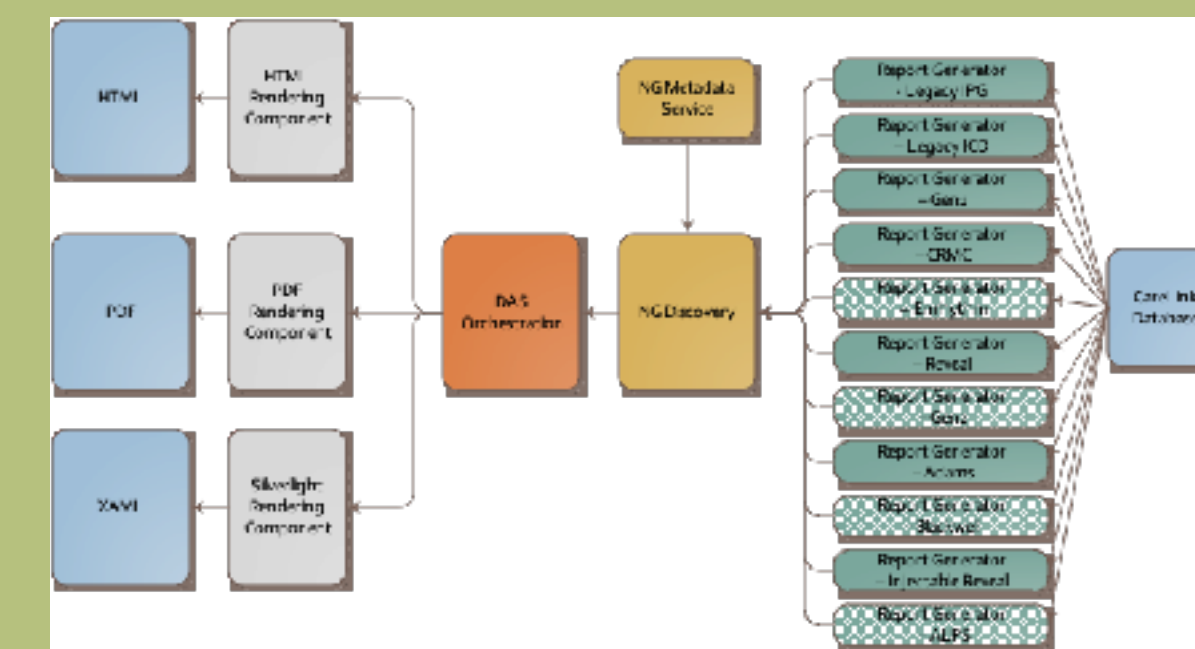


Figure 1-5. Homework System Interfaces



Our EV experience started in 2015 with leasing a BMW i3 and we have been 100% EV since March 2020.



BMW i3 charging at Carlton College in Northfield, MN








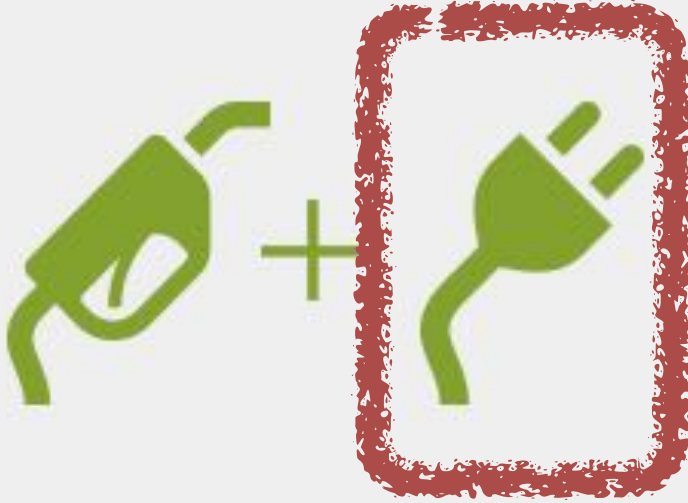









Agenda

- Types of EV's
 - EV Myth Busting
 - Full Lifecycle Emissions (another busted myth)
 - Charging (How, How Long, When, Where)
 - Total Cost of Ownership (Purchase, Energy, Maintenance, Insurance)
 - Electric Vehicle News Sources
 - What is out there?
 - What model is right for me?
-

There are some new terms to learn when talking about the future of personal transportation.

