NE Iowa Electric Vehicle (EV) Market Analysis & Acceleration Project

Winneshiek Energy District – Energy Lunch

March 2021

National Trends:

U.S. sales of EVs/PHEVs between 2011 – 2019 total more than 1.4 million

There are about 1 million EVs on US roads today

That number is expected to rise to **18 million by 2030**

Global Trends:

Global EV sales are expected to increase from 10 million a year in 2025 to 56 million in 2040

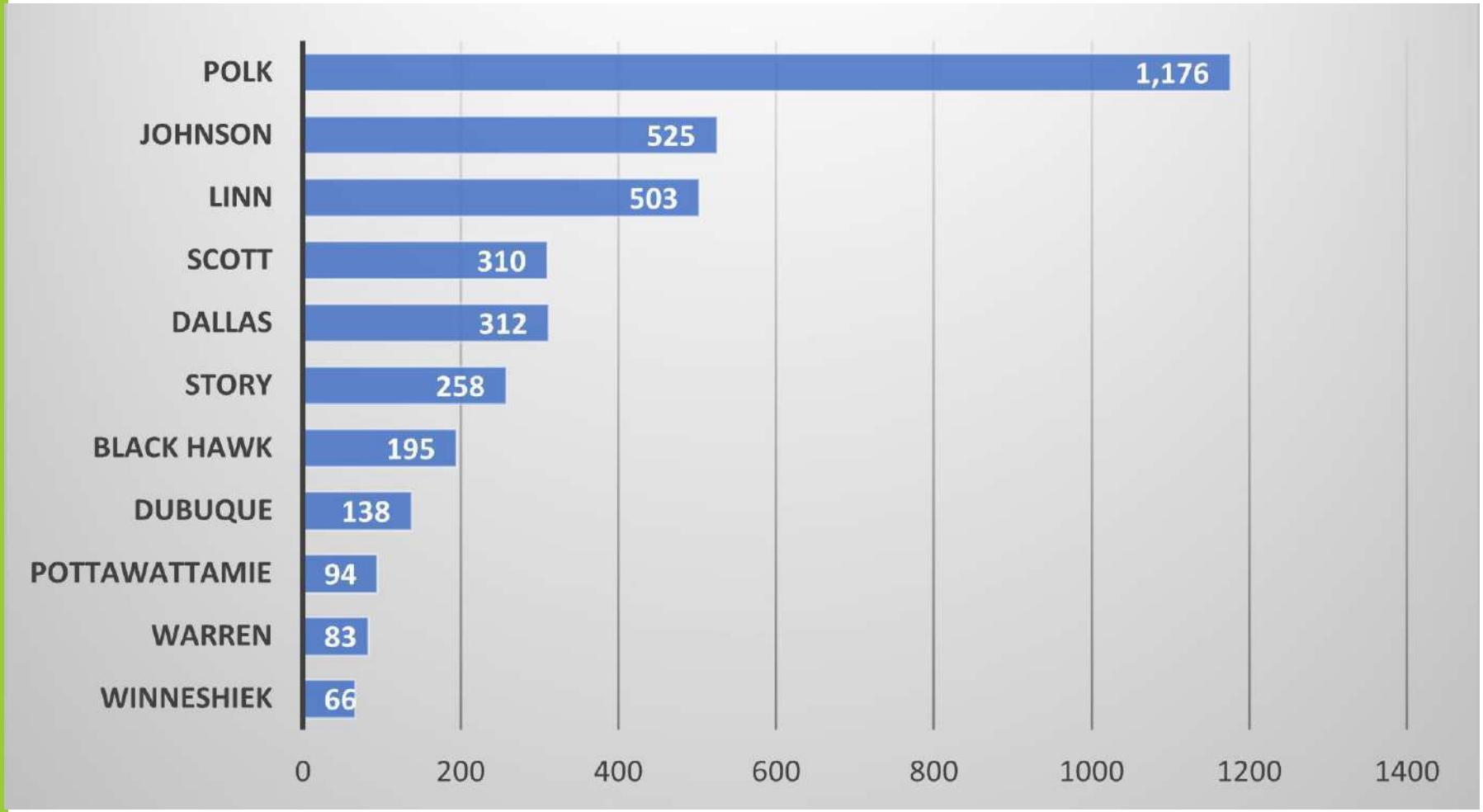
Total EVs may surge to **125 million globally by 2030**

Sources: Consumer Guide to Electric Vehicles, Electric Power Research Group, April 2020, https://mienergy.coopwebbuilder3.com/sites/mienergy/files/pdf/EPRI%20Guide.pdf; Alliant Energy Website, https://www.alliantenergy.com/WaysToSave/Rebates/RebateLocatorTool/ElectricVehicleWorkplaceChargingStation

Growth of Iowa's EV Market

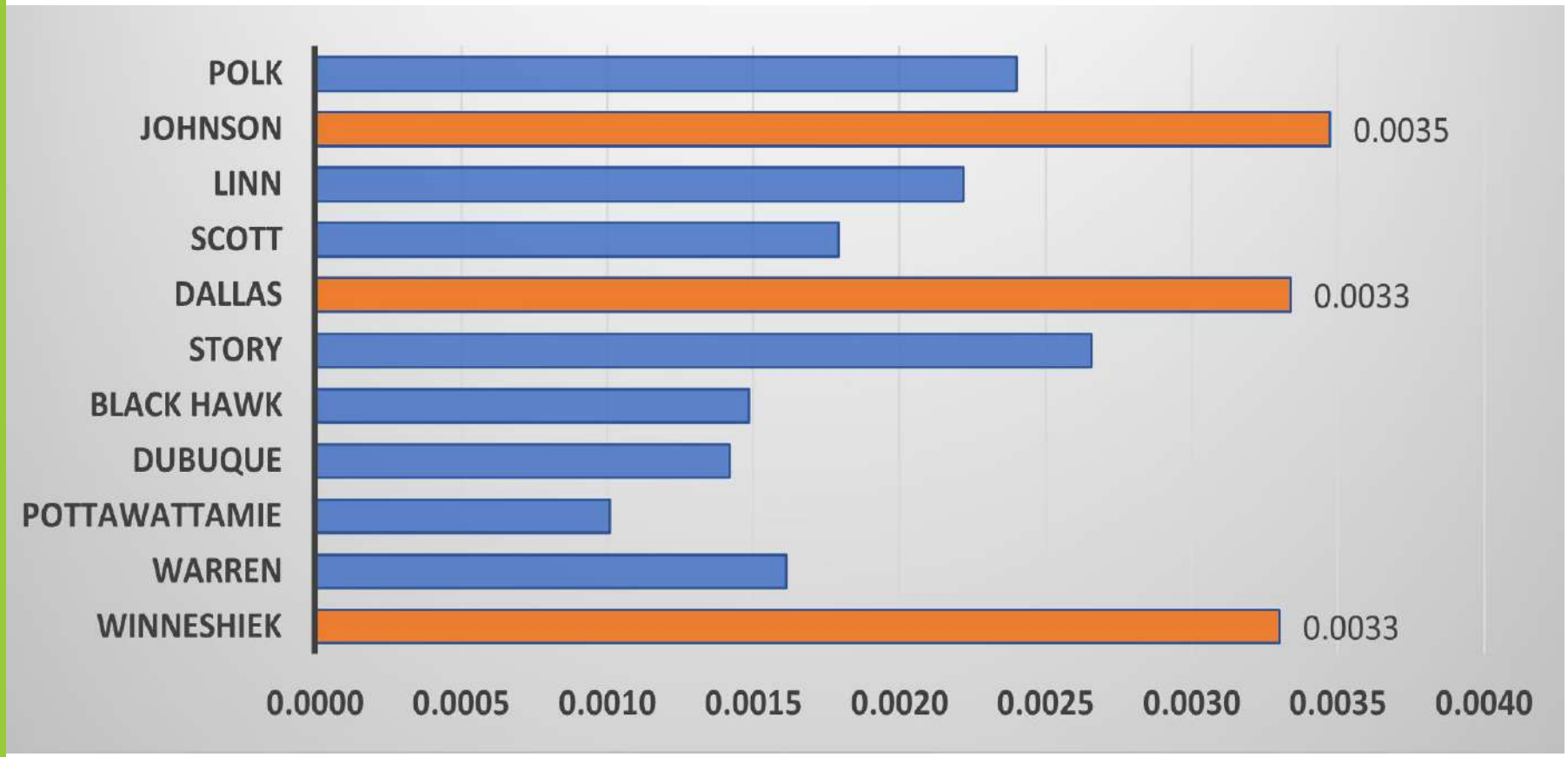
- **Combined Battery Electric Vehicle (BEV) and Plug-in Hybrid Electric Vehicle (PHEV) sales in IA increased 1,771% from 2011 to 2018.**
- The increase during the same time period for BEV alone was 24,050% (only 2 in 2011, up to 483 in 2018), and for PHEV 823% (47 in 2011, up to 434 in 2018).

Source: https://autoalliance.org/energy-environment/advanced-technology-vehicle-sales-dashboard/



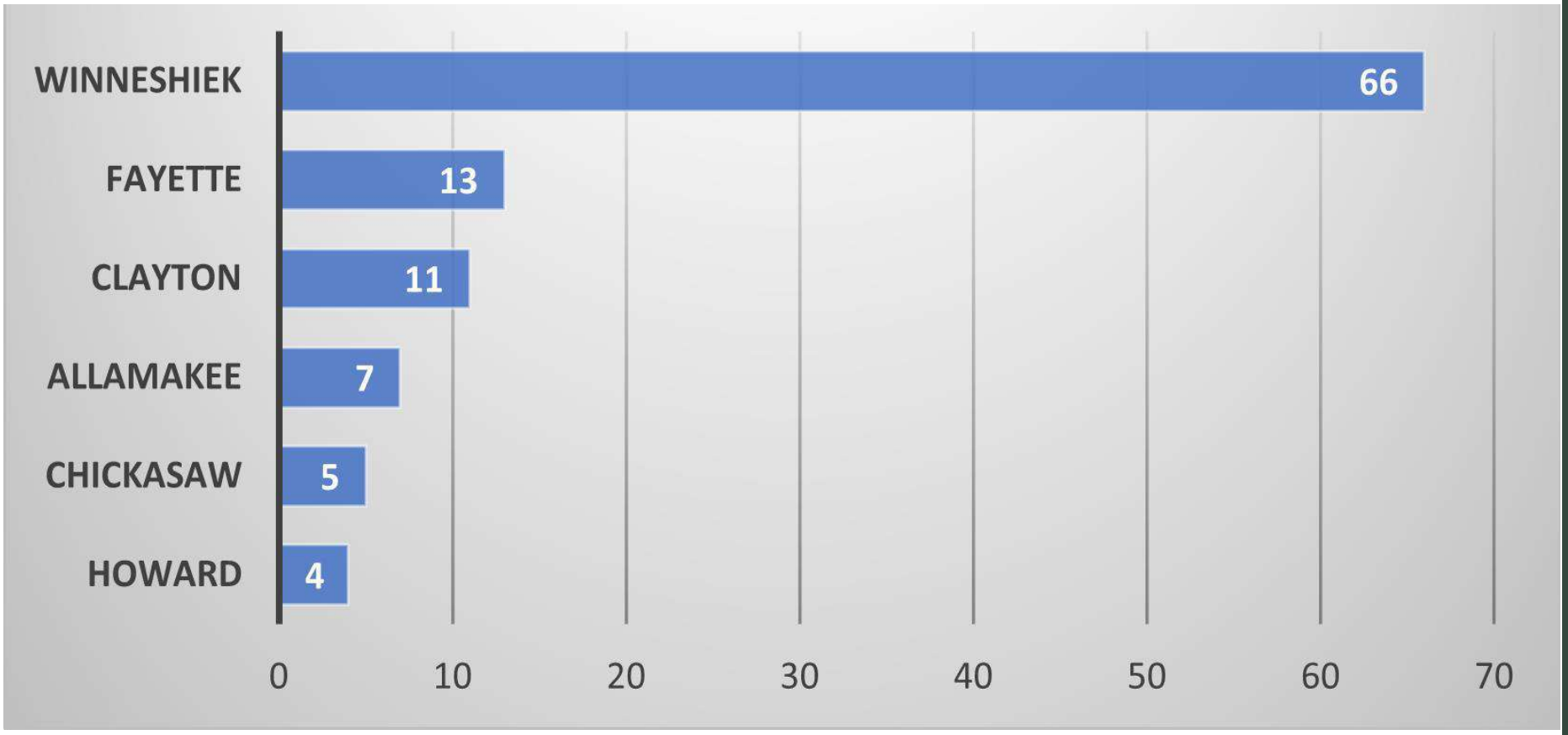
Top EV/PHEV Registrations in IA by County (2019)

