

Why all the excitement about Electric Vehicles?



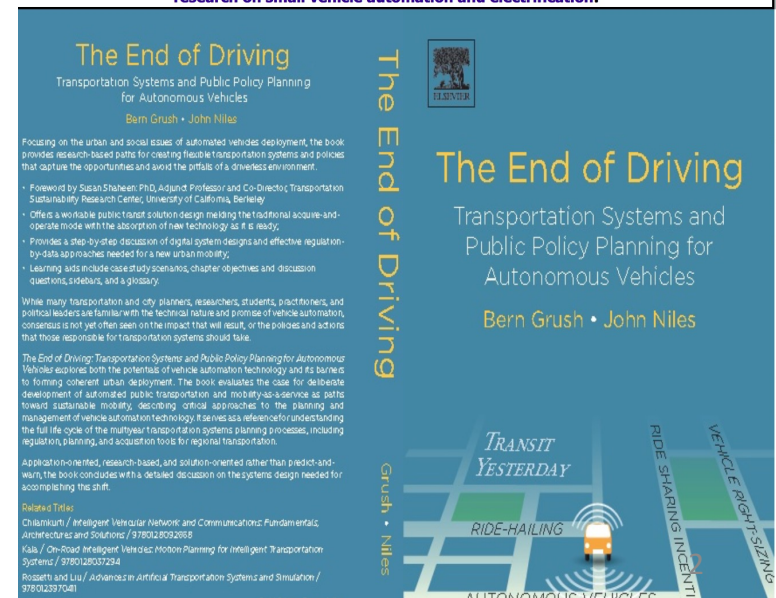
Presenter info

- Tony Billera
 - 35 years in telecom, wireless, and IT product development and program mgt.
 - Senior Fellow at the Center for Advanced Transportation and Energy Solutions (www.aboutCATES.org)
 - Autonomous
 - Connected
 - Electric
 - Shared Vehicles
 - 3 years Student Transportation
 - Owner of 2 EVs:
 - KIA Niro (250-300 mile range)
 - FIAT 500e (75-90 mile range)
 - BMW C Evolution motorcycle (sold)

CATES

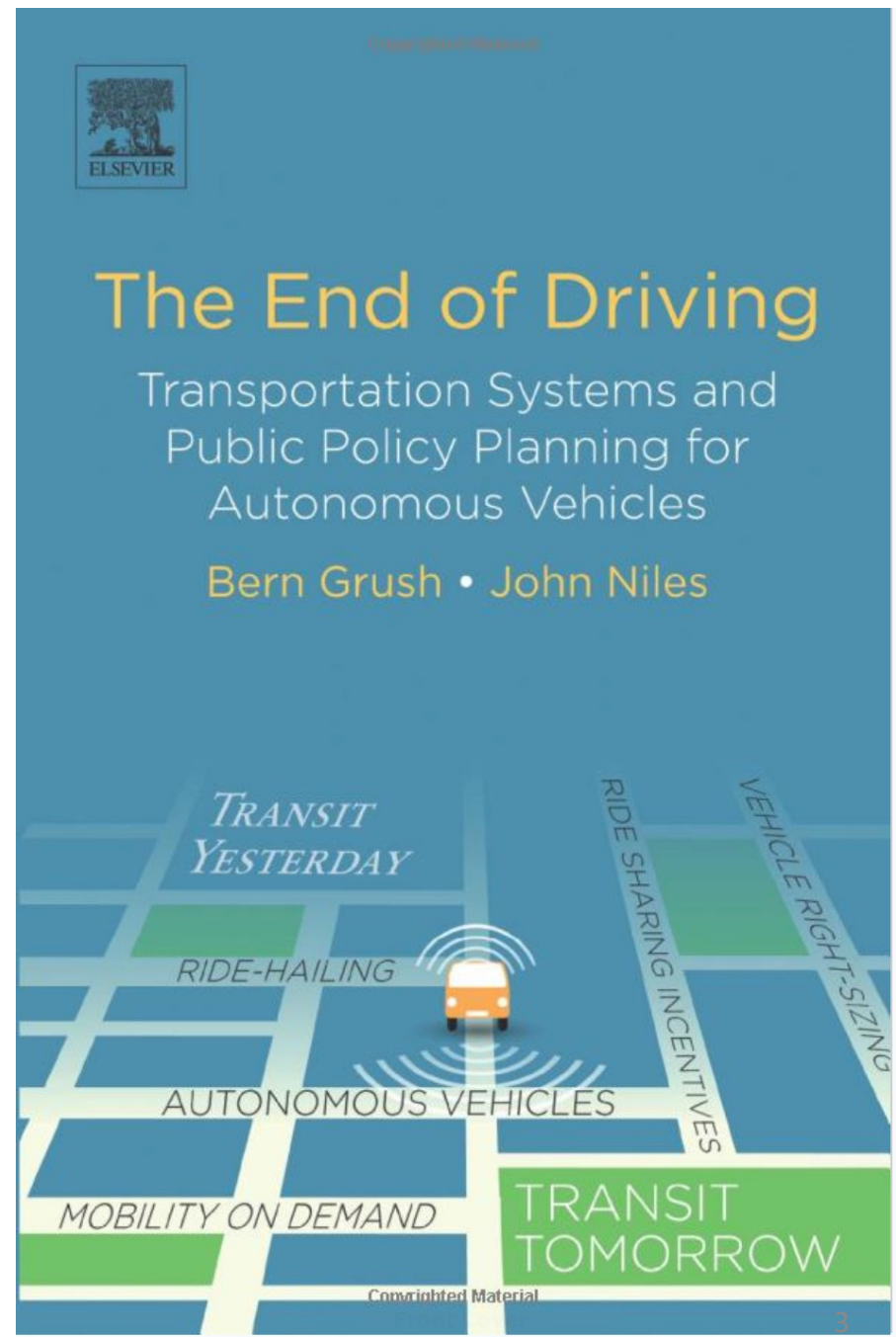
Center for Advanced Transportation and Energy Solutions

Call on CATES for technical and management consulting, policy advisory services, and contract research on small vehicle automation and electrification.



The End of Driving: Transportation Systems and Public Policy Planning for Autonomous Vehicles

- explores the potential of vehicle automation technology
- the barriers to urban deployment
- evaluates the case of automated public transportation and mobility-as-a-service as paths toward sustainable mobility



Why all the excitement about EVs?

1. EVs Past
2. Why Now?
3. Batteries
4. EVs & Hybrid Efficiency
5. Owning an EV
6. Market Disruption
7. Charging Stations
8. Charging Networks
9. Tax Incentives

Early EVs



1919 Rauch & Lang
Vintage Electric car



Battery Scooter
London 1916

THE SATURDAY EVENING POST

A Four-Passenger Coupe with removable top which may be replaced with Leather Victoria or Buggy top. Exide, Waverley or National Batteries. Choice of solid or pneumatic tires.

Price \$2,250

Waverley

Perfection of
Style and Service
In an Electric

An illustration of a Waverley electric car, a four-passenger coupe with a removable top. The car is shown from a side profile, facing right. It has large spoked wheels and a boxy body. The background is a light, textured surface.

Studebaker

ELECTRICS

VEHICLES OF GREAT UTILITY
FOR THE BUSINESS MAN

An illustration of a Studebaker Electric Stanhope, a two-seater open-top car. The car is shown from a side profile, facing right. It has large spoked wheels and a simple body. The background is a light, textured surface.

ELECTRIC STANHOPE

GM EV1 2,300 built 1996 - 1999

Movie : “Who killed the electric car?”

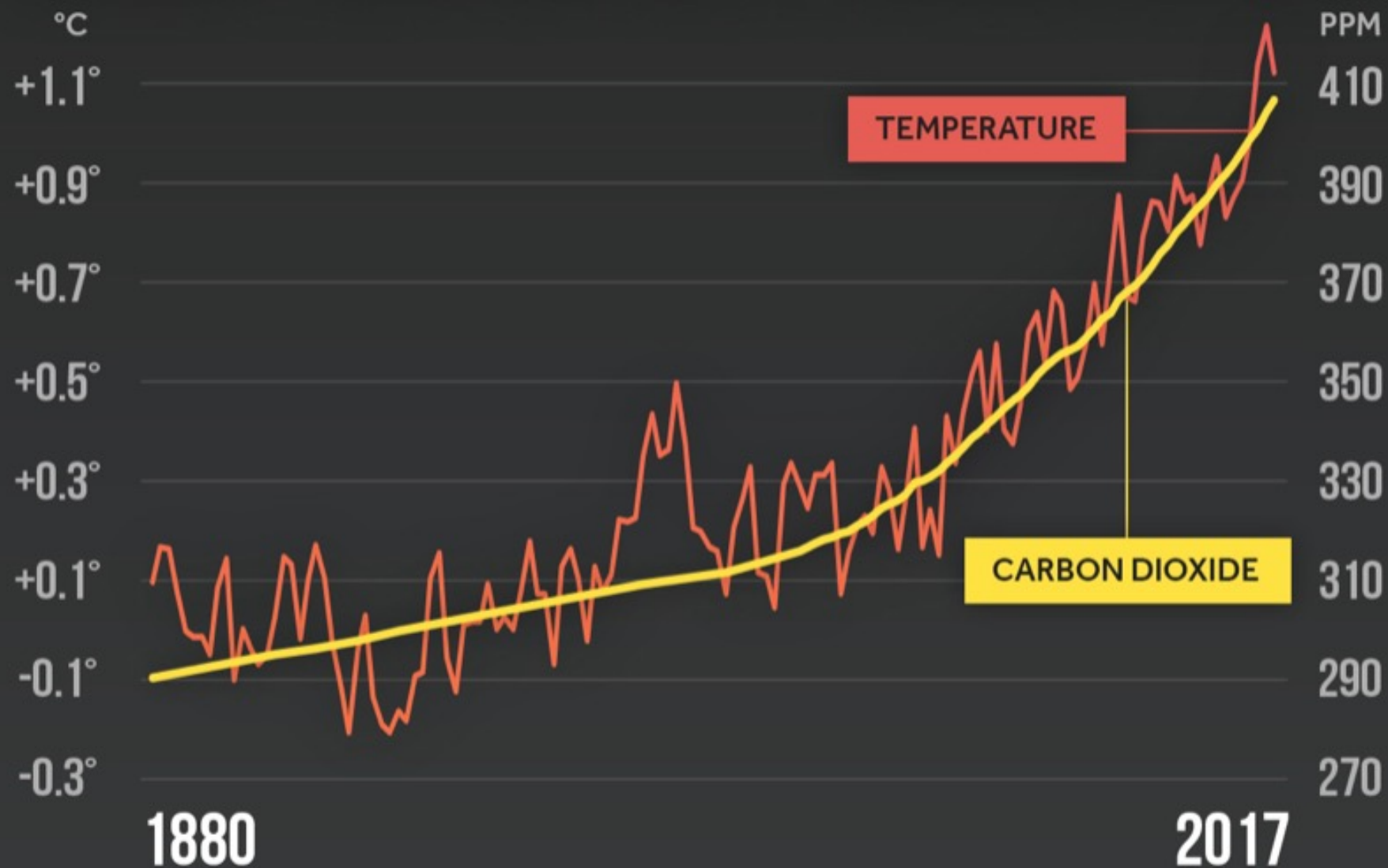


Why all the excitement today?