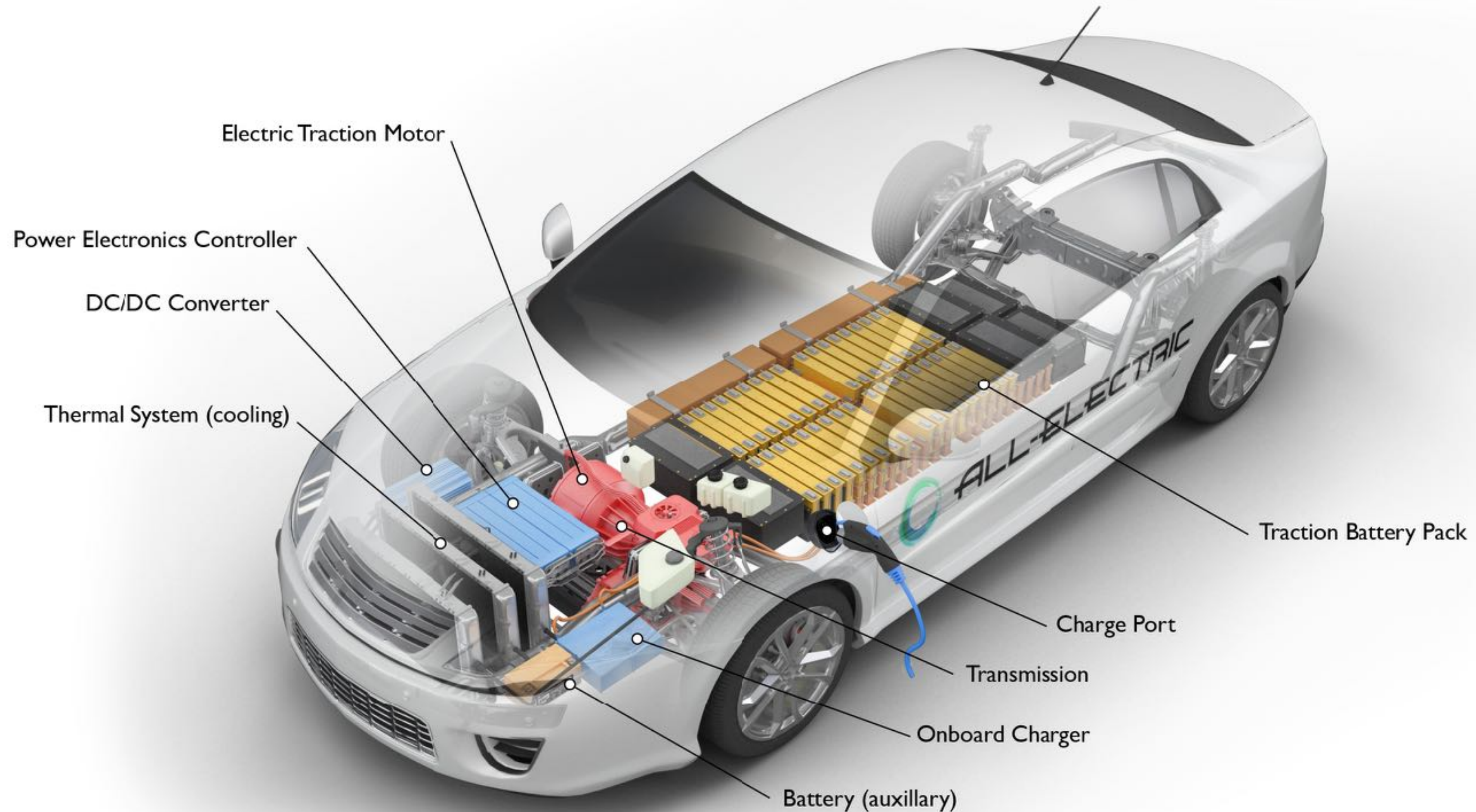
Term	Definition
BEV	Battery Electric Vehicle
BMS	Battery Management System
CCS	Combined Charging Standard
DCFC	DC Fast Charger
EV	Electric Vehicle
EVSE	Electric Vehicle Service Equipment (for L1 & L2 AC charging)
ICE(V)	Internal Combustion Engine (Vehicle)
J1772	North American standard for electric vehicle AC (L1-L2 AC charging)
PHEV	Plug-in Hybrid Electric Vehicle
SOC	(Battery) State of Charge

The source of energy for a vehicle is key to understanding its environmental impact. For example, hybrids are 100% fossil fuel powered.

					
		CONVENTIONAL	HYBRID	PLUG-IN HYBRID	ALL-ELECTRIC
SOURCES OF ENERGY					
		Internal Combustion Engine Vehicle (ICEV)			Electric Vehicle (EV)
CONSUMPTION					
EMISSIONS					

Electric Vehicle Components

All-Electric Vehicle



MYTH: It will take decades for the the industry to convert over to producing primarily electric vehicles.