Iowa DOT, Motor Vehicle Statistics and Research Studies
https://iowadot.gov/mvd/factsandstats



Top EV/PHEV Registrations in Iowa, Per Capita (2019)

Iowa DOT, Motor Vehicle Statistics and Research Studies
https://iowadot.gov/mvd/factsandstats

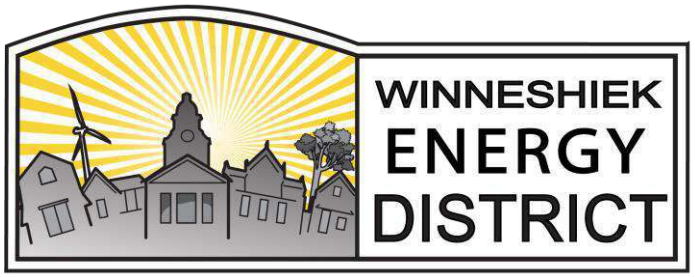


EV/PHEV Registrations 6-County Region

Iowa DOT, Motor Vehicle Statistics and Research Studies

https://iowadot.gov/mvd/factsandstats

Partners:



upper explorerland regional planning commission

NORTHEAST IOWA RC&D

LUTHER COLLEGE

Funders:

ALLAMAKEE CLAYTON ELECTRIC COOPERATIVE

Northeast Iowa Funders Network

IOWA DOT

- **Electric Vehicle (EV) Study – UERPC**
  - EV growth trends, universal benefits, rural considerations
  - Current EV market & infrastructure in NE Iowa
  - EV technology (vehicles & chargers)
  - Models for public EV charging
  - EV incentives
  - EV policy & ordinance

- **EV Economic Review – Steve Holland (Luther College)**
  - Economic costs & benefits for EV adoption
  - Focus on economic impacts of EV adoption for different users and communities

NE IA EV Project Summary

- **EV Tourism Considerations – Josh Dansdill (NE Iowa Resource Conservation & Development)**
  - Analysis of visitation and tourism in the region
  - Strategizing EV charger availability & location with Byway boards, Convention & Visitor Bureaus, etc.
- **Northeast Iowa Community College EV Training**
  - Program & curriculum development for EV training
  - "Train the trainer" opportunities
  - EV curriculum to serve students in credit programs & community members through non-credit training (e.g. independent auto servicers, first responders, fleet managers, code/inspection officials, etc.)

NE IA EV Project Summary

- **Regional EV Workgroup**
  - Engage economic development, energy district, utility, energy, community, auto dealer, and other stakeholders
  - Review information from EV study
  - Plan regional EV charging corridor
  - Create regional EV goals and strategies
  - Coordinate EV outreach and events
  - Identify opportunities for EV technical assistance
- **TA for EV Implementation (Winneshiek Energy District)**
  - Targeted to communities & employers
  - Discuss EV use, charging impacts, & feasibility of chargers
  - Plan implementation options for chargers
  - Education/outreach to employees

NE IA EV Project Summary

Electric Vehicles

What are they, and why are they important?

Types of EVs

- **Plug-in Electric Vehicles (PEVs)** have onboard rechargeable batteries that store energy to power electric motors
- **Battery Electric Vehicles (BEVs)** are powered solely by battery
- **Plug-in Hybrid Vehicles (PHEVs)** can be powered by the battery or internal combustion engine (ICE); battery plugs in to recharge
- **Hybrid Electric Vehicles (HEVs)** powered by ICE & an electric motor that uses energy stored in a battery; battery is charged through regenerative braking & by ICE

Benefits of EV Use

- **EV Environmental Benefits:**
  - Reduced dependence on fossil fuels; take advantage of renewables
  - Reduced tailpipe emissions
- **EV Economic Benefits:**
  - Electricity costs less than gasoline (per gallon equivalent)
  - Less maintenance requirements - fewer moving parts and fluids to change
  - Utility program & tax incentives
- **Other Benefits:**
  - Convenience! Can fuel at home or work!
  - Serving visitors/tourism

Rural Benefits of EV Use

- Save more than urban residents (we travel further, repair vehicles more & spend more on gas)
- More money in the pocket = good for rural economies!
- Have off-street parking for easier charger installation

Rural Concerns for EV Use

- "Range Anxiety" - Significant distance between public charging locations & EV batteries can only go about 200 miles.
- New charging stations are not cheap
- Few auto dealers provide EV models
- Cost of new EVs may still be inhibiting
- Cold weather can cut into a car battery's range

A Closer Look at EV Emissions Benefits…

Transitioning to a light-duty fleet of HEVs and PEVs could **reduce U.S. foreign oil dependence by 30-60% and greenhouse gas emissions by 30-45%**, depending on the exact mix of technologies…

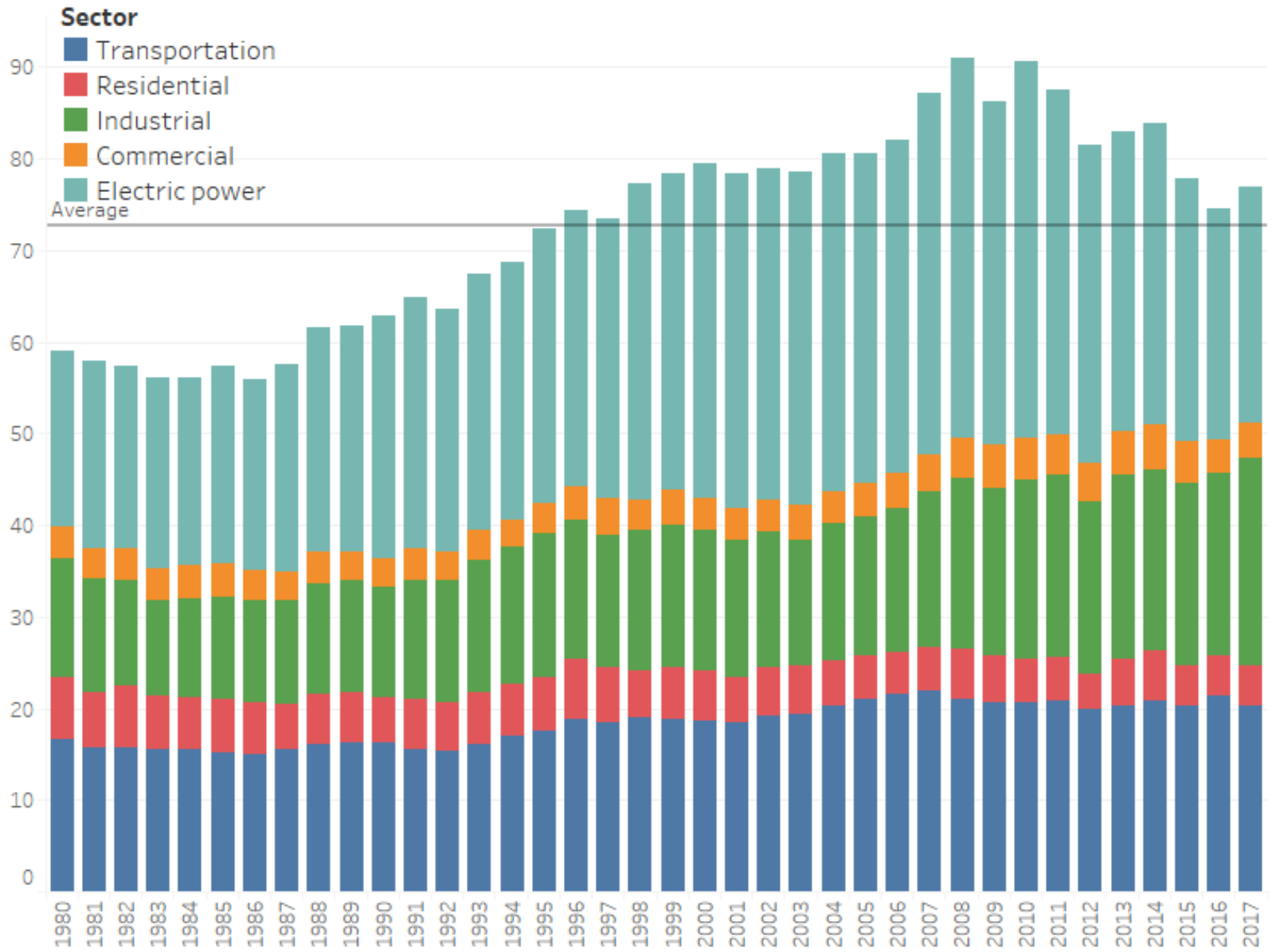
Source: Energy.gov, Office of Energy Efficiency and Renewable Energy, https://www.energy.gov/eere/vehicles/batteries

Types of Vehicle Emissions

- **Direct Emissions**: Tailpipe, evaporation from fueling system, & during fueling process
  - PEVs produce lower tailpipe emissions than conventional vehicles (zero by all-electric)
- **Well-to-Wheel Emissions**: Fuel production, processing, distribution, and use
  - Electricity source is important (as emissions also result from non-renewable energy production)