- Impacts of GHG emissions are recognized thru the climate science research and evidence, driving the urgent need to rapidly reduce anthropogenic co2 emissions
 - Transportation sector is largest share of U.S. co2 emissions at 29%
 - One gallon of gas or diesel emits about 21 lbs of co2
- Advanced Battery Technology
 - Lighter
 - Denser
 - Reliable
- Battery costs are falling thru mass production economies of scale and making electric vehicles more affordable and life cycle costs very compelling



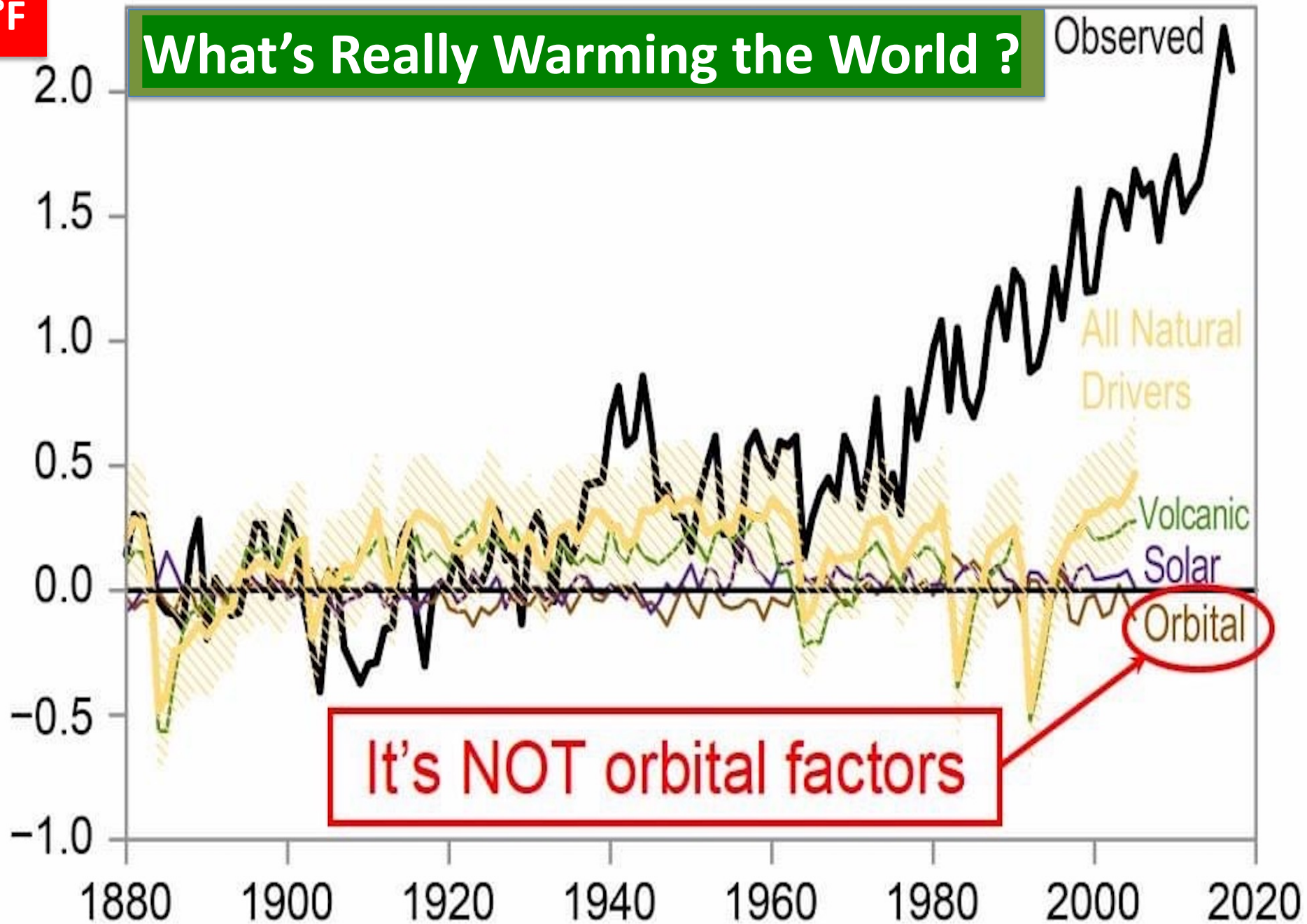
GLOBAL TEMPERATURE & CARBON DIOXIDE



Global temperature anomalies averaged and adjusted to early industrial baseline (1881-1910)
Source: NASA GISS, NOAA NCEI, ESRL

°F

What's Really Warming the World ?



- WHATS REALLY WARMING THE WORLD?

<https://www.bloomberg.com/graphics/2015-whats-warming-the-world/>

Emissions per capita

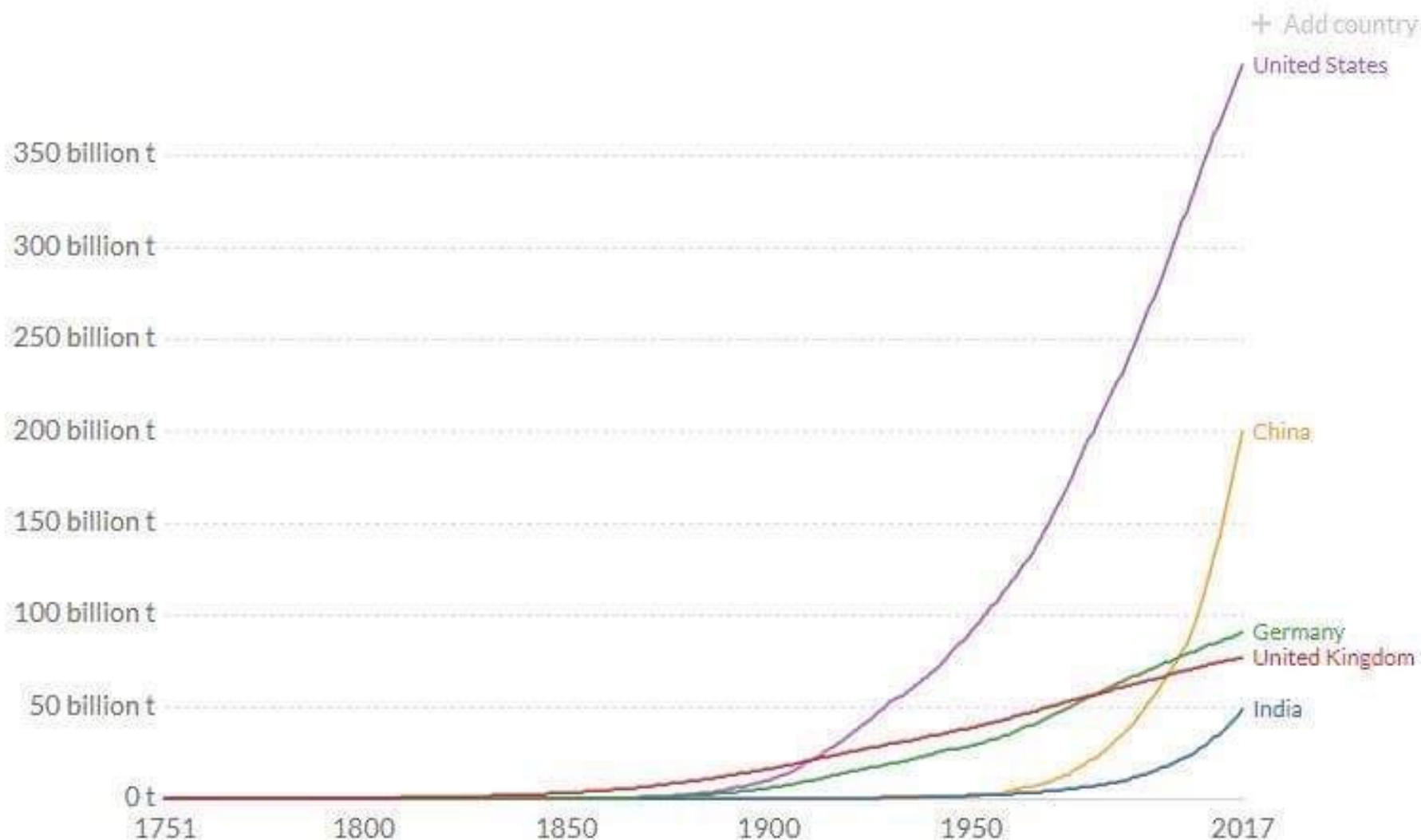
Household lifestyle consumption emissions (tonnes of CO₂ per capita)**



** In G20 countries for which data is available
Visual journalism: Steven Bernard/@sdbernard and Chelsea Bruce-Lockhart/@C_BruceLockhart
Source: Oxfam
© FT