5th AVE NYC

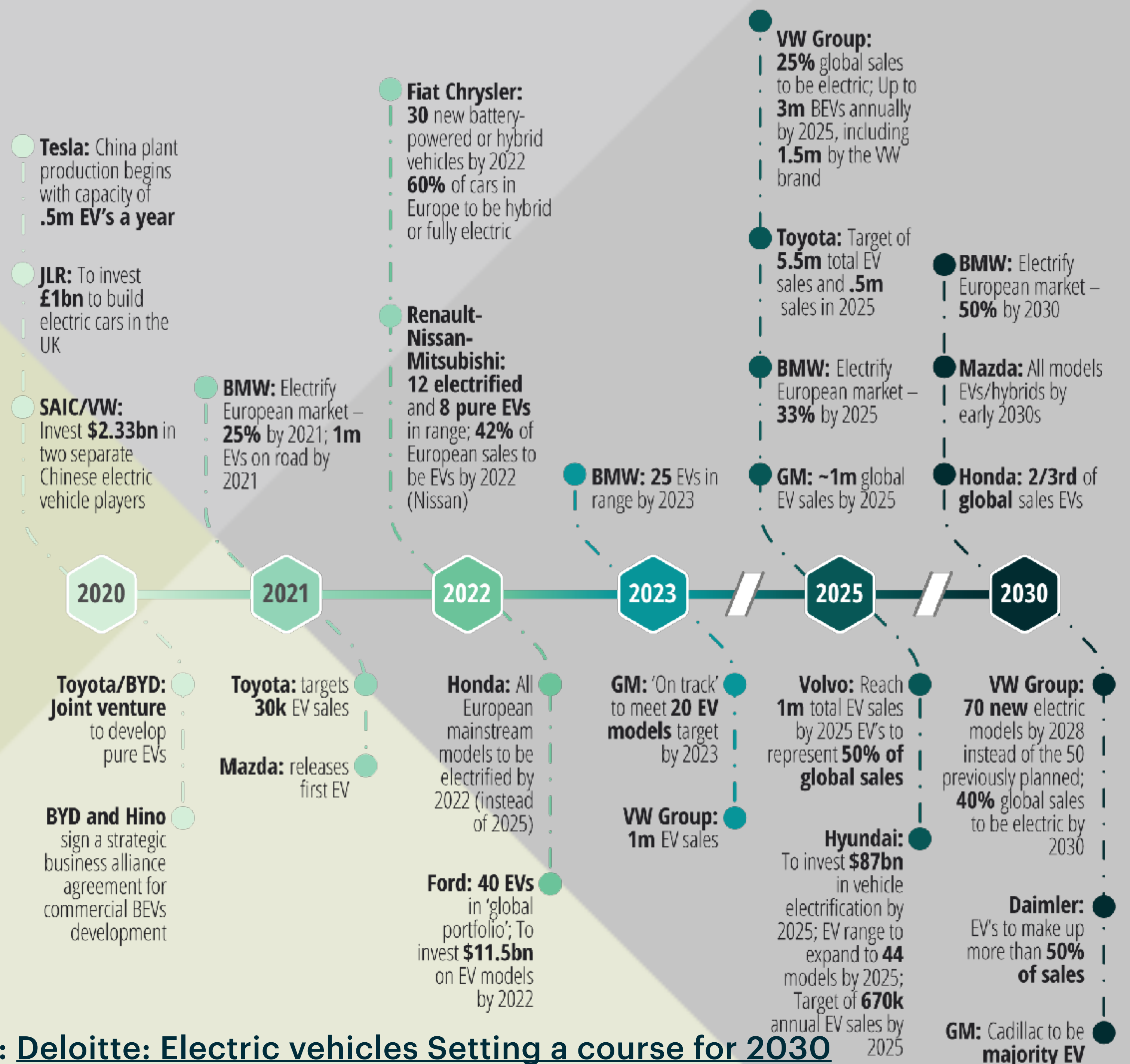
1913

Where is
the
horse?



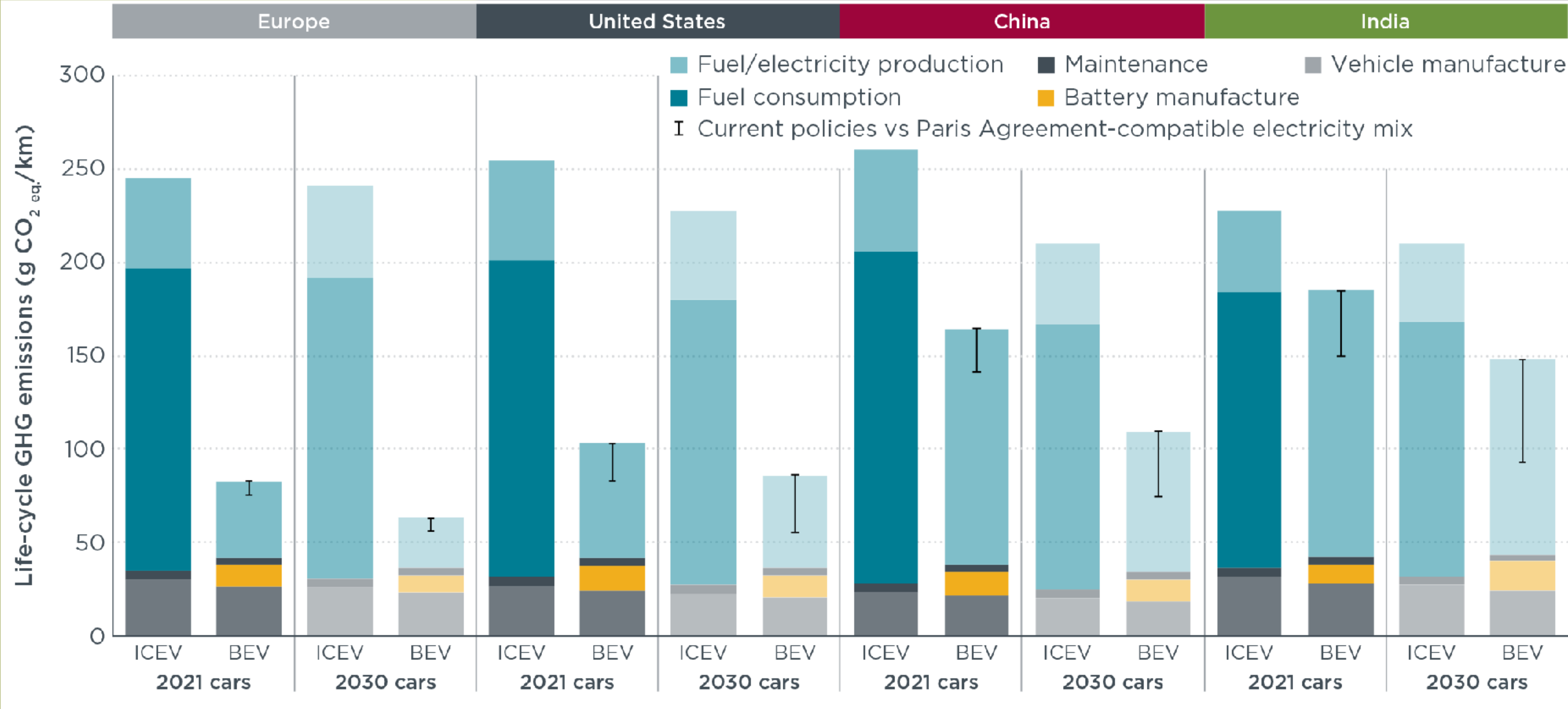
MYTH: It will take decades for manufacturers to convert over to producing EVs (from ICEVs).