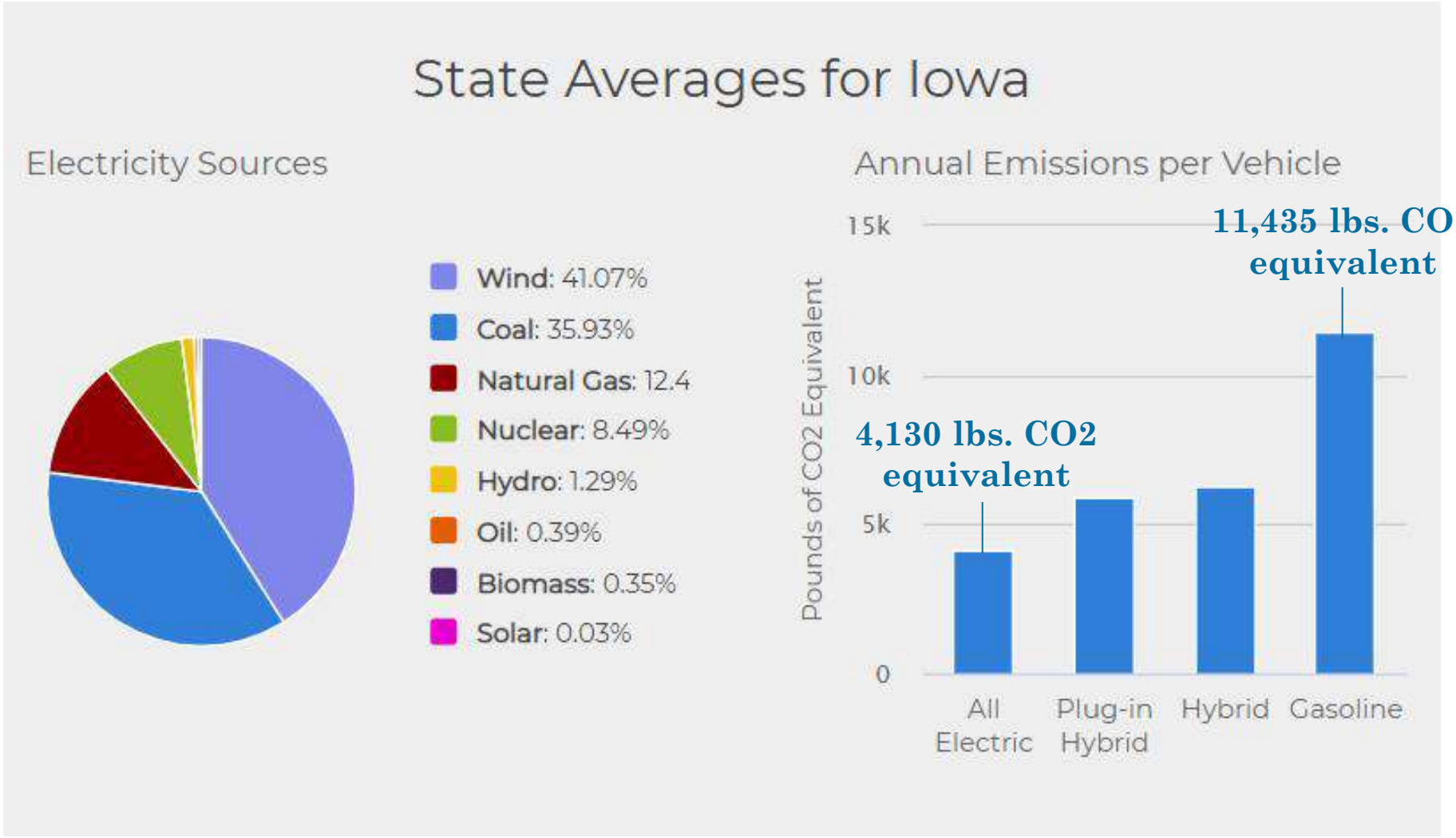
Sources: U.S. Dept. of Energy, Alternative Fuels Data Center, Emissions from Hybrid and Plug-In Electric Vehicles, https://afdc.energy.gov/vehicles/electric_emissions.html

CO2 Emissions by Sector, State of Iowa



Sources: Bureau of Transportation Statistics, State Transportation Statistics, Energy Consumption and Energy Related CO2 Emissions, https://www.bts.gov/energy-consumption-and-energy-related-co2-emissions

Electricity Sources & Emissions



Sources: U.S. Dept. of Energy, Alternative Fuels Data Center, Emissions from Hybrid and Plug-In Electric Vehicles, https://afdc.energy.gov/vehicles/electric_emissions.html

A Closer Look at EV Financial Benefits…

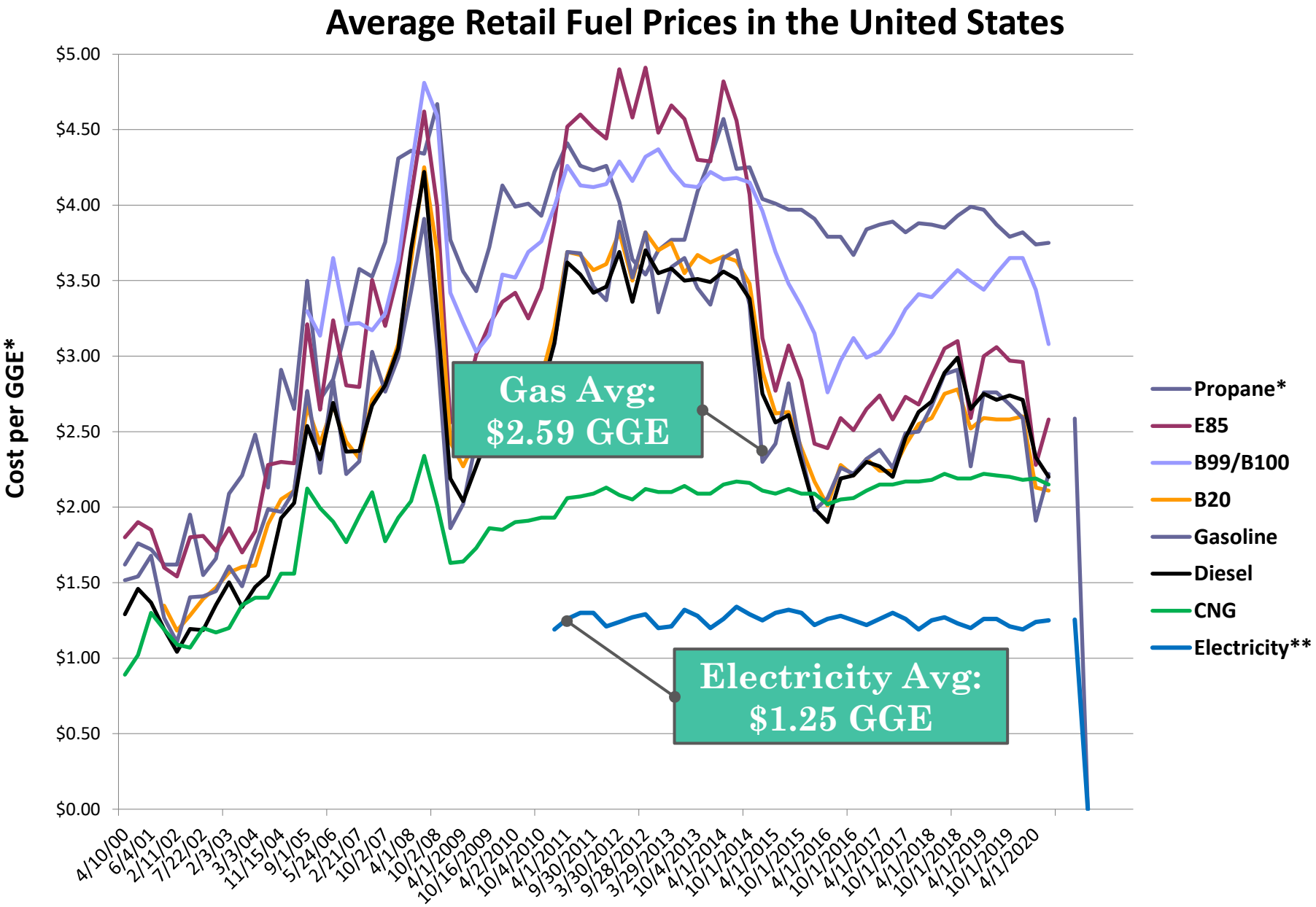
EVs are Efficient!

Electric drivetrains are mechanically more efficient than internal combustion engines…

EVs convert about **59%–62%** of the electric energy from the grid to power at the wheels, while conventional gasoline vehicles only convert about **17%–21%** of the energy stored in gasoline to power at the wheels.

Sources: U.S. Dept. of Energy, Alternative Fuels Data Center, Publications, "Electric-Drive Vehicles," https://afdc.energy.gov/files/u/publication/electric_vehicles.pdf

And Electricity is Cheaper!



*GGE = Gasoline Gallon Equivalent

** Electricity prices are reduced by a factor of 3.6 because electric motors are 3.6 times more efficient than internal combustion engines, and converted to GGEs at a rate of 33.7 kWh per GGE.

afdc.energy.gov/data

What Does This Mean for Fuel Costs?

EV Fuel Costs:

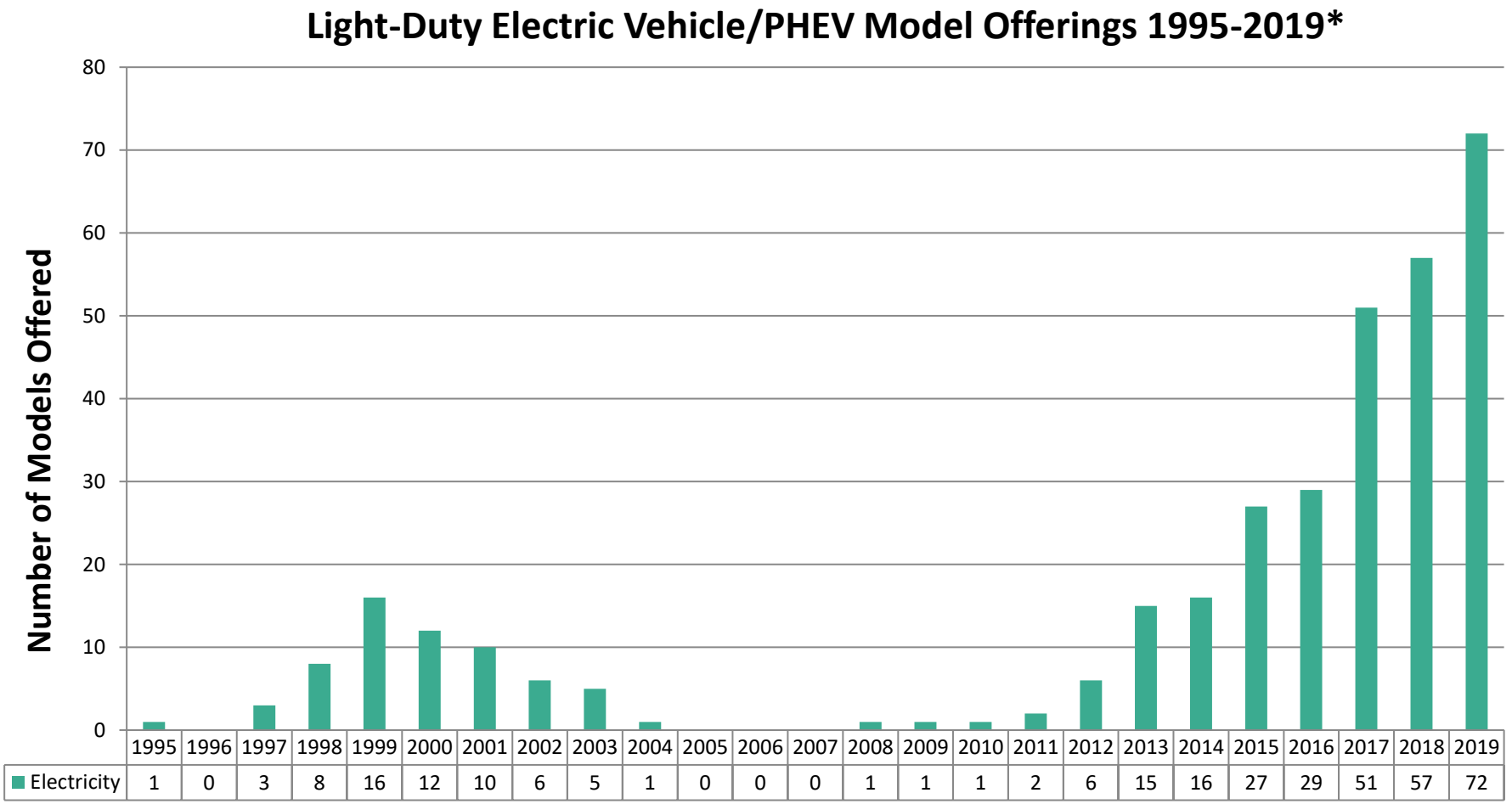
- Average cost per kWh of electricity in Iowa as of Oct. 2020 was **12.51 cents**
- A Nissan Leaf needs 30 kWh to go 100 miles. Based on 12.51 cents/kWh it costs **$3.75 to go 100 miles!**
- A year of driving (@15,000 miles) would be **$562.5/year** (15,000/100 miles x $3.75)