Cumulative CO₂ emissions

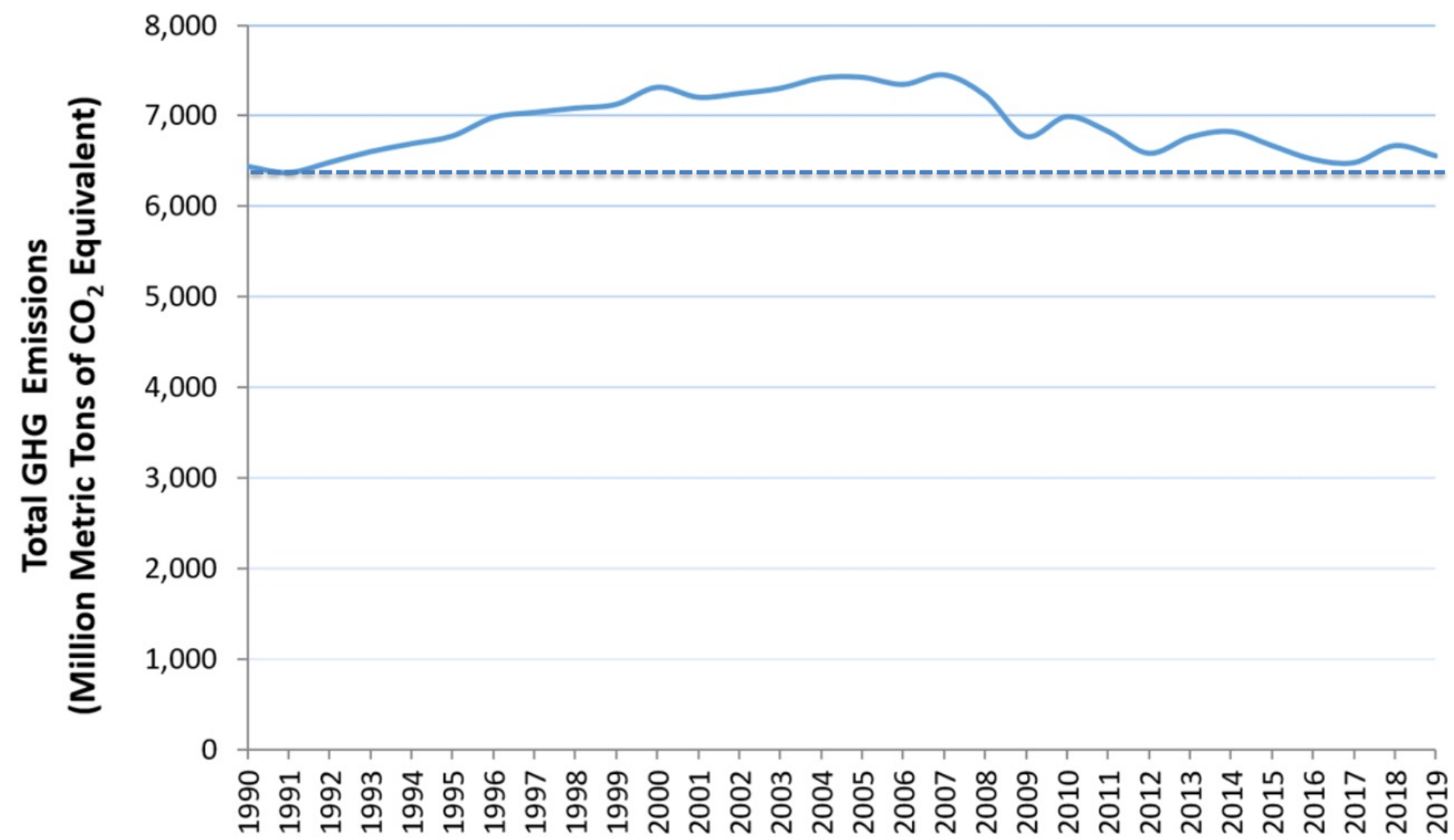
Cumulative carbon dioxide (CO₂) emissions represents the total sum of CO₂ emissions produced from fossil fuels and cement since 1751, and is measured in tonnes.



Source: Global Carbon Project (GCP); Carbon Dioxide Information Analysis Centre (CDIAC)

CC BY

Total U.S. Greenhouse Gas Emissions, 1990 - 2019

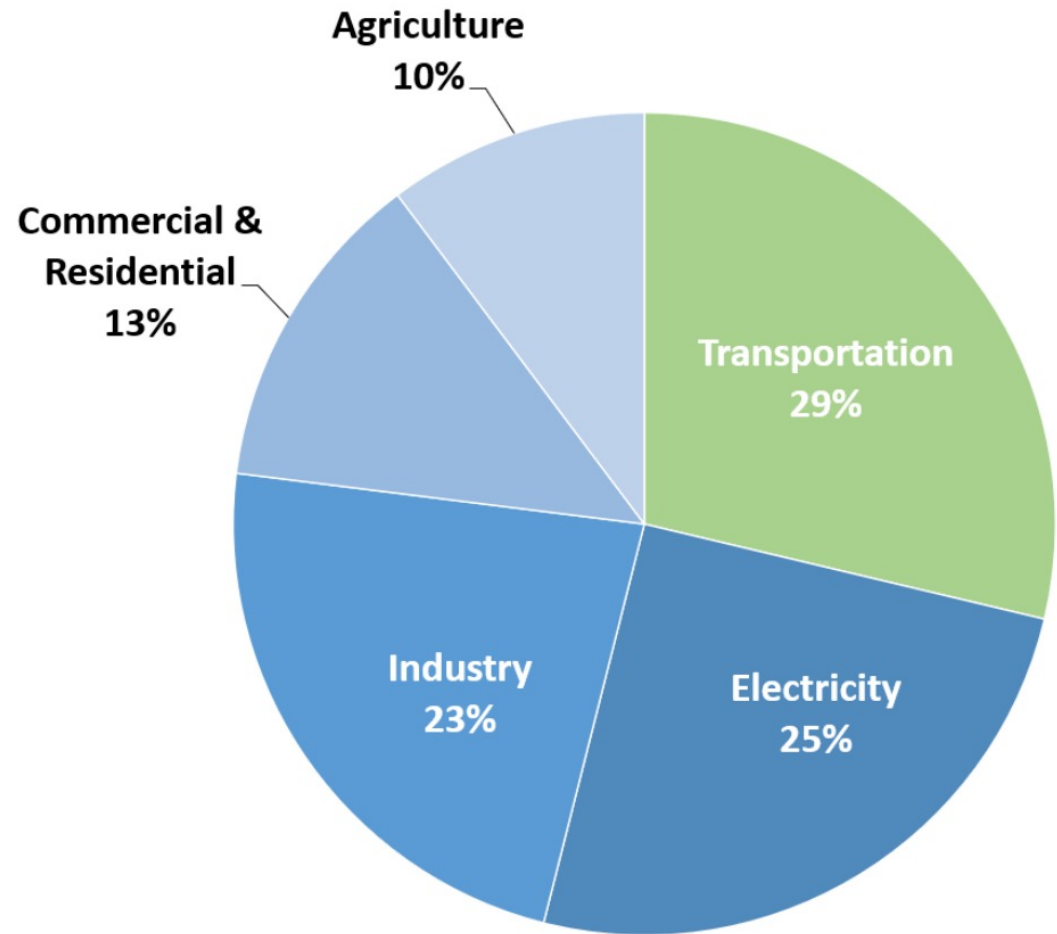


Note: All emission estimates from the [Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2019](#).

Total U.S. Greenhouse Gas Emissions By Sector in 2019

Transportation is largest share

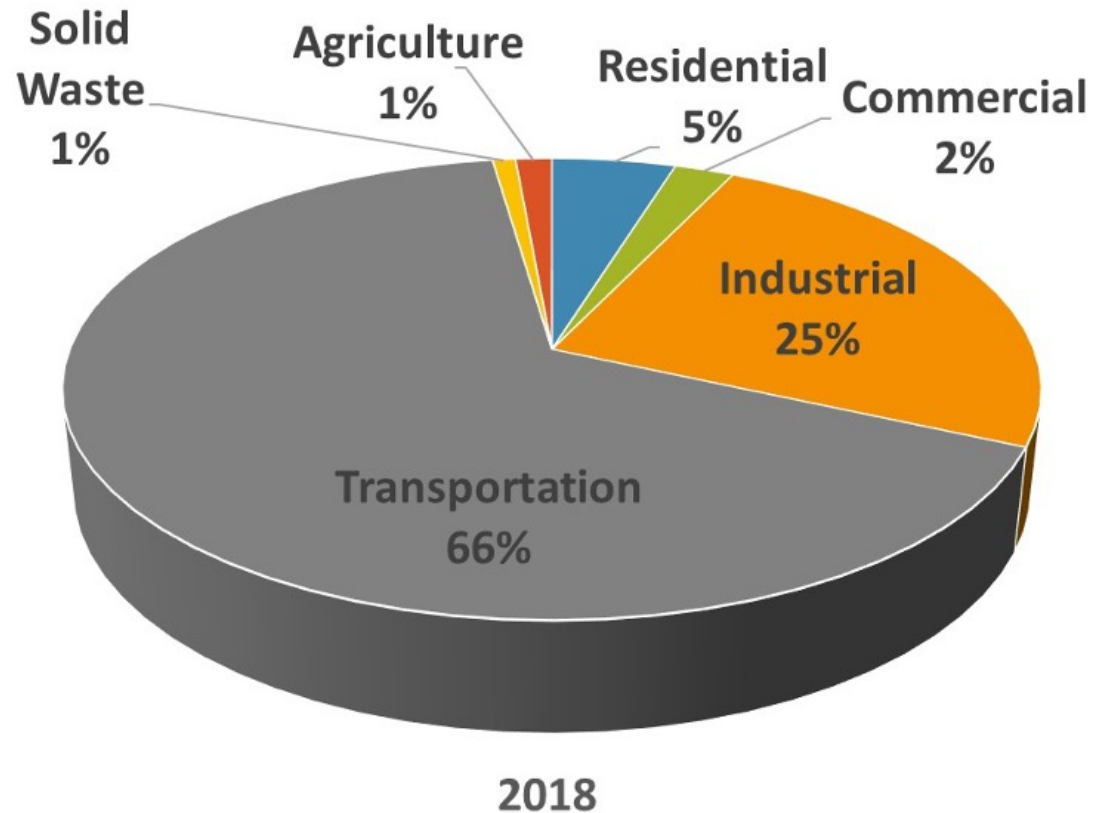
- Primarily :
passenger cars, medium-
and heavy-duty trucks,
buses, and light-duty
trucks
- commercial aircraft,
ships, boats, and trains,
as well as pipelines and
lubricants



Total Emissions in 2019 = 6,558 [Million Metric Tons of CO2 equivalent](#).