Reality: The 2020s are last ICE decade.



Source: [Deloitte: Electric vehicles Setting a course for 2030](#)

MYTH: Electrically powered vehicles pollute just as much as, or more than, ICE vehicles (the long tailpipe concept).



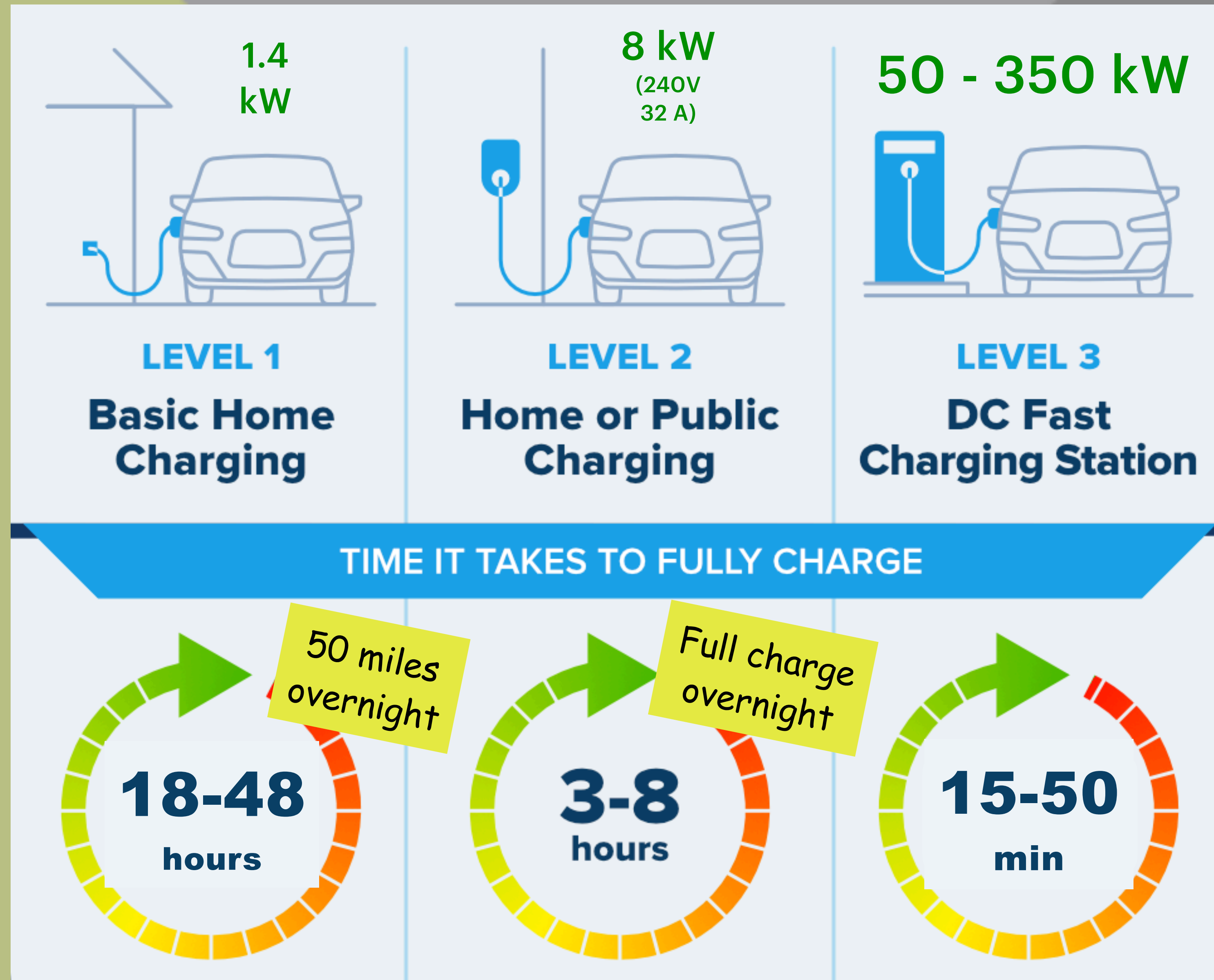
Source: <https://theicct.org/publications/global-LCA-passenger-cars>

MYTH: EVs can't replace ICEVs in real-world use, or are at least, way less convenient.