ICE Fuel Costs:

- It costs an average of $10.08 to go 100 miles on gasoline
- A year of driving (@15,000 miles) would be **$1,512/year (3x more than electricity)**

Electric Vehicle Market

US Department of Energy data illustrates growth of EVs by model year:



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Electricity	1	0	3	8	16	12	10	6	5	1	0	0	0	1	1	1	2	6	15	16	27	29	51	57	72

*Years refer to vehicle model years

Source: Dept. of Energy Alternative Fuels Data Center, "Light-Duty AFV/HEV/Diesel Model Offerings, by Technology/Fuel Type, 1991-2019," https://afdc.energy.gov/data/

What's Available Then?

127 models are expected by 2023, **almost tripling what is available within 3 years:**

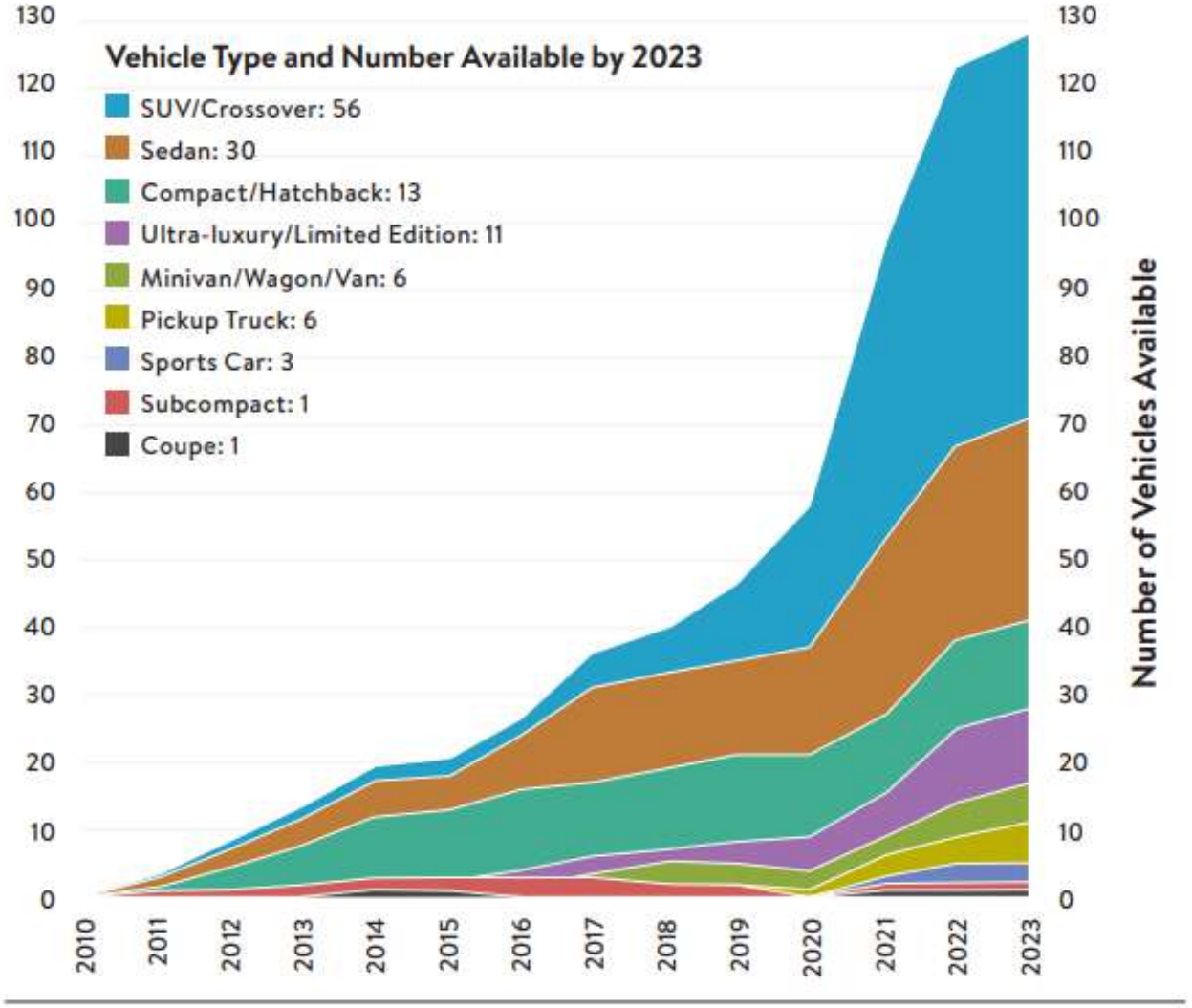
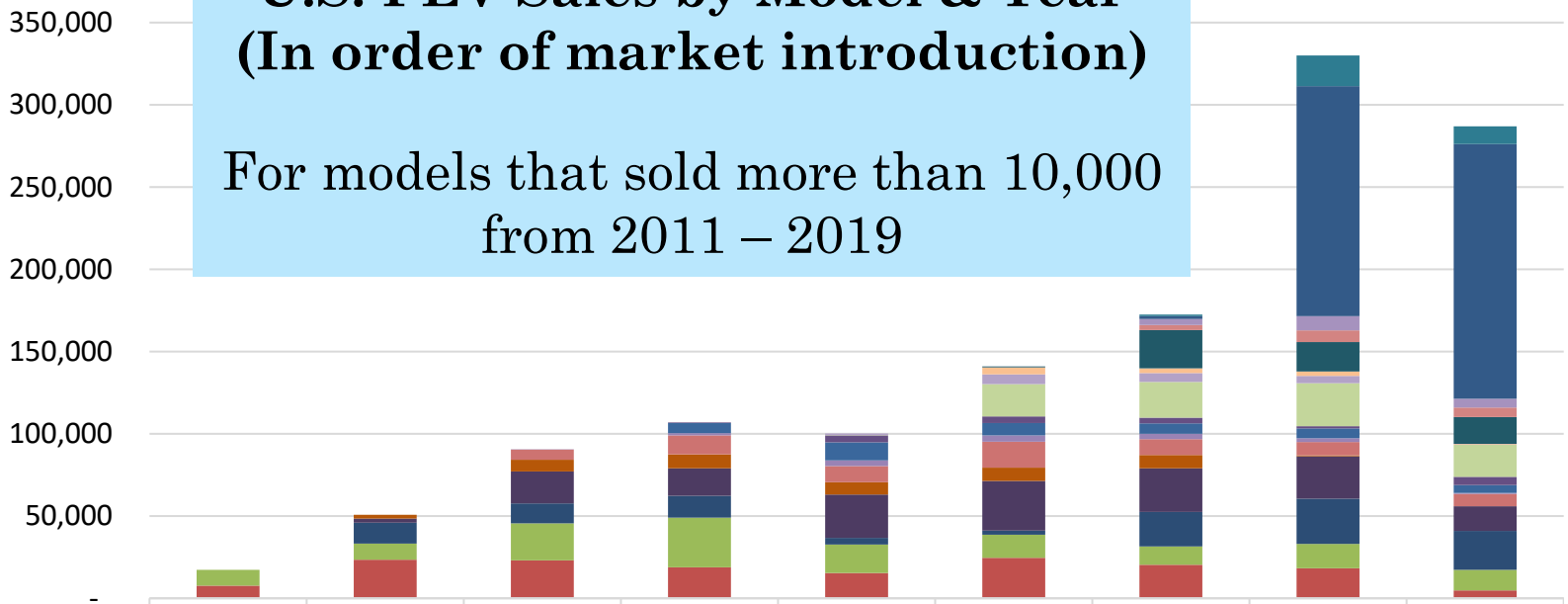


Figure 1. *The number and variety of EV models continues to grow. By the end of 2020, about 63 different models are expected to be available in the U.S. By 2023, approximately 127 models are projected.*

Source: Consumer Guide to Electric Vehicles, Electric Power Research Group, April 2020, https://mienergy.coopwebbuilder3.com/sites/mienergy/files/pdf/EPRI%20Guide.pdf

U.S. PEV Sales by Model & Year (In order of market introduction)

For models that sold more than 10,000 from 2011 – 2019



	2011	2012	2013	2014	2015	2016	2017	2018	2019
Honda Clarity Plug-in	-	-	-	-	-	-	903	18,602	10,728
Tesla Model 3	-	-	-	-	-	-	1,770	139,782	154,840
BMW 5-Series Plug in	-	-	-	-	-	-	3,759	8,664	5,442
Chrysler Pacifica Plug-in Hybrid	-	-	-	-	-	-	2,981	7,062	5,811
Chevy Bolt	-	-	-	-	-	579	23,297	18,019	16,313
Audi A3 Plug In	-	-	-	-	-	4,280	2,877	2,597	437
BMW X5	-	-	-	-	892	5,995	5,349	4,434	167
Tesla Model X	-	-	-	-	208	19,600	21,700	26,100	19,425
VW e-Golf	-	-	-	357	4,232	3,937	3,534	1,354	4,863
BMW i3	-	-	-	6,092	11,024	7,625	6,276	6,117	4,854
Fiat 500E	-	-	260	1,503	3,477	3,737	3,336	2,250	632
Ford Fusion Energi	-	-	6,089	11,550	9,750	15,938	9,632	8,074	7,476
Ford C-Max Energi	-	2,374	7,154	8,433	7,591	7,957	8,140	582	-
Tesla Model S	-	2,400	19,400	16,750	26,200	30,200	26,500	25,745	15,090
Prius PHEV	-	12,749	12,088	13,264	4,191	2,474	20,936	27,595	23,630
Nissan Leaf	9,674	9,819	22,610	30,200	17,269	14,006	11,230	14,715	12,365
Chevy Volt	7,671	23,461	23,094	18,805	15,393	24,739	20,349	18,306	4,915

Source: Dept. of Energy, Alternative Fuels Data Center, "U.S. Plug-in Electric Vehicle Sales by Model," https://afdc.energy.gov/data/

EVs - Beyond Just Passenger Vehicles

- US Dept of Energy identifies **532 electric vehicles**:
  - 249 Hybrid electric
  - 173 Electric
  - 110 Plug-in hybrid electric

- **Including:**

  Sedan/wagons, SUVs, pick-ups, vans, cabs, street sweepers, refuse vehicles, tractors, passenger vans, shuttle buses, transit buses, school buses

- Highest number of EVs is sedans, transit buses, & SUVs

- Highest number of PHEVs is sedans, SUVs, pickups

What Vehicles Do Rural Drivers Want?