Jefferson County 2018 Community Emissions By Sector

- Jefferson County / Port Townsend Climate Action Committee in 2020
- Transportation emissions increased 13% since 2005
- Electricity > 90% hydroelectric

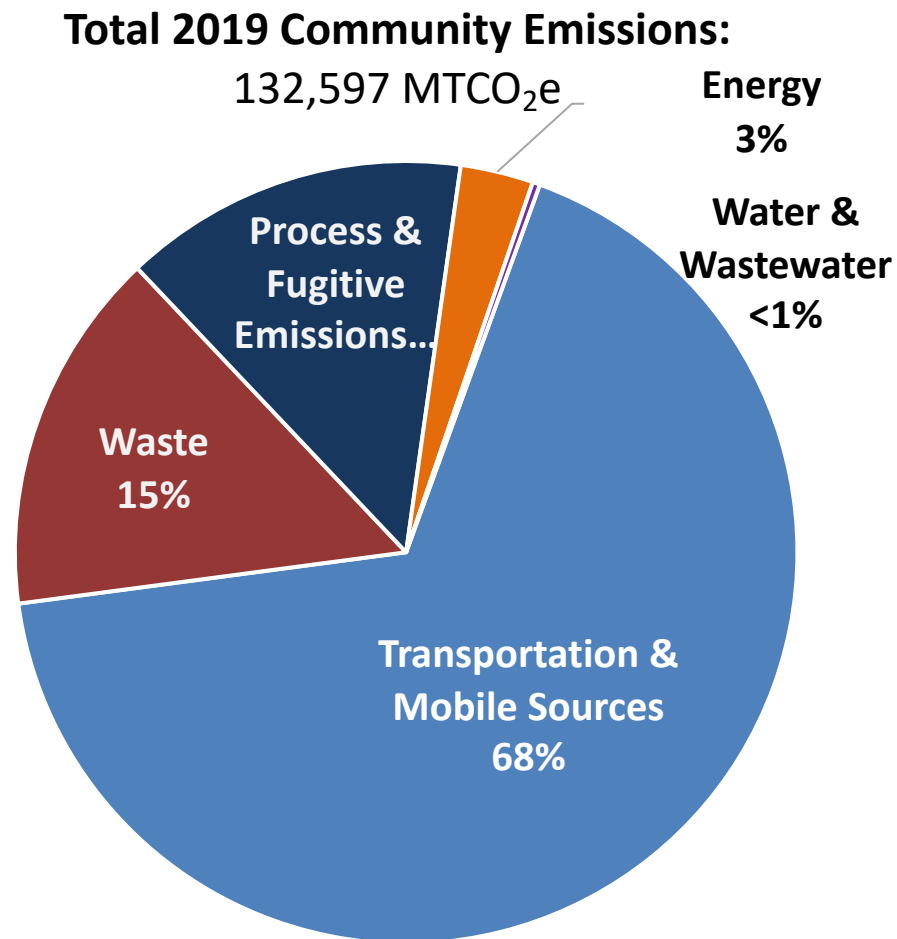


Port Angeles Climate Resiliency Project

Inventory Results: 2019 Community Snapshot

Main Sources of Emissions (in order):

1. Transportation & mobile sources
2. Solid waste generation & landfill operations
3. Process & fugitive emissions (e.g., refrigerants)
4. Residential, Commercial, & Industrial Energy
5. Electricity > 90% hydroelectric



Global greenhouse gas emissions and warming scenarios

Our World
in Data

- Each pathway comes with uncertainty, marked by the shading from low to high emissions under each scenario.
- Warming refers to the expected global temperature rise by 2100, relative to pre-industrial temperatures.

Annual global greenhouse gas emissions
in gigatonnes of carbon dioxide-equivalents

150 Gt

100 Gt

50 Gt

Greenhouse gas emissions
up to the present

0

1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100

No climate policies

4.1 – 4.8 °C

→ expected emissions in a baseline scenario
if countries had not implemented climate
reduction policies.

Current policies

2.7 – 3.1 °C

→ emissions with current climate policies in
place result in warming of 2.7 to 3.1°C by 2100.

Pledges & targets (2.4 °C)

→ emissions if all countries delivered on reduction
pledges result in warming of 2.4°C by 2100.

2°C pathways

1.5°C pathways

7.2 -
8.6F

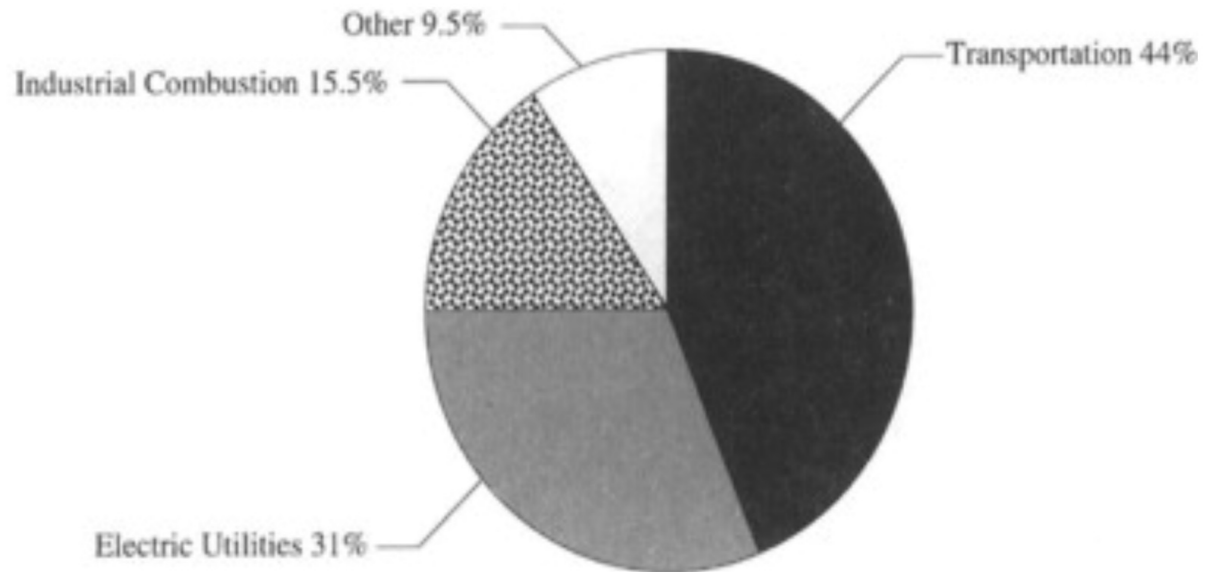
4.5 -
5.5F

4.3F

2.7 -
3.8F

...and don't forget about Nitrogen oxides

- Primarily burning of fossil fuel
- NO₂ forms from emissions from cars, trucks and buses, power plants, and off-road equipment



Total Emission: 22.6 [Mton/year]

- contribute to the development of asthma
- increase susceptibility to respiratory illnesses
- Acid rain
- Haze
- Nutrient pollution : algae blooms

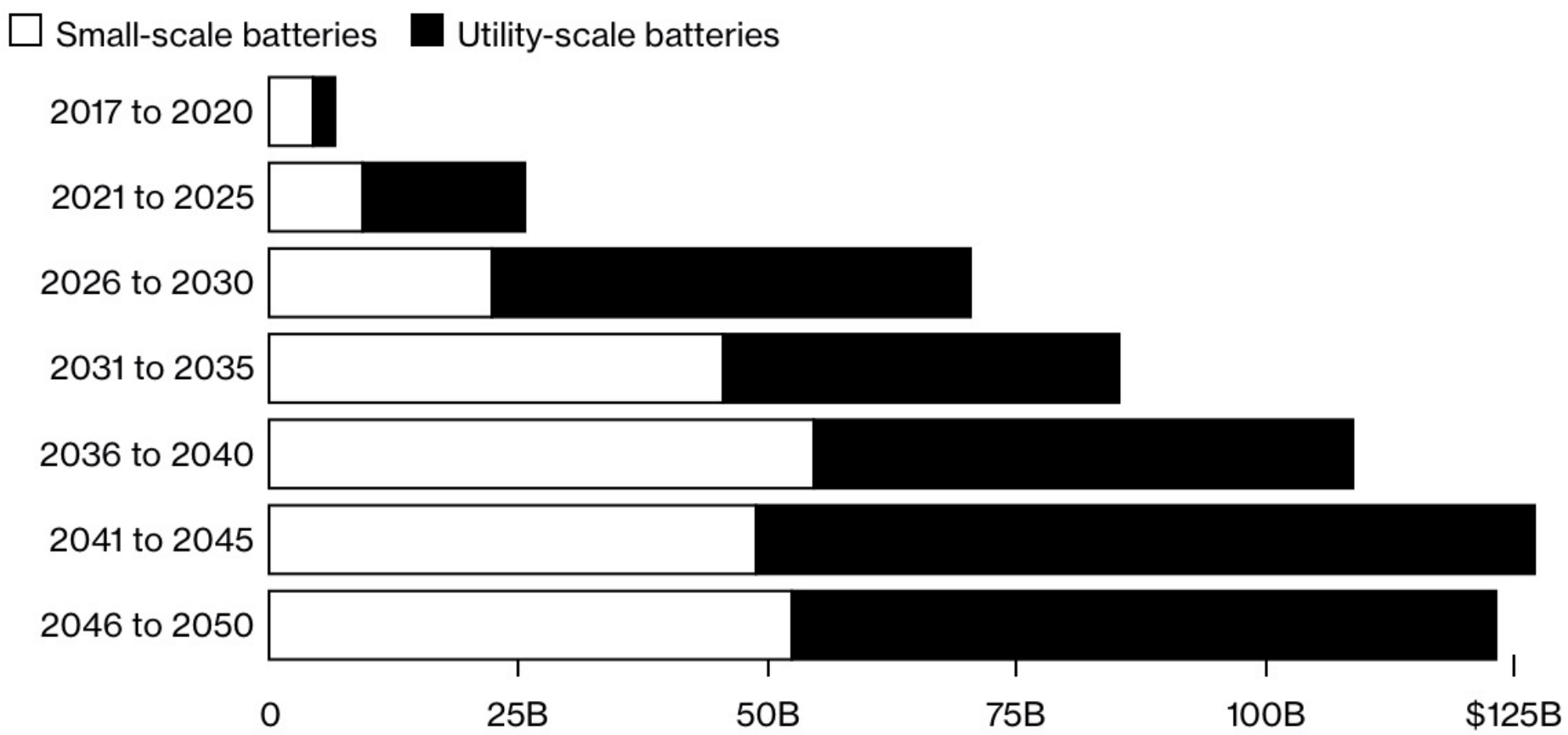
The Future of clean energy includes batteries