- Most EV “refueling” takes place in your garage. We never have to take any time to stop at a gas station to regularly handle an explosive, carcinogenic chemical in our daily routine.
 - Tesla and 3rd parties have built networks of DC fast chargers that allow travel to all 50 states. (More on that later).
 - Since 2015, we've driven about 75,000 all-electric miles in all weather across 5 different electric vehicles from 3 different manufacturers.
 - We have taken 6 multi-state road trips, including below 0 temps and towing a trailer.
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ELECTRIC VEHICLE CHARGING

There are three levels of Electric Vehicle charging.



There are several types of Electric Vehicle charging equipment.



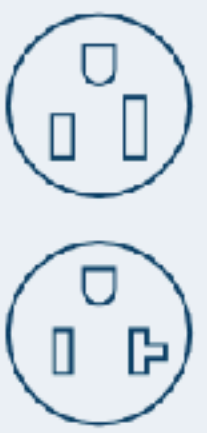






Portable EVSE
(home charger)
L1-L2
120V or 240V AC



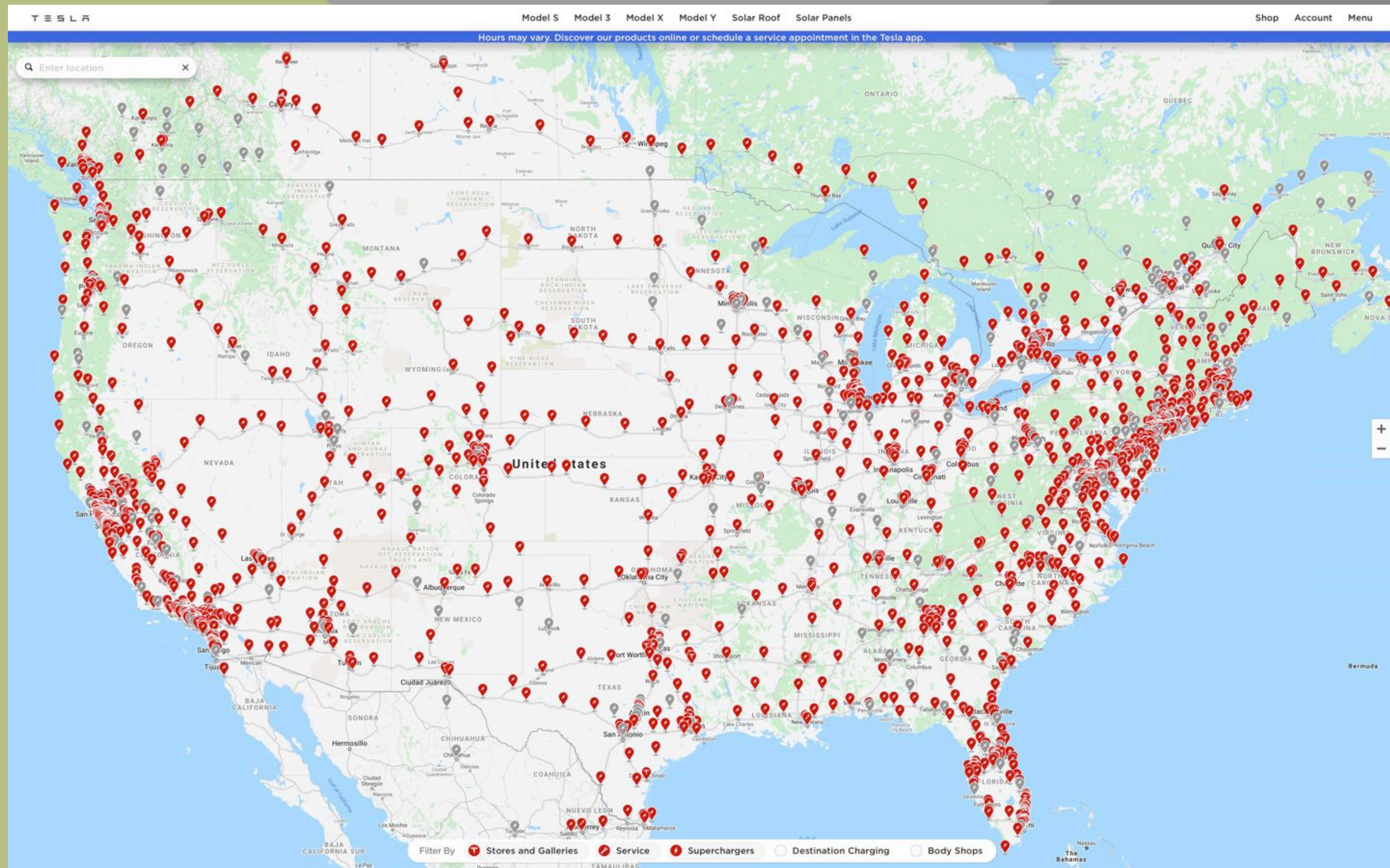
Public DC Fast Charger
(Electrify America)
L3 - Main Battery DC Voltage