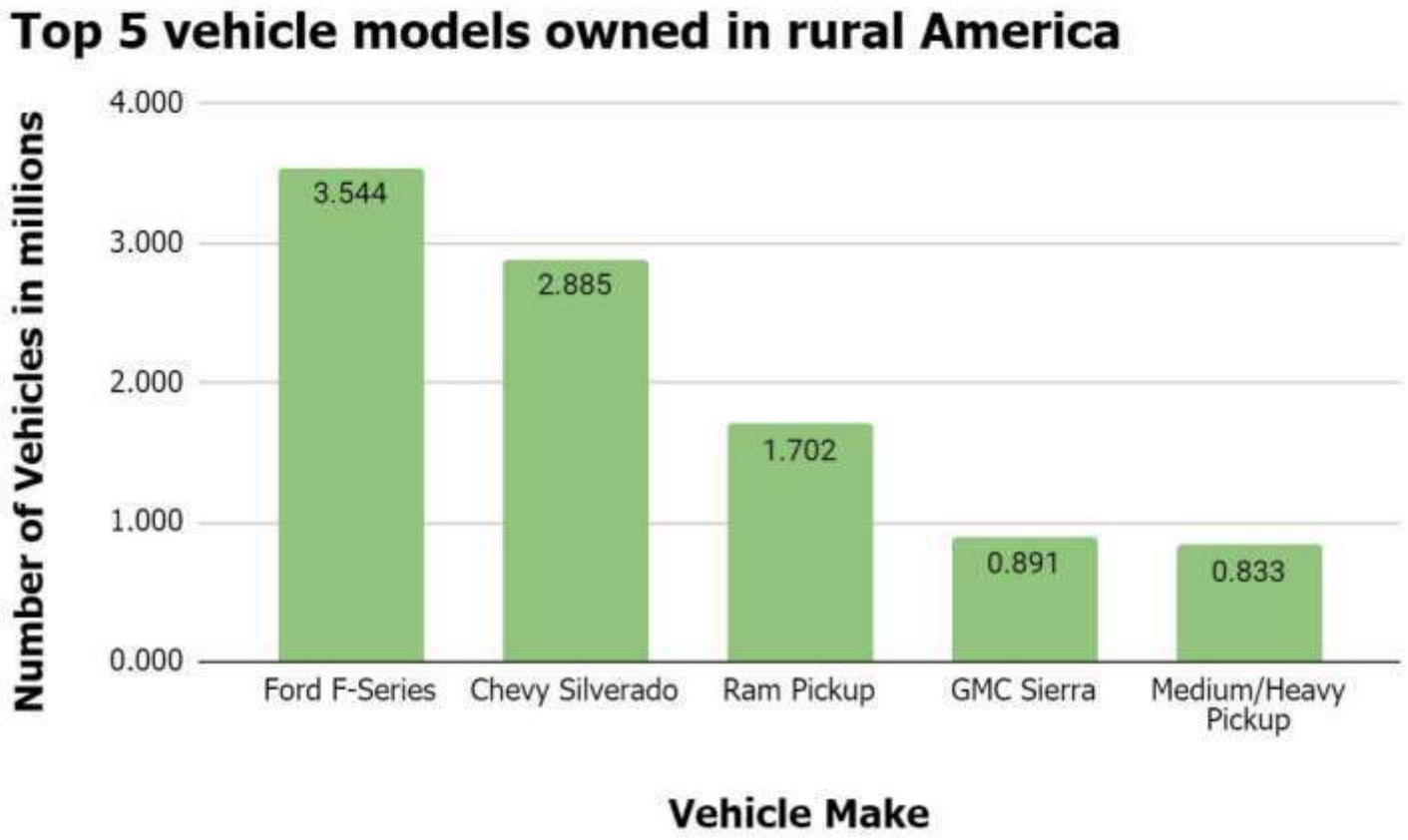


Figure 4. Top 5 vehicle models owned in rural America. It can be seen from the bar chart above that the preferred vehicles of choice consist of medium/ heavy duty pickup trucks. Source: NHTS, 2017

Source: "Preparing Rural America for the Electric Vehicle Revolution," by Bilegt Baatar, Kassidy Heckmann, Tiffany Hoang, Ruby Jarvis, and Priya Sakhiya University of California, Davis Environmental Policy & Management Program, https://epm.ucdavis.edu/blog/epm-students-policy-clinic-presentations

Electric Vehicle Technology

The Range Issue

EVs generally have a shorter range per charge than comparable conventional vehicles have per tank of gas

Through 2021, the average range for Battery Electric Vehicles (BEV) will be **252 miles**

Conventional cars in the U.S. tend to have a top range between **300 - 400 miles**

And don't forget range anxiety…where will we charge our EV?

Source: Dept. of Energy, Alternative Fuels Data Center, Alternative Fuel and Advanced Vehicle Search, "All-Vehicles" Excel Spreadsheet, https://afdc.energy.gov/vehicles/search/; SolarChargedDriving.com, https://solarchargeddriving.com/2011/05/13/whats-your-gasoline-cars-range/

The Battery Issue

- **Batteries are the energy storage systems for EVs**
- Most use **lithium-ion batteries**
- **Low battery storage capacity, and high battery costs, have contributed to fear of EV use & higher costs!**

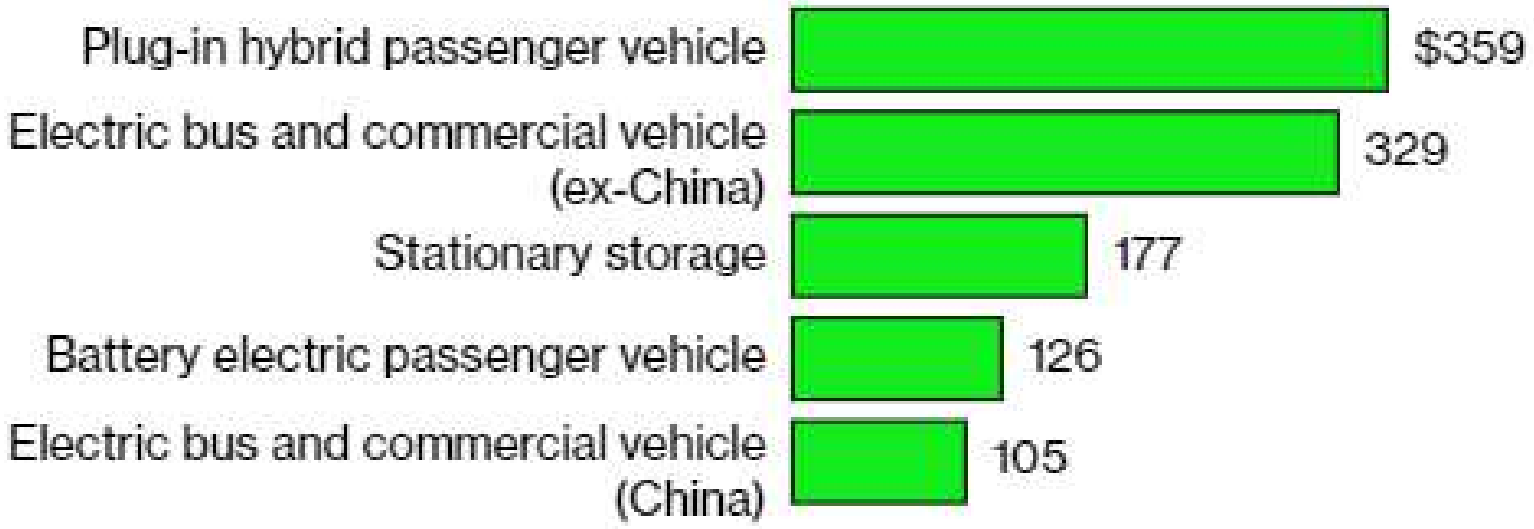
EV Range is Rising!
EV Costs are Falling!

- **Battery storage volumes are increasing, resulting in greater ranges!**
- Average range of BEVs will increase from **235 miles in 2020 to 279 miles by 2023**
- **Battery prices (per kWh) are going down,** increasing battery demand & EV affordability!
- **$100 per kWh is the lithium-ion storage battery's magic number.** At that point, the upfront cost for a passenger EV will be the same as—or less than—an ICE!

Source: Electric Power Research Group, Guide to Electric Vehicles, https://mienergy.coopwebbuilder3.com/sites/mienergy/files/pdf/EPRI%20Guide.pdf

Volume-weighted battery pack price by sector, real 2020 dollars per kilowatt-hour