Battery Investments

Storage Spree

About \$548 billion may be invested in battery storage capacity by 2050



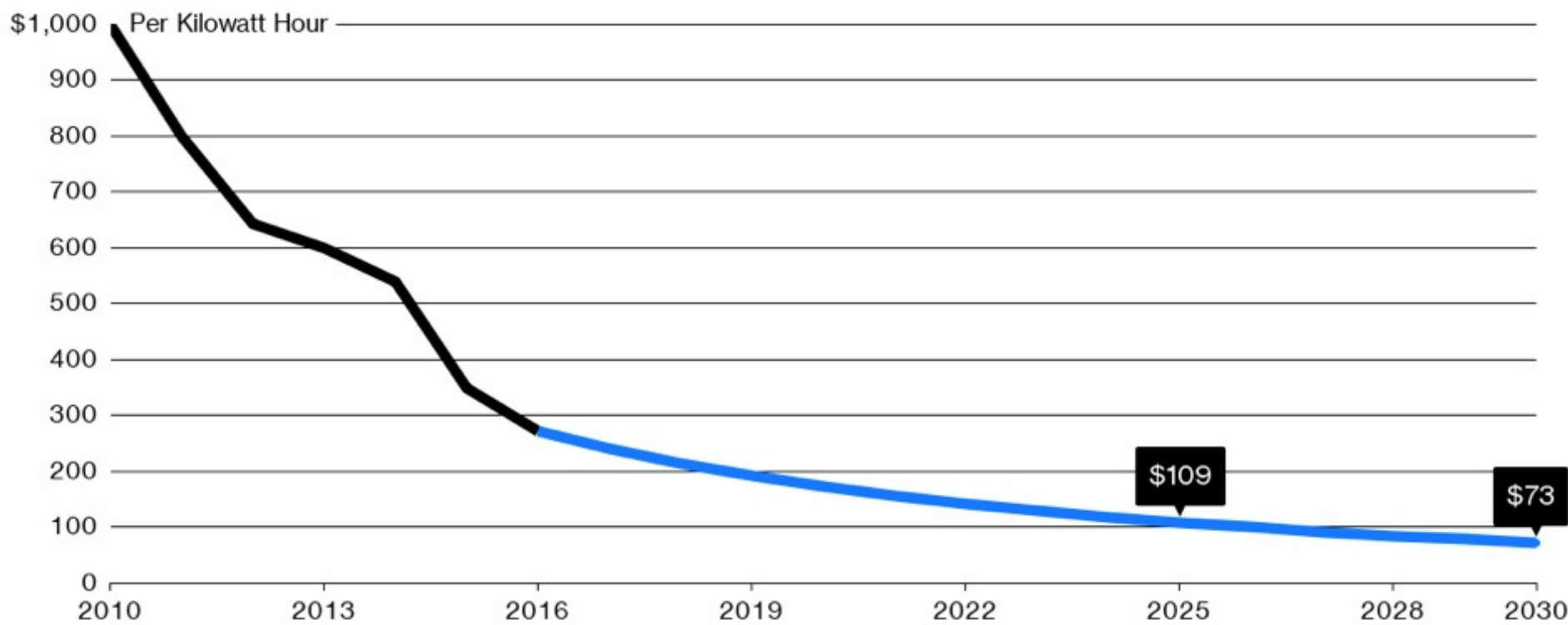
Source: Bloomberg NEF

Battery costs falling rapidly

More Bang for Your Buck

Greater efficiency means a \$1,000 battery in 2010 will cost \$73 in 2030

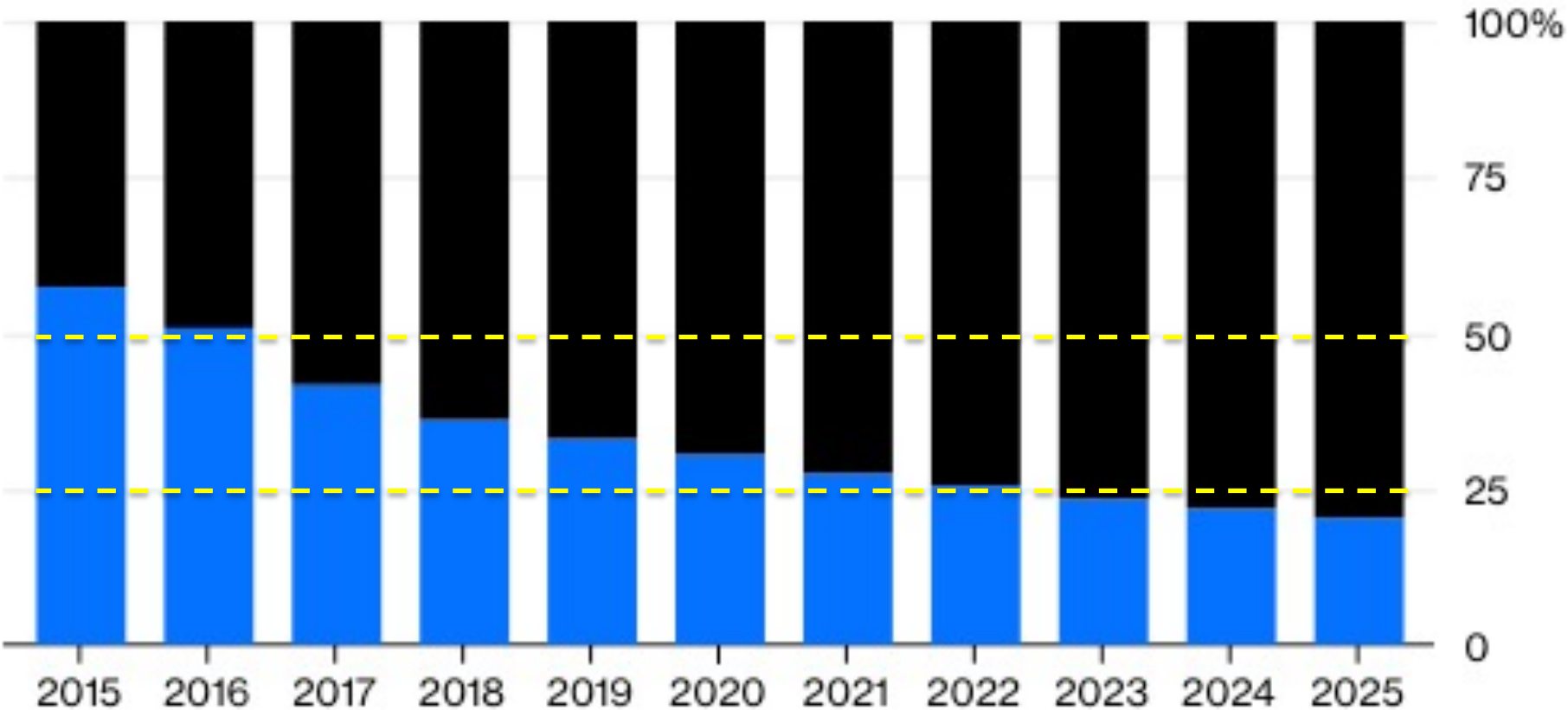
■ Average prices ■ Forecast



Source: Bloomberg New Energy Finance

EV battery cost for U.S. medium-size car as a percentage of retail price

Battery Everything else



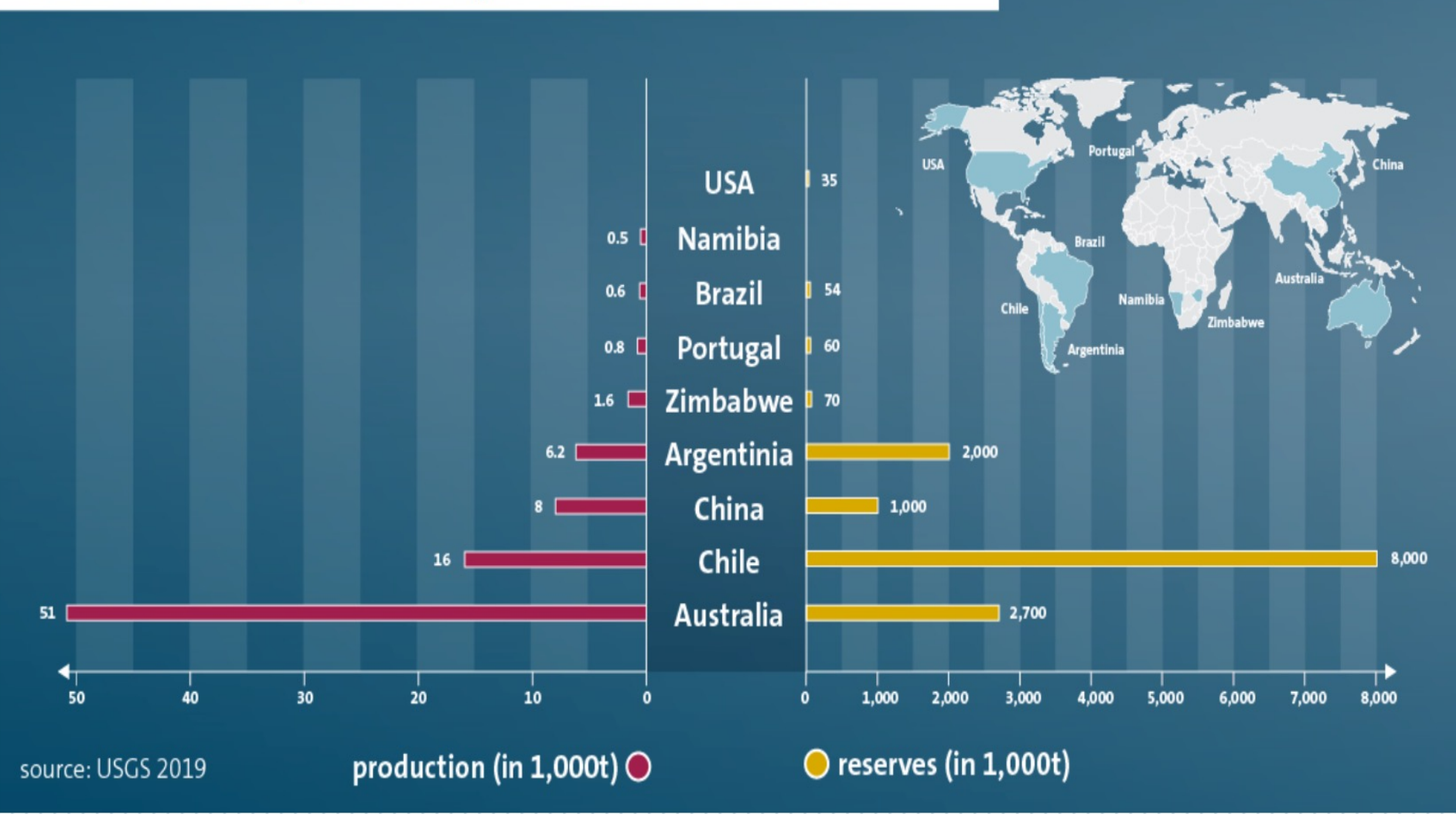
Source: BloombergNEF

Note: Includes profit margins and costs other than direct manufacturing costs.