Public EVSE L2 240V AC

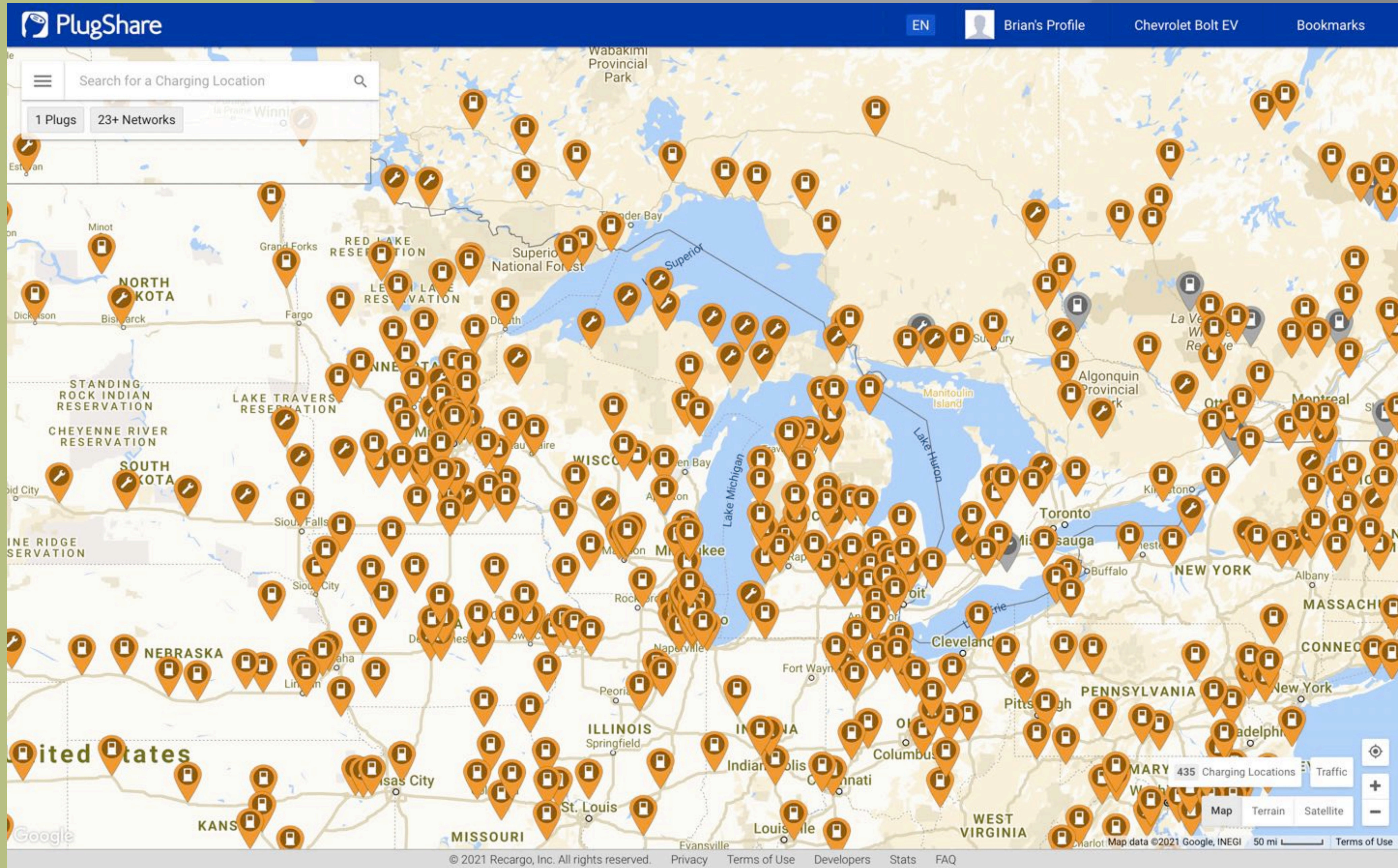


CONNECTORS	LEVEL	ASIAN MAKES	US / EU MAKES	TESLA
Wall outlets (Nema 515, Nema 520) 	1	With adapter	With adapter	With adapter
Port J1772 		✓	✓	With adapter
Nema 1450 (RV plug) 	2	With adapter	With adapter	With adapter
Tesla HPWC 		✗	✗	✓
CHAdeMO 		✓	✗	With adapter
SAE Combo CCS 	3	✗	✓	✗
Tesla supercharger 		✗	✗	✓