Keeping in mind, battery prices vary depending on sector…

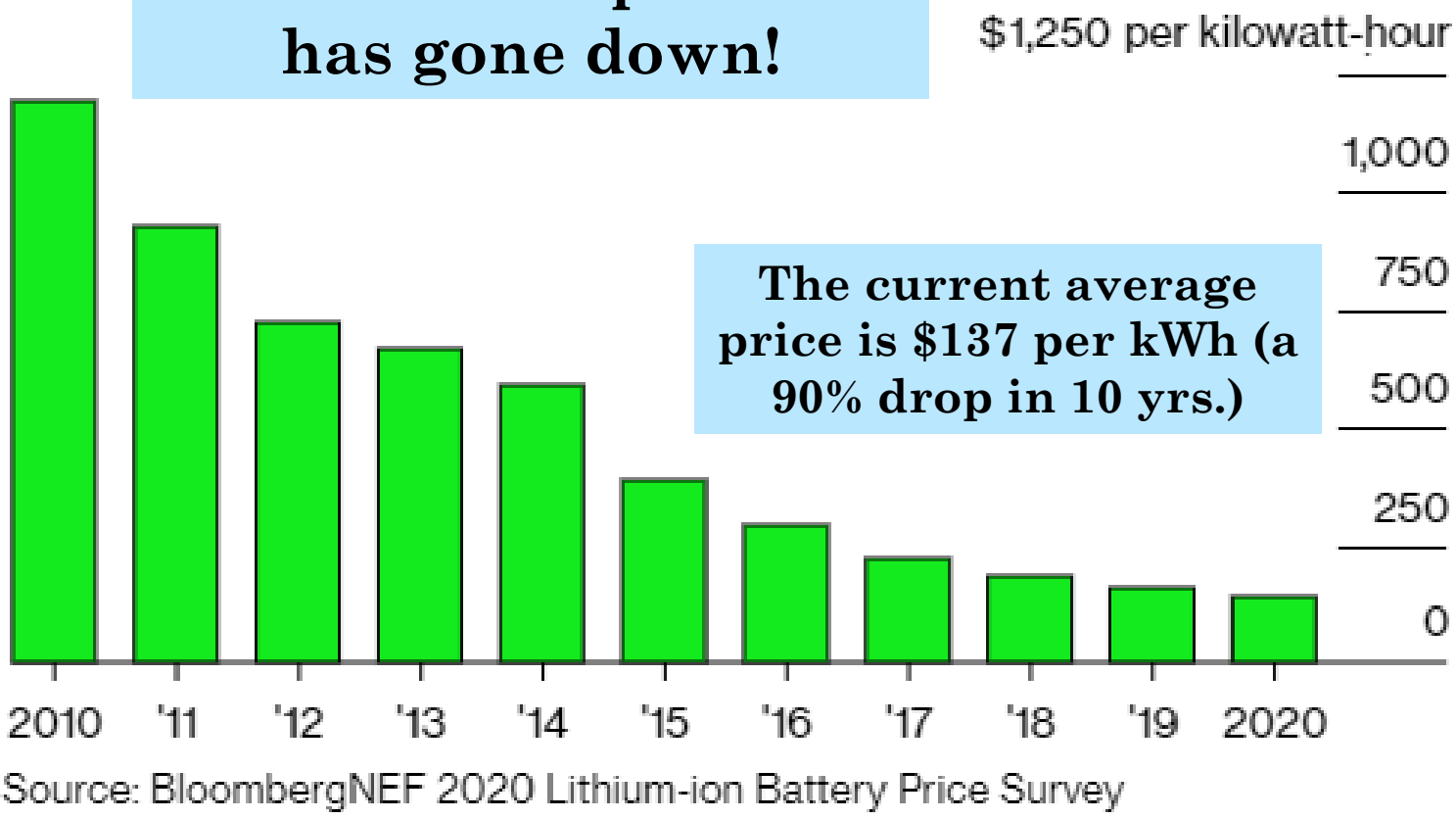


Source: BloombergNEF 2020 Lithium-ion Battery Price Survey

Source: Bloomberg Green, Sparklines, "This Is the Dawning of the Age of the Battery," by Nathaniel Bullard, December 17, 2020, https://www.bloomberg.com/news/articles/2020-12-17/this-is-the-dawning-of-the-age-of-the-battery?fbclid=IwAR2GDLQMAnQGj9crVhmnnJzcu-plVQIwyhDVPp9sHn1Vp7P3id8Lessih20

Lithium-ion battery price, volume-weighted average, all sectors (real 2020 dollars)

The price of lithium-ion batteries per kWh has gone down!



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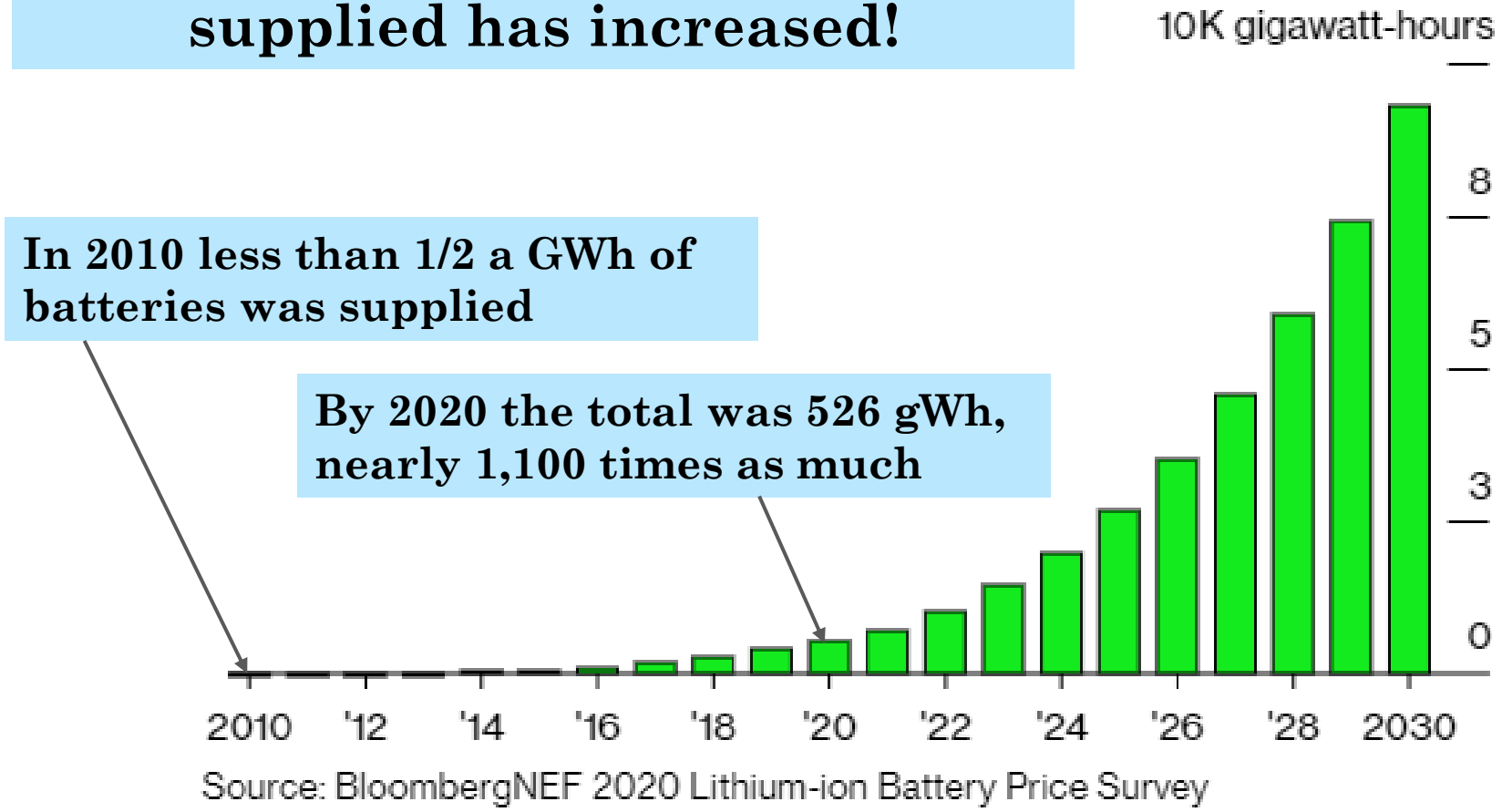
Cumulative lithium-ion battery demand for EV and energy storage applications:

Battery storage volume & gWh supplied has increased!



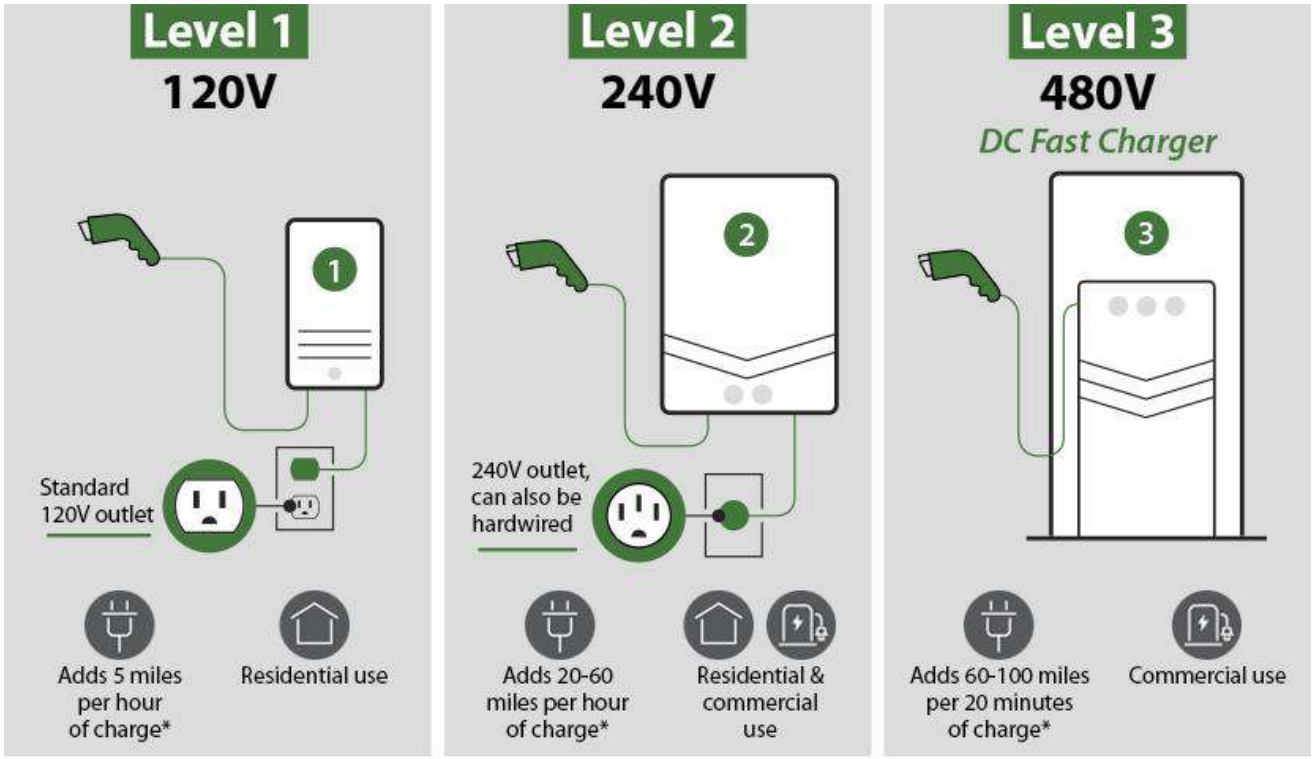
Source: Bloomberg Green, Sparklines, "This Is the Dawning of the Age of the Battery," by Nathaniel Bullard, December 17, 2020, https://www.bloomberg.com/news/articles/2020-12-17/this-is-the-dawning-of-the-age-of-the-battery?fbclid=IwAR2GDLQMAnQGj9crVhmnnJzcu-plVQIwyhDVPp9sHn1Vp7P3id8Lessih20

Electric Vehicle Charging Infrastructure

Technology, Design and Use

As more drivers purchase Plug-in Electric Vehicles (PEVs) there is a growing need for a network of Electric Vehicle Supply Equipment (EVSE) to provide power to those vehicles

Access to charging infrastructure factors into who can purchase an EV & where owners will travel



** Estimated. Actual charge times may vary.*

Charging Levels

Charging Considerations

- **What is the purpose of charging?**
  - **Main Harbor**: Charging at or near a home or workplace.
  - **Destination**: Charging when parked somewhere while an activity takes place. E.g. restaurants, shopping, etc.
  - **Range Extension**: Similar to fuel stations -- vehicles need to be rapidly recharged during a journey.
- **Will charging be public or private?**
  - **Public:** Located in publicly accessible areas or along highway corridors
  - **Private**: Available to certain drivers for specific purposes

Source: https://www.avnet.com/wps/portal/abacus/solutions/markets/automotive-and-transportation/automotive/power-train-and-ev-hc-phev-systems/ev-on-board-chargers/