Where will the Lithium come from ?

AUSTRALIA AND CHILE IN THE FRONT ROW

Countries with major Lithium production and reserves





GM Will Suck Lithium from the Salton Sea to Make Batteries

“California Energy Commission’s estimate that the Salton Sea area could produce 600,000 tons of lithium per year, which is amazing since the entire world’s industry produced a mere 85,000 tons of lithium in all of 2019..”

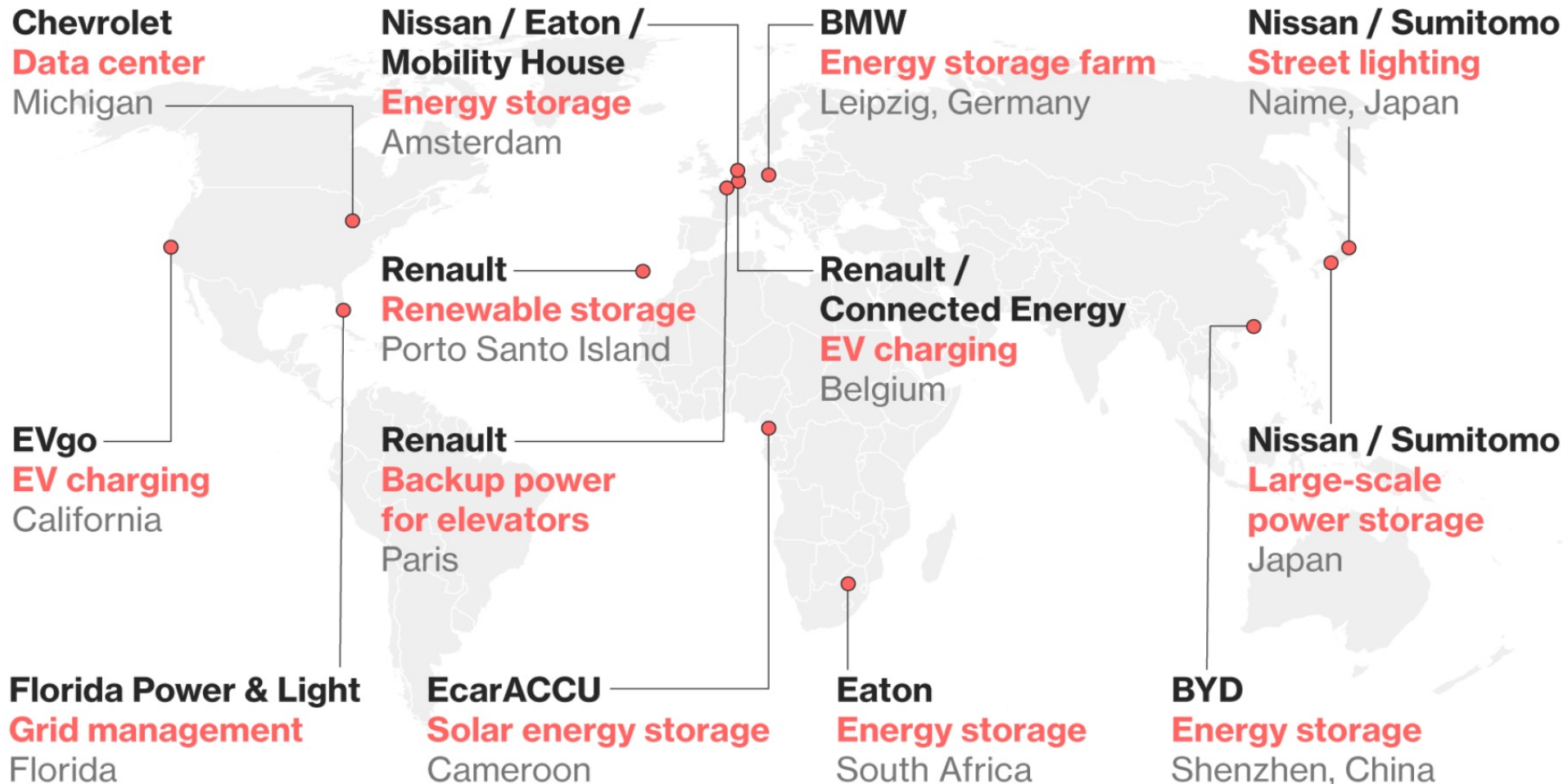
Source: AutoWeek July 2021



What about the “old” batteries?- Re-purposing

A New Lease on Life

Where electric-vehicle batteries are being used and tested for new roles



What about the “old” batteries? — Re-cycling

VW plans to scale up process to recover 95% of EV batteries' raw materials



STEPHEN EDELSTEIN

MARCH 10, 2021

9 COMMENTS



[View Gallery](#)

Volkswagen is just starting to ramp up production of electric cars based on its MEB platform, but the automaker is already thinking of how to recycle battery packs once those vehicles have reached the end of their lifecycles.

VW announced on Tuesday that it will scale up a process for recovering raw materials from used EV batteries. The automaker opened what it calls a pilot battery-recycling plant in Salzgitter, Germany, earlier this year, and hopes to open similar plants around the world.

LITHIUM-ION BATTERY RECYCLING FINALLY TAKES OFF IN NORTH AMERICA AND EUROPE

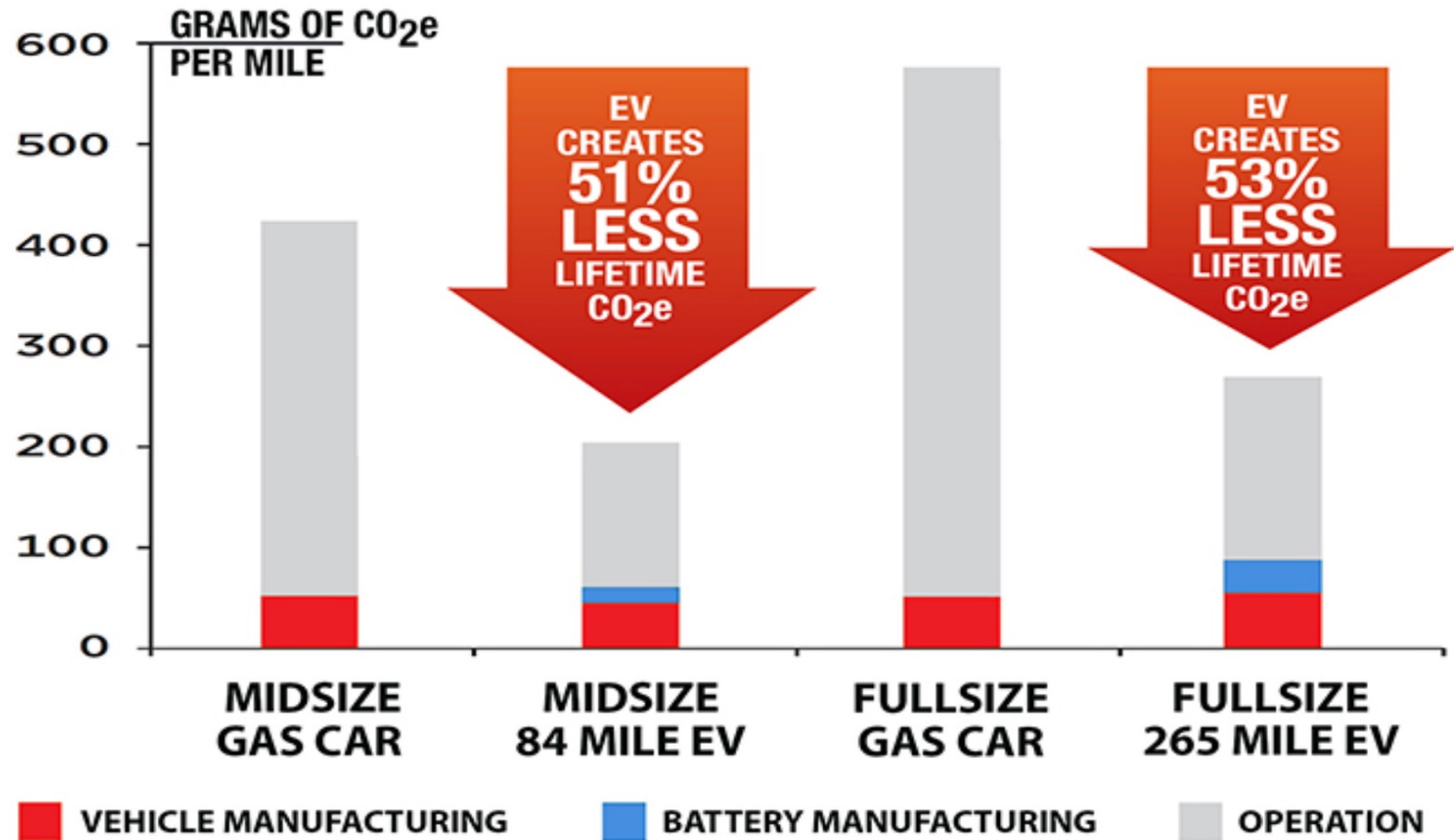
Li-Cycle, Northvolt, and Ganfeng Lithium are among those building recycling plants, spurred by environmental and supply-chain concerns

LATER THIS YEAR, the Canadian firm Li-Cycle will begin constructing a US \$175 million plant in Rochester, N.Y., on the grounds of what used to be the Eastman Kodak complex. When completed, it will be the largest lithium-ion battery-recycling plant in North America.

The plant will have an eventual capacity of 25 metric kilotons of input material, recovering 95 percent or more of the cobalt, nickel, lithium, and other valuable elements through the company's zero-wastewater, zero-emissions process. "We'll be one of the largest domestic sources of nickel and lithium, as well as the only source of cobalt in the United States," says Ajay Kochhar, Li-Cycle's cofounder and CEO.