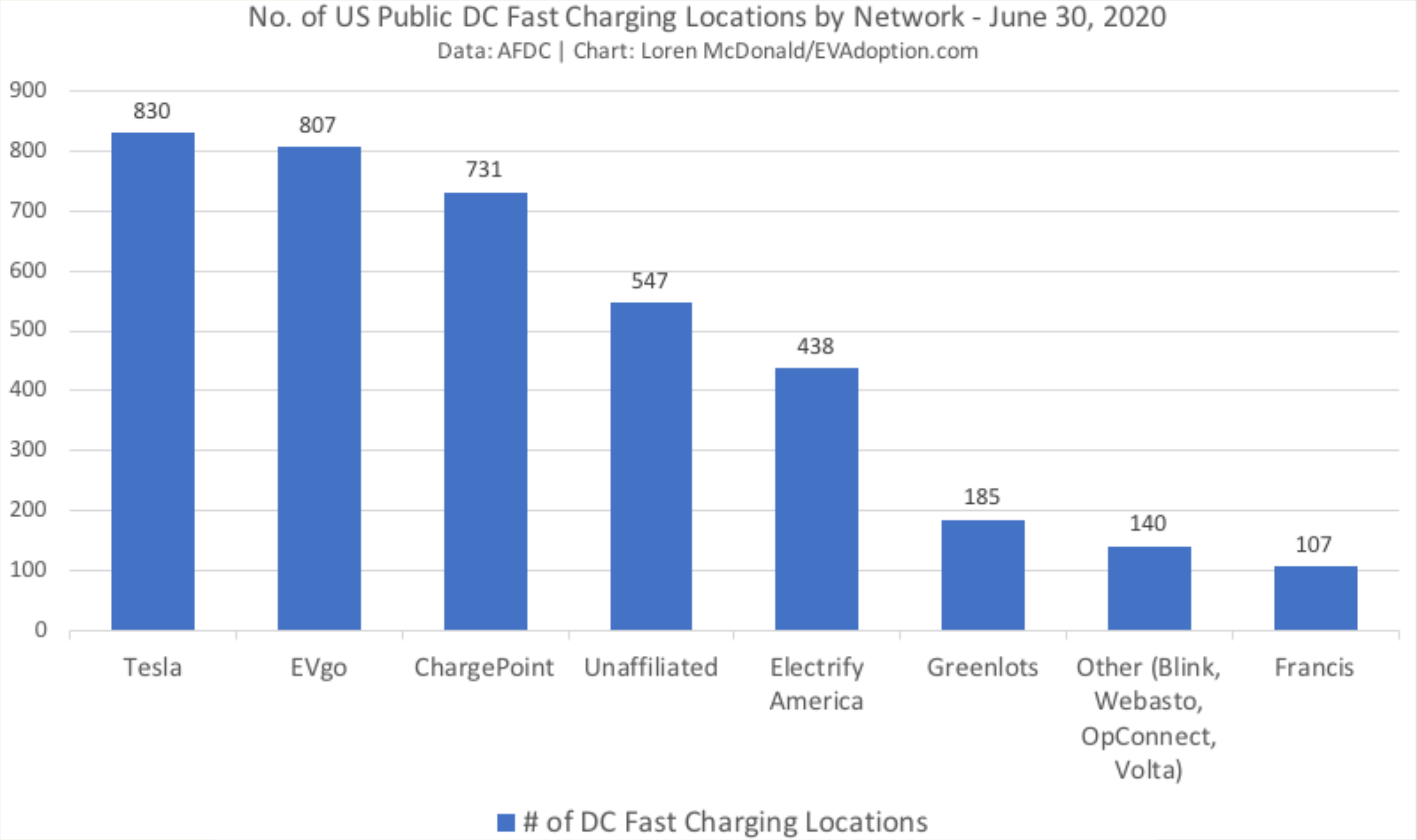
The Tesla charging network provides convenient travel to any location via the in-car navigation and automatic billing for energy.



Third party networks also cover the US and are expanding rapidly.



DC fast charging infrastructure is already robust and is in a high-growth mode. Tesla has fewer locations, but more connections / location.



US Public DC Fast Charging (DCFC) Locations

MYTH: EVs are more expensive to own and operate than equivalent ICEVs.

Lifetime savings of Best Selling EVs under \$50,000 compared to Best Selling & Top Rated ICE vehicles in each EV's class

Consumer Reports



EV model and trim	Leaf E+ S+	Bolt LT	Prius Prime LE	Clarity PHEV	Mach E Select	RAV4 Prime SE	Escape PHEV SE	Model 3 SR Plus	Model Y LR
Best Selling	Civic Hatchback LX			Camry LE	RAV4 LE		330i	RX 350 FWD	
Top Rated	Elantra GT automatic			Legacy 2.5	CX5 Sport		A4	QX50 Pure	

Source: <https://www.consumerreports.org/hybrids-evs/evs-offer-big-savings-over-traditional-gas-powered-cars/>

Connecticut Winter Round Trip

Two days driving each way plus
nine days of local driving

	Time (hh:mm)	Energy (kWh)	Miles
All Driving	50:20	-1093.5	3,096
Highway Driving	42:31		2,802
Supercharging	9:32	898.3	
Supercharging sessions	27		
Time / SC session	0:21:10		
Supercharging vs. Driving Time	22%		

CT Trip Energy costs (3096 miles)

Total Supercharger Costs	\$288.77
Energy cost / mi	\$0.10
Cost / kWh	\$0.32
Equivalent gallons of gas (23 mpg)	134.6
Cost of gas (premium) @ \$4.13/gal	\$556.01
Equivalent gas price	\$2.14
Cost savings vs. gas	48%

ICE vehicle used for comparison: 2020 Volvo XC60 AWD

News Sources - where can I find out more and stay current?