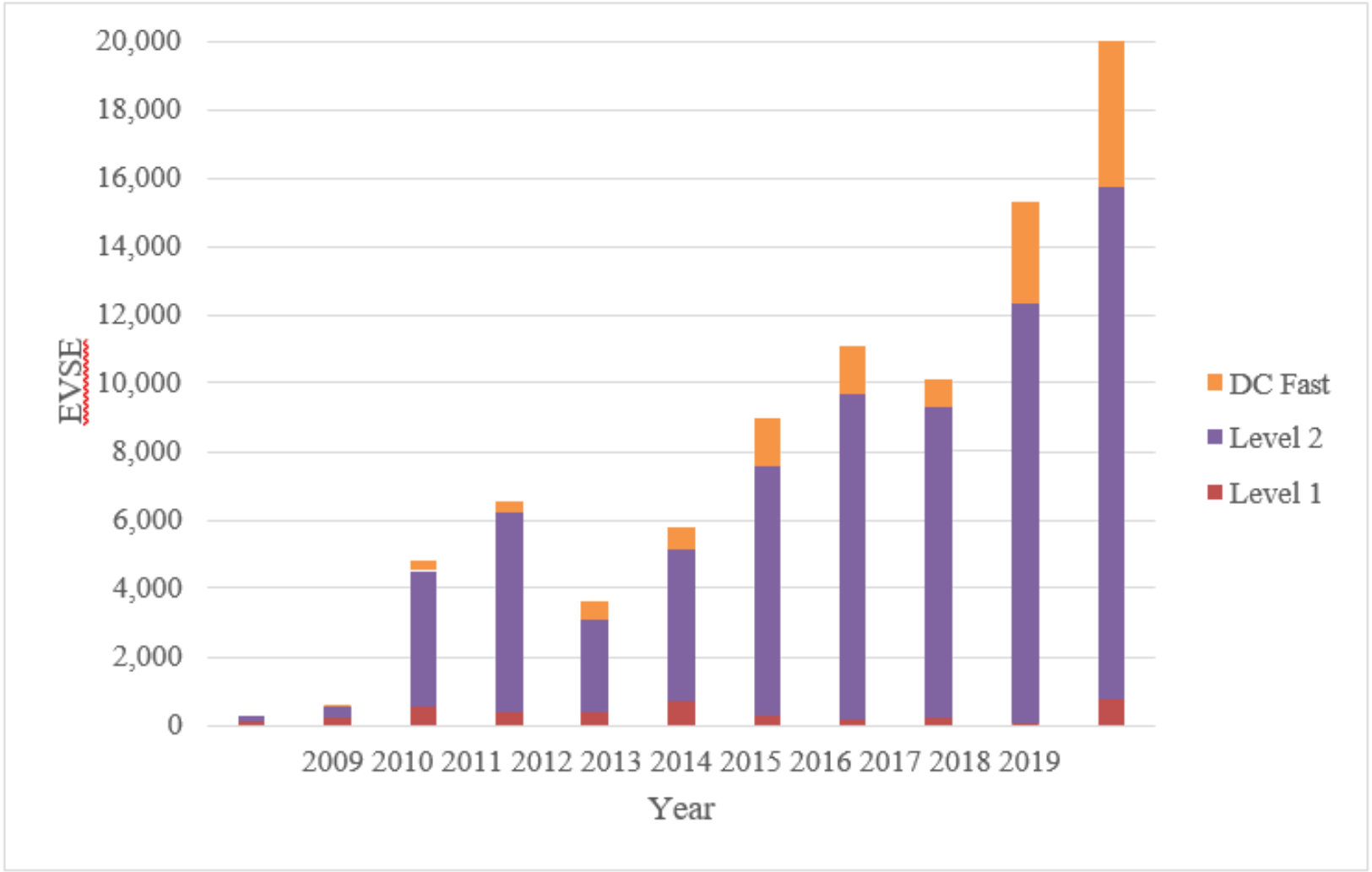
Charging Levels 1 & 2

- Provides alternating current (AC) to EV & onboard charger converts to direct current (DC) to charge batteries
- All EVs can charge at Level 1 & 2
- **Level 1:**
  - Level 1 cordset can be plugged into a 120-volt household outlet
  - Residential & workplace charging
  - Adds 2-5 miles of range per hour of charging
- **Level 2:**
  - 240-volt charging outlet needed (can be installed at home)
  - Residential, workplace, & public charging
  - Adds 10-20 miles of range per hour of charging

DC Fast Charging

- Charger is located off-board the vehicle
- Provides DC electricity directly to PEV's battery
- Has highest power output, so provides most charge in the least amount of time
- Most PEVs are equipped to accept DC Fast charging
- Cannot be installed at home
- Common for public charging, and increasingly used for fleets

EV Station Introduction by Charging Level



Source: Brown, Abby, Stephen Lommele, Alexis Schayowitz, and Emily Klotz. 2020. Electric Vehicle Charging Infrastructure Trends from the Alternative Fueling Station Locator: First Quarter 2020. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5400- 77508. www.nrel.gov/docs/fy20osti/77508.pdf

Overview of Charging Infrastructure & Charging Level Needs

Sources: U.S. DOE, Energy Efficiency & Renewable Energy, "Costs Associated With Non-Residential Electric Vehicle Supply Equipment," November 2015, https://afdc.energy.gov/files/u/publication/evse_cost_report_2015.pdf#:~:text=The%20cost%20of%20a%20single,51%2C000%20for%20DC%20fast%20charging.

Public Charging Infrastructure in US Today

- **In the U.S., as of March 2021, there were 100,282 charging outlets:**
  - Level 1: 1,383
  - **Level 2: 81,658**
  - DC Fast: 17,191
- And 41,164 fueling stations

**These numbers do not include residential electric charging infrastructure*

Sources: DOE Alternative Fuels Data Center, Publications, https://afdc.energy.gov/files/u/publication/electric_vehicles.pdf

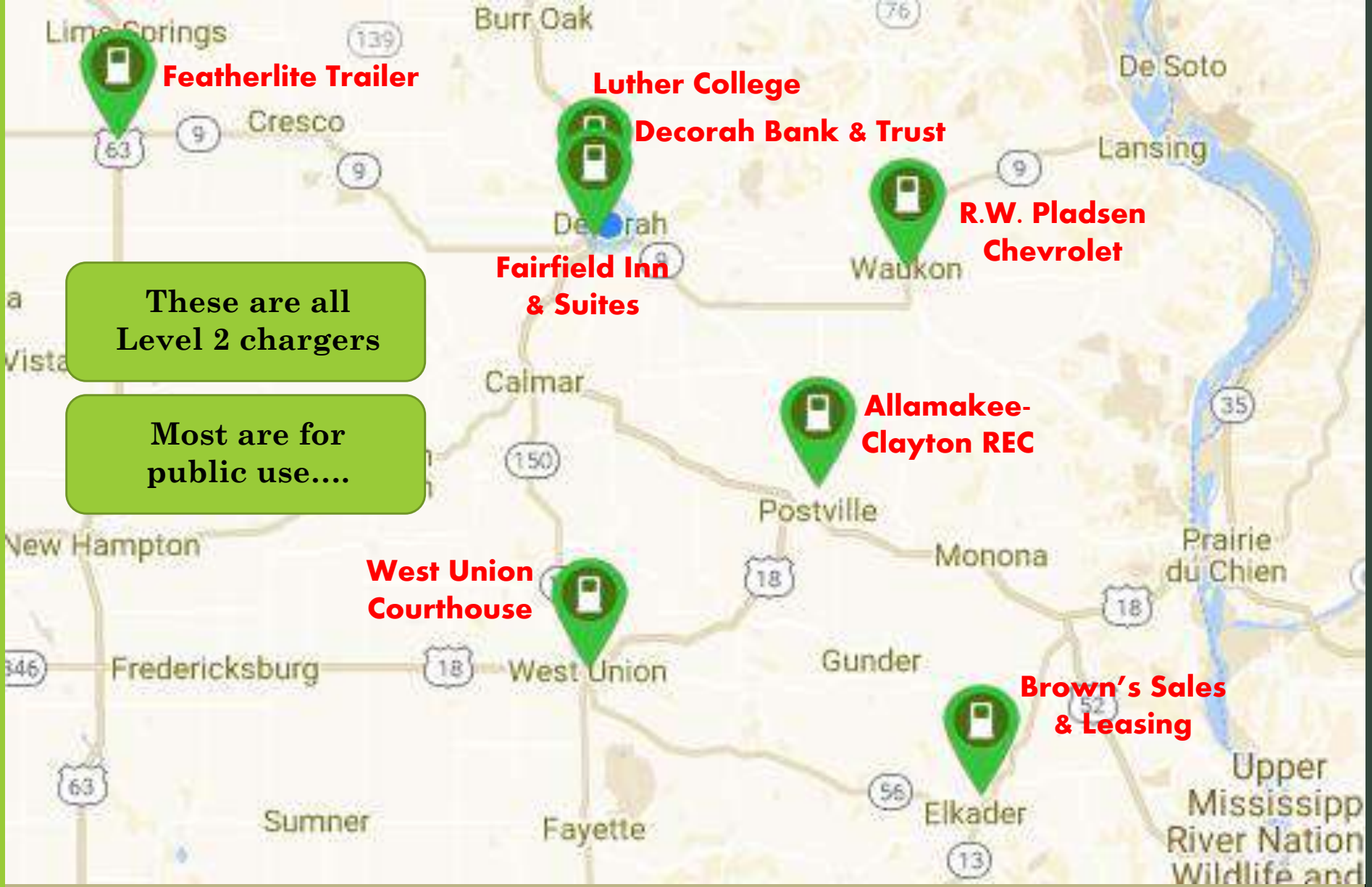
Public Charging Infrastructure in Iowa Today

- **In Iowa, as of March 2021, there were 460 charging outlets:**
  - Level 1: 27
  - **Level 2: 313**
  - DC Fast: 120