CO2 Footprint of EV

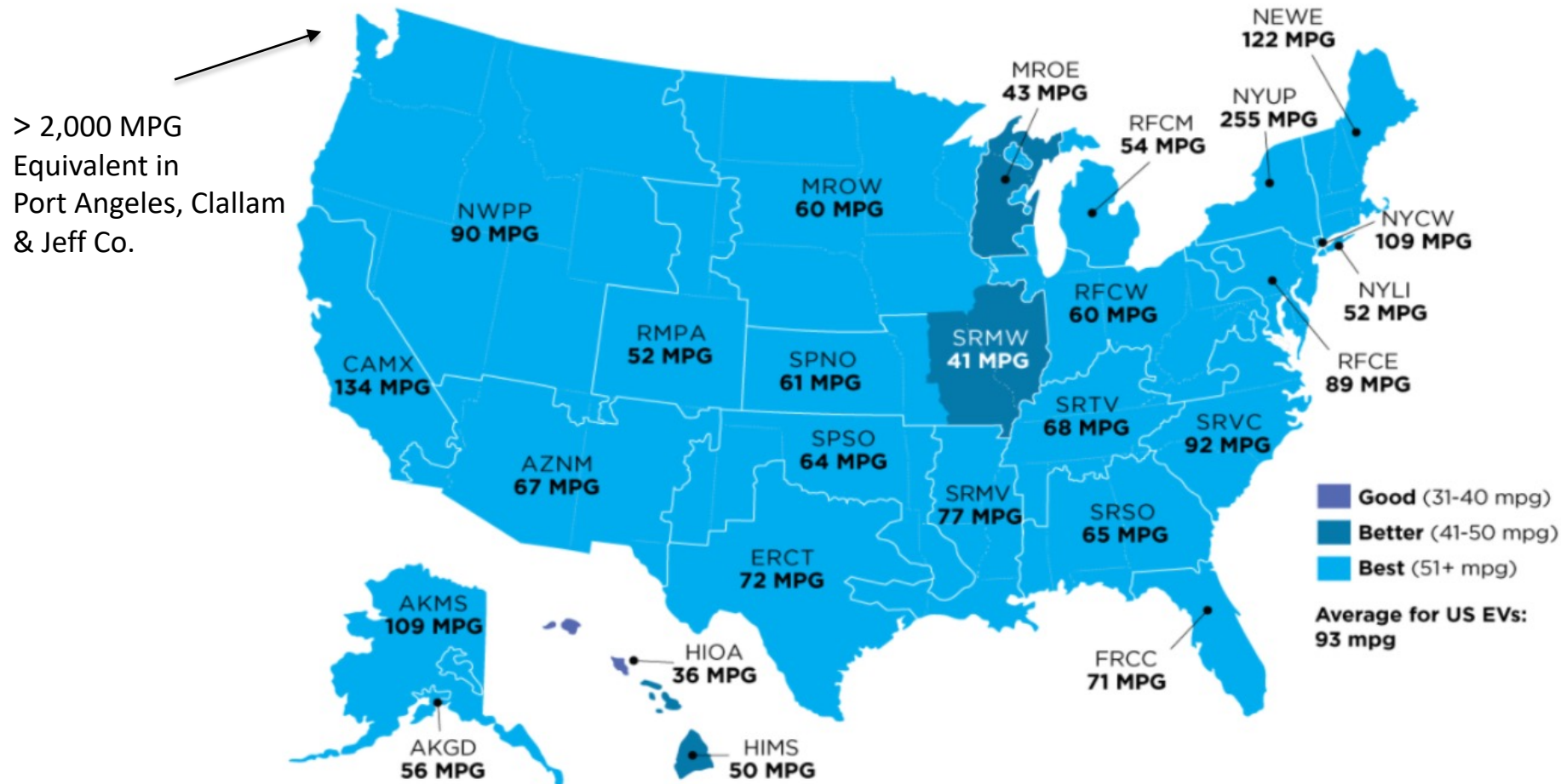
LIFECYCLE GLOBAL WARMING EMISSIONS GAS VEHICLE VS. ELECTRIC VEHICLE



Based on modeling of the two most popular BEVs available today and the regions where they are currently being sold, excess manufacturing emissions are offset within 6 to 16 months of average 28 driving.

Where you live makes a difference

EV Emissions as Gasoline MPG Equivalent Average EV, 2021*



* based on 2019 reported electricity generation emissions

© Union of Concerned Scientists

Source: Union of Concerned Scientists, 2021

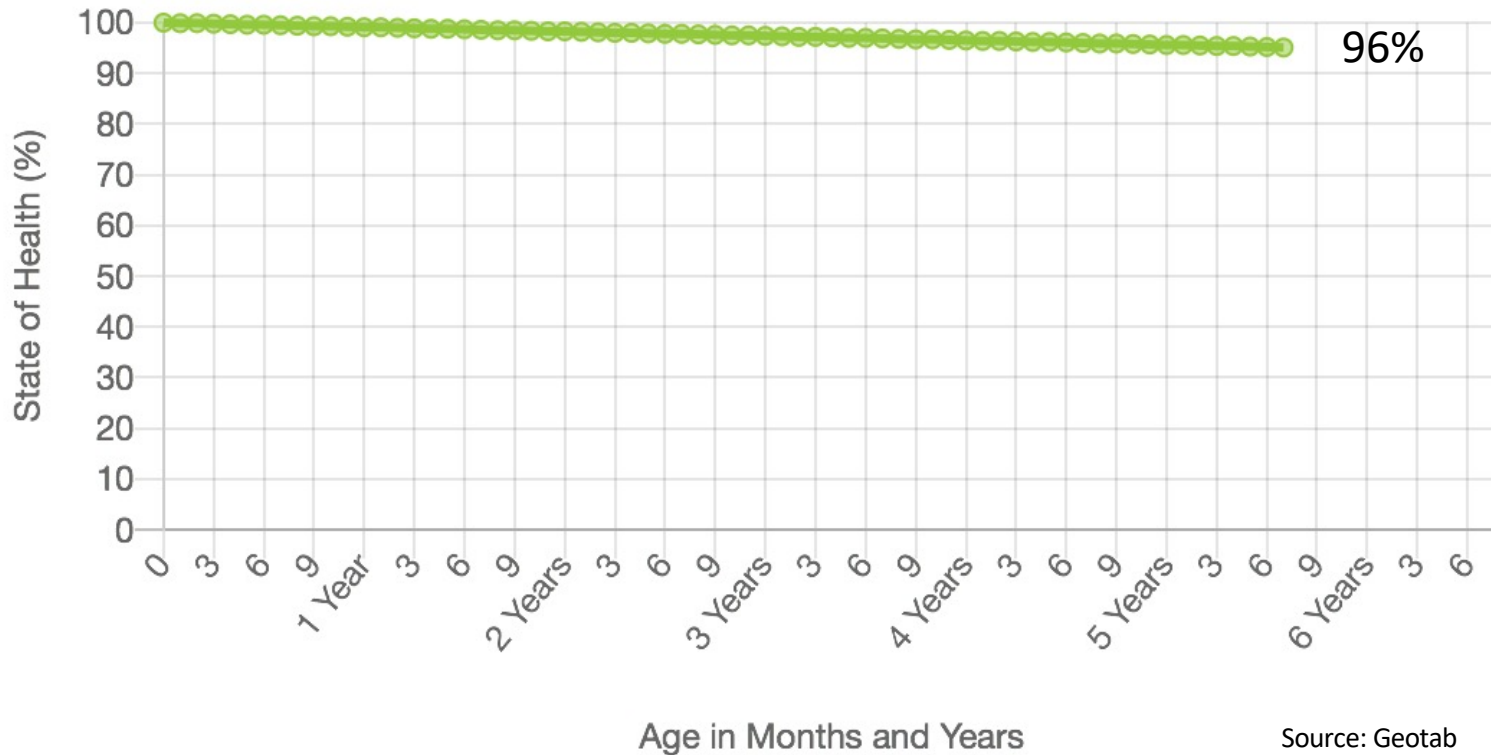
What about Degradation?

Make & Model

Chevrolet Volt

Year

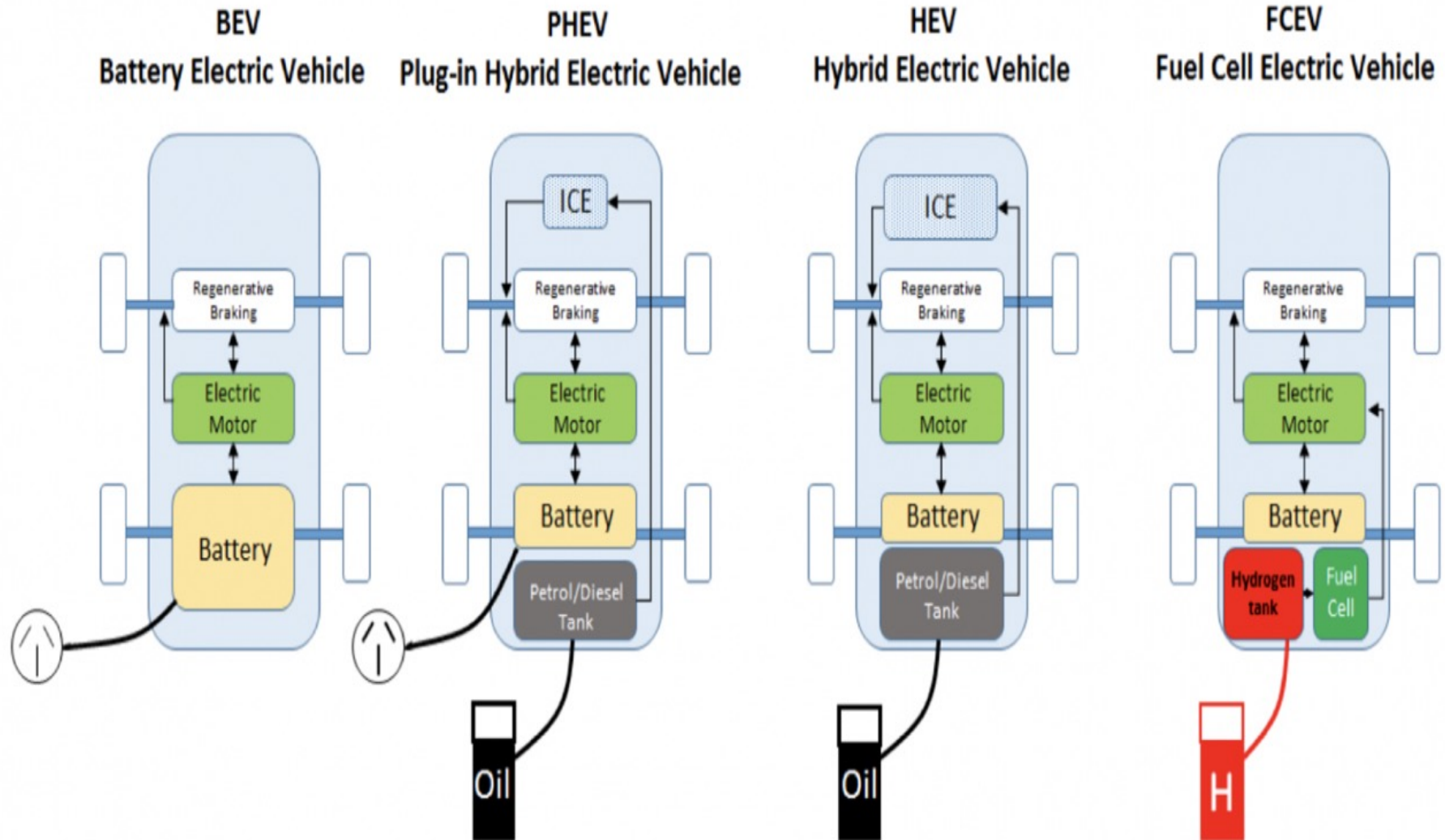
2014



Causes:

- Degradation increases if using DCFC frequently (DC fast charging)
- Avoid operating much below 10%
- Battery Mgt Systems differ between vehicles
Passive Thermal management systems (ex. Leaf)
vs Active liquid cooled & heated (preferred)

Types of Electrified Vehicles Today

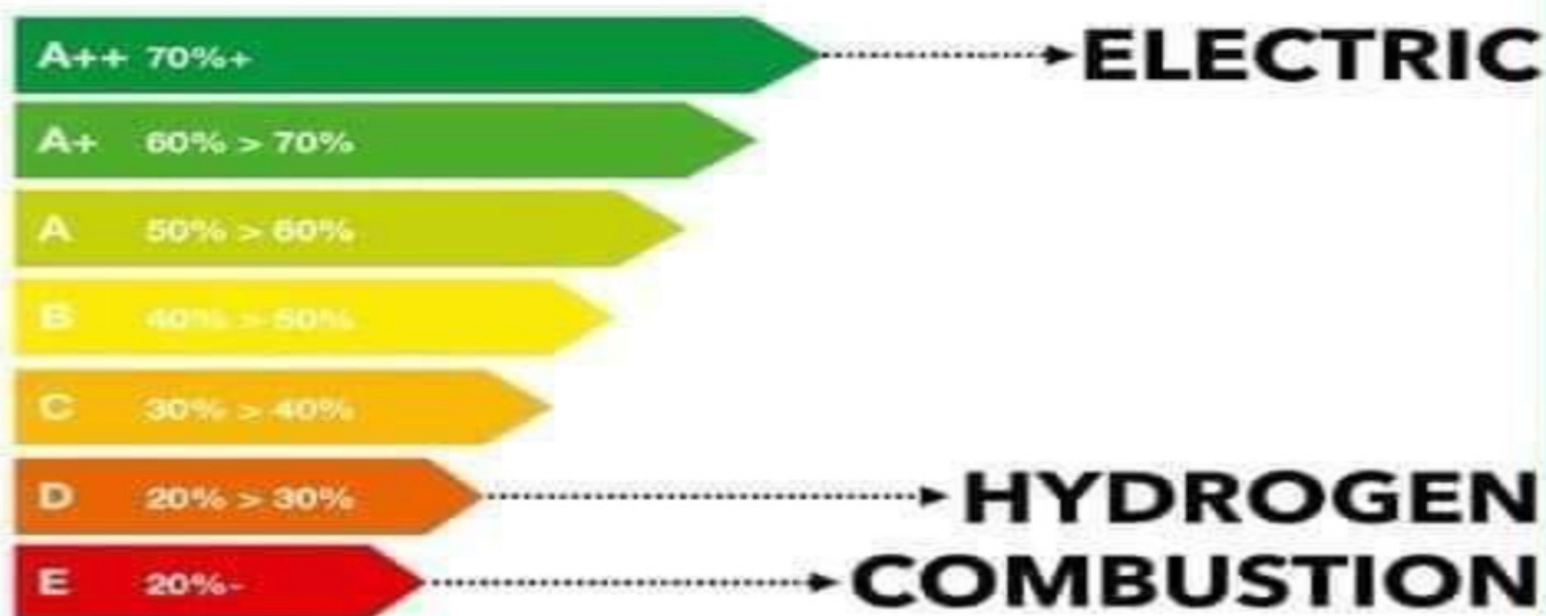


- *Series or parallel ?*



ENERGY EFFICIENCY LABEL

VEHICLES



The World requires your Leadership and contribution in order to better use the energy and ensure the transition from fossil sources to renewable sources. Hence, it is important to realize 30% of the energy contained in the fuel of a conventional vehicle (known as 'ICE' Internal Combustion Engine) is actually used to power the car. Even worse, when adding the required energy to produce the final product (fuel) and its transport, the efficiency drops to 13% whereas an electric vehicle obtains a general score of 73%.

Battery Electric Simplicity & Efficiency

GAS ENGINES



2,000 Moving Parts

ELECTRIC MOTORS



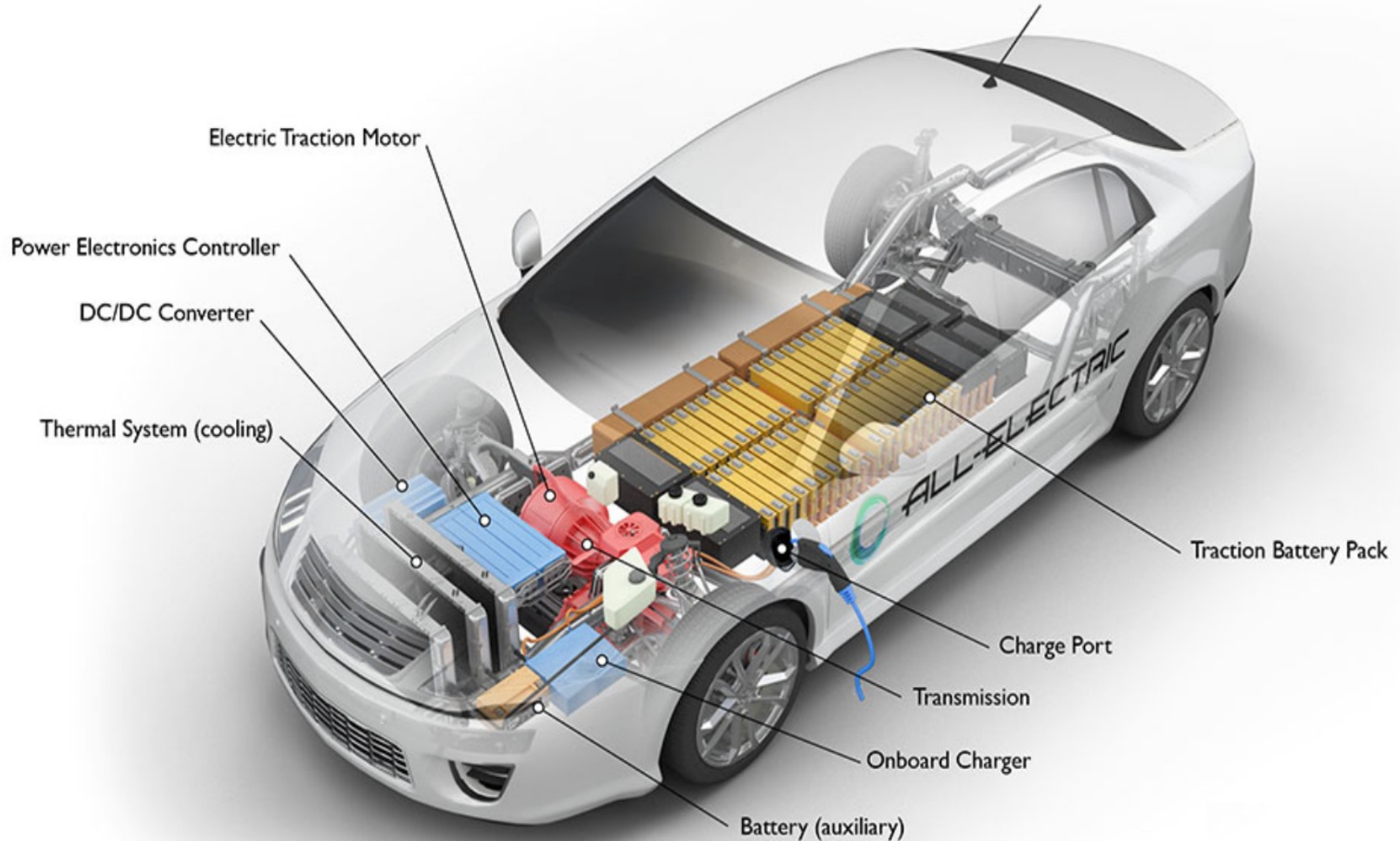
20 Moving Parts

VS

Energy Efficiency




100% Battery Electric Simple Design



Owning an EV

- Highly reliable – 20 moving parts vs 2000 (ICE)

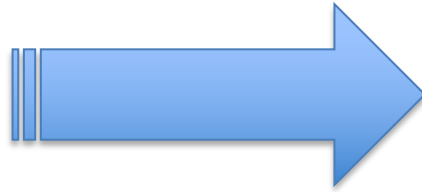
Maintenance Schedule for your 2017 Chevrolet Bolt EV

 Certified Service	7,500 miles	15,000 miles	22,500 miles	30,000 miles	37,500 miles	45,000 miles	52,500 miles	60,000 miles	67,500 miles	75,000 miles	82,500 miles	90,000 miles	97,500 miles	105,000 miles	112,500 miles	120,000 miles	127,500 miles	135,000 miles	142,500 miles	150,000 miles
Rotate tires, if recommended for the vehicle, and perform Required Services.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Replace passenger compartment air filter (or 2 years, whichever comes first).			✓			✓			✓			✓			✓			✓		
Drain and fill vehicle coolant circuits.																				✓

Owning an EV