- InsideEVs: insideevs.com
- CleanTechnica: cleantechnica.com
- Electrek: electrek.co
- GreenCarReports: www.greencarreports.com/news/electric-cars
- EV Obsession: evobsession.com

Source: EV News | Shift2Electric: www.shift2electric.com/evnews

Several models have been for sale in MN for years and have used model availability.



2011 Nissan LEAF (2011)

Many new EV models have been introduced or are in the pipeline for 2022 release. ~~2022~~ 2023 is the year of the electric pickup!



Mustang Mach-E (Now)

What factors should I consider in choosing an Electric Vehicle?

- Basic parameters
 - What size vehicle do I need (passengers, cargo)?
 - How much am I willing to spend?
 - New, used, or both?

- EV parameters
 - How many miles / day do I drive?
 - What road trips do I want to use the EV for?
 - Max distance per day
 - Max distance off main routes

- Special circumstances
 - What size / weight trailers do I want to tow with the EV?
 - Off-roading? Pick-up?



There are a number of EVs available for purchase in Minnesota.

Plug-in vehicles available in Midwest (January 2019)



Manufacturer									Range		Charging speed (miles/hr)			Performance						
Name	Model	Photo	Seating	PEV Type	FWD/RWD/AWD	Base MSRP	Federal tax credit	Price after federal tax credit	Battery size (kWh)	Electric Range (miles)	Total Range (miles)	Level 2 Charging Rate (kW)	Level 1 120v	Level 2 240v	DCFC 400+v	MPGe/MPG	Top Spd (mph)	0-60 mph (sec)	Towing capacity (lbs)	NHTSA Crash Rating
Audi	A3 E-Tron		5	PHEV	FWD	\$38,900	\$4,168	\$34,732	9	17	430	3.3	3	8	N/A	86/39	130	7.6	0	NR
BMW	i3		4	BEV	RWD	\$44,450	\$7,500	\$36,950	42	153	153 (200)	7.4	4	27	166	124 (39)	93	6.9-7.2	0.0	4 star
BMW	i8		4	PHEV	AWD	\$147,500	\$3,793	\$143,707	7.2	15	330	3.3	3	7	N/A	76/28	155	4.2	0	NR
BMW	XS xDrive40e		5	PHEV	AWD	\$62,100	\$4,700	\$57,400	9	14	540	3.3	2	5	N/A	56/24	130	6.5	0	NR
BMW	330e		5	PHEV	RWD	\$45,600	\$4,000	\$41,600	7.6	14	350	3.7	3	8	N/A	72/31	130	5.9	0	NR
BMW	530e		5	PHEV	RWD/AWD	\$1,400	\$4,200	\$49,200	9.2	16	370	3.5	3	7	N/A	72/29	146	6	0	NR
BMW	740e		5	PHEV	RWD/AWD	\$1,700	\$4,200	\$86,500	9.2	14	340	3.7	2	7	N/A	64/27	130	5.1	0	NR
Chevrolet	Bolt EV		5	BEV	FWD	\$37,495	\$7,500	\$29,995	60	238	238	7.2	4	25	159	119	98	6.5	0	5 star
Chevrolet	Volt		4.5	PHEV	FWD	\$33,170	\$7,500	\$25,670	18.4	53	420	3.3	4	10	N/A	106/42	98	8.4	0	5 star
Chrysler	Pacifica Hybrid (PHEV)		7	PHEV	FWD	\$42,000	\$7,500	\$34,500	16	33	570	6.6	3	16	N/A	84/32	107	7.8	0	NR
Ford	Fusion Energi		5	PHEV	FWD	\$31,120	\$4,007	\$27,113	7.6	21	610	3.3	3	10	N/A	97/42	85	8.5	0	5 star
Honda	Clarity PHEV		5	PHEV	FWD	\$33,400	\$7,500	\$25,900	17	48	340	6.6	4	22	N/A	110/42	110	8.8	0	NA
Jaguar	I-PACE		5	BEV	AWD	\$69,500	\$7,500	\$62,000	90	234	234	7	4	18	180	76	124	4.5	0	NR
Kia	Niro PHEV		5	PHEV	FWD	\$27,900	\$4,543	\$23,357	8.9	26	560	3.3	4	10	N/A	105/46	107	9	0	NA
Mini	Cooper S E ALL4		5	PHEV	FWD	\$36,900	\$4,001	\$32,899	7.6	12	270	3.3	4	8	N/A	65/27	NA	6.8	0	NR

Click for full list

Resources

- [Alternative Fuels Data Center: How do Electric Vehicles Work?](#)
 - [Deloitte: Electric vehicles Setting a course for 2030](#)
 - [ICCT: A global comparison of the life-cycle greenhouse gas emissions of combustion engine and electric passenger cars](#)
 - [EVadoption: EVGo and GM Partner to Add 2,700 New Fast Chargers Over the Next Five Years](#)
 - [Consumer Reports: EVs Offer Big Savings Over Traditional Gas-Powered Cars](#)
 - [Shift2Electric: Available EV Model Lists](#)
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Thank You for your attention

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