** These numbers do not include residential electric charging infrastructure*

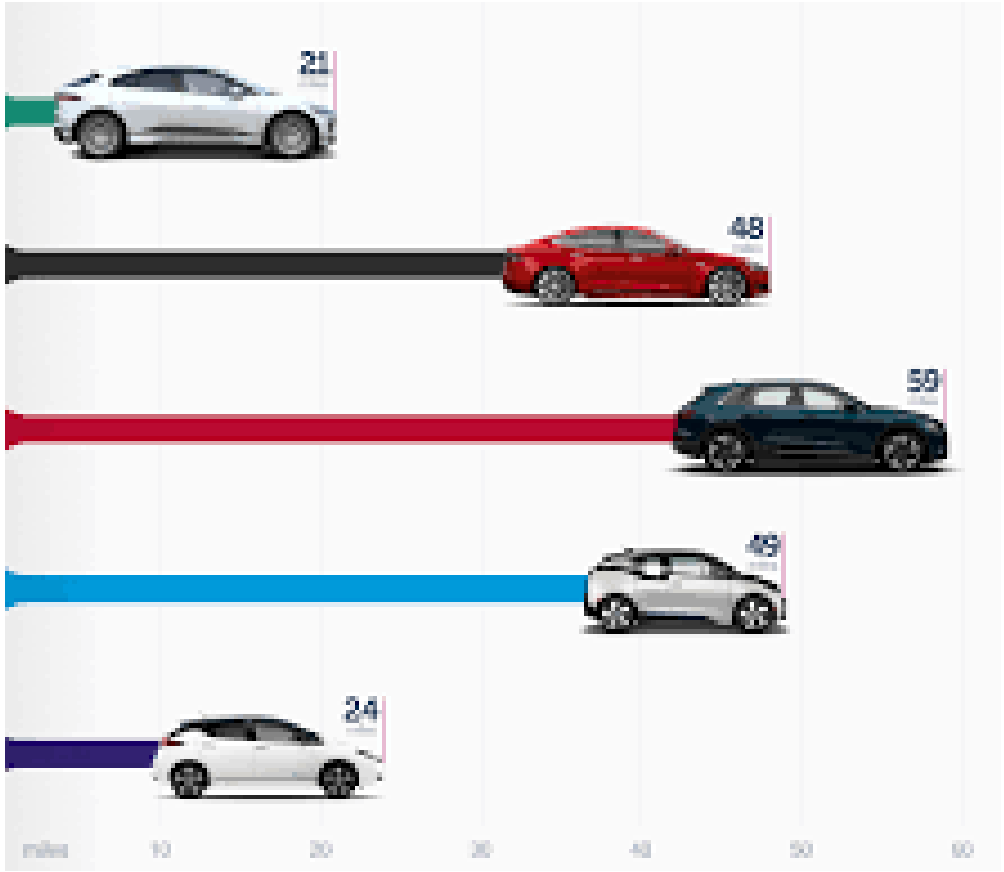
- And 222 stations
- **Iowa is 34th in the U.S.** for number of stations

Sources: DOE Alternative Fuels Data Center, Publications, https://afdc.energy.gov/files/u/publication/electric_vehicles.pdf



Public EV Charging Available in NE Iowa

Source: https://www.plugshare.com/location/206193



Power, Range & Charging Time

Power, Range & Charging Time

The vehicle's charging time depends on the state of charge of the battery, the power coming from the charger, and the rate a vehicle can accept power

Charging Level	Vehicle Range Added per Charging Time and Power	Supply Power
AC Level 1	4 mi/hour @ 1.4kW 6 mi/hour @ 1.9kW	120VAC/20A *(12-16A continuous)*
AC Level 2	10 mi/hour @ 3.4kW 20 mi/hour @ 6.6kW 60 mi/hour @ 19.2 kW	208/240VAC/20-100A *(16-80A continuous)*
DC Fast Charging	24 mi/20minutes @24kW 50 mi/20minutes @50kW 90 mi/20minutes @90kW	208/480VAC 3-phase *(input current proportional to output power; ~20-400A AC)*

Extreme fast charging with power output of 350 kW+ (2018)

Sources: U.S. DOE, Energy Efficiency & Renewable Energy, "Costs Associated With Non-Residential Electric Vehicle Supply Equipment," November 2015, https://afdc.energy.gov/files/u/publication/evse_cost_report_2015.pdf#:~:text=The%20cost%20of%20a%20single,51%2C000%20for%20DC%20fast%20charging.

Charger Design & Features

Charger Design Basics

- Level 1, 2, or DC Fast
- Single port or multiple ports
- Wall mounted or pedestal mounted
- Networked or non-networked

Sources: U.S. DOE, Energy Efficiency & Renewable Energy, "Costs Associated With Non-Residential Electric Vehicle Supply Equipment," November 2015, https://afdc.energy.gov/files/u/publication/evse_cost_report_2015.pdf#:~:text=The%20cost%20of%20a%20single,51%2C000%20for%20DC%20fast%20charging.

Networked or Non-Networked EV Charging Stations?

- **Non-Networked Stations**:
  - Not connected to the internet
  - Provide basic charging capabilities
  - Generally free or offered as amenity for those accessing a business
- **Networked Stations:**
  - Connected to internet via a cable or wireless
  - Lets station owners or site hosts manage who can access stations & control how much it costs drivers to charge
  - Networks provide websites & apps for drivers, payment plans & tech, collect & store usage data, etc.

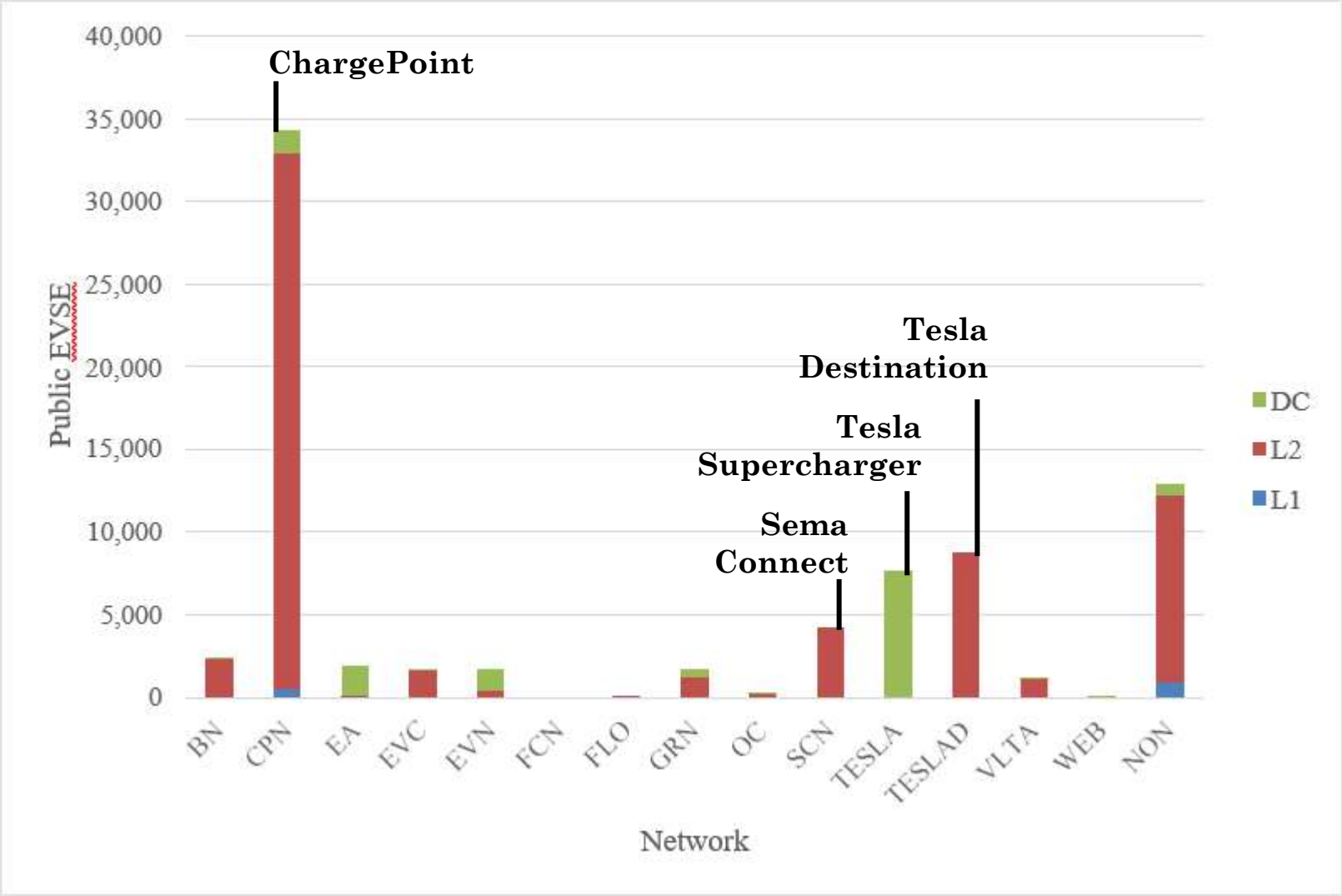
Source: Brown, Abby, Stephen Lommele, Alexis Schayowitz, and Emily Klotz. 2020. Electric Vehicle Charging Infrastructure Trends from the Alternative Fueling Station Locator: First Quarter 2020. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5400-77508. www.nrel.gov/docs/fy20osti/77508.pdf

Charing Networks In U.S.

- Blink (BN)
- ChargePoint (CPN)
- Electrify America (EA) – Mostly DC Fast
- EV Connect (EVC)
- EVgo (EVN) – Mostly DC Fast
- FLO (FLO)
- Francis (FCN)
- Greenlots (GRN)
- OpConnect (OC)
- SemaConnect (SCN)
- Tesla Supercharger (TESLA) – Mostly DC Fast
- Tesla Destination (TESLAD)
- Volta (VLTA)
- Webasto (WEB)

Source: Brown, Abby, Stephen Lommele, Alexis Schayowitz, and Emily Klotz. 2020. Electric Vehicle Charging Infrastructure Trends from the Alternative Fueling Station Locator: First Quarter 2020. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5400- 77508. www.nrel.gov/docs/fy20osti/77508.pdf

EV Stations by Charging Network



Source: Brown, Abby, Stephen Lommele, Alexis Schayowitz, and Emily Klotz. 2020. Electric Vehicle Charging Infrastructure Trends from the Alternative Fueling Station Locator: First Quarter 2020. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5400- 77508. www.nrel.gov/docs/fy20osti/77508.pdf

Networked Charging Features

- **Communications capabilities:** Between user, site host, utility grid & Internet; mobile apps; remotely control charging parameters
- **Access control**: Restrict users
- **Point of sale (POS):** Allows units to recover costs/fees (credit card reader, RFID reader, mobile phone app)
- **Energy monitoring**: Track energy consumption & report on emissions reductions

Sources: U.S. DOE, Energy Efficiency & Renewable Energy, "Costs Associated With Non-Residential Electric Vehicle Supply Equipment," November 2015, https://afdc.energy.gov/files/u/publication/evse_cost_report_2015.pdf#:~:text=The%20cost%20of%20a%20single,51%2C000%20for%20DC%20fast%20charging.

Charging Features

- **Energy management & demand response**: Optimizes load management to maximize charging during low-rate periods
- **Advanced display screen:** Provides user communication, advertising, & brand promotion
- **Automated diagnostics**: Troubleshoots issues or malfunctions that occur

Sources: U.S. DOE, Energy Efficiency & Renewable Energy, "Costs Associated With Non-Residential Electric Vehicle Supply Equipment," November 2015, https://afdc.energy.gov/files/u/publication/evse_cost_report_2015.pdf#:~:text=The%20cost%20of%20a%20single,51%2C000%20for%20DC%20fast%20charging.

Charging Station Gap Analysis

- As of 2019 registration data, there are approximately 100 local EV/PHEV registrations in the 6-county area
- There are 6, Level 2 J-1772 (highly compatible) public charging plugs in the 6-county region
- Industry reports have estimated that for every 100 EVs on the road, there should be 20–40 public charging ports
- **Based on this, NE Iowa is <u>at a minimum 14 charging outlets short</u>, and at the high end, 34 outlets short**
- **<u>This is just to serve current local EV/PHEV registrations (doesn't account for tourism)</u>**

Source: Advancing Iowa's Electric Vehicle Market Report, 2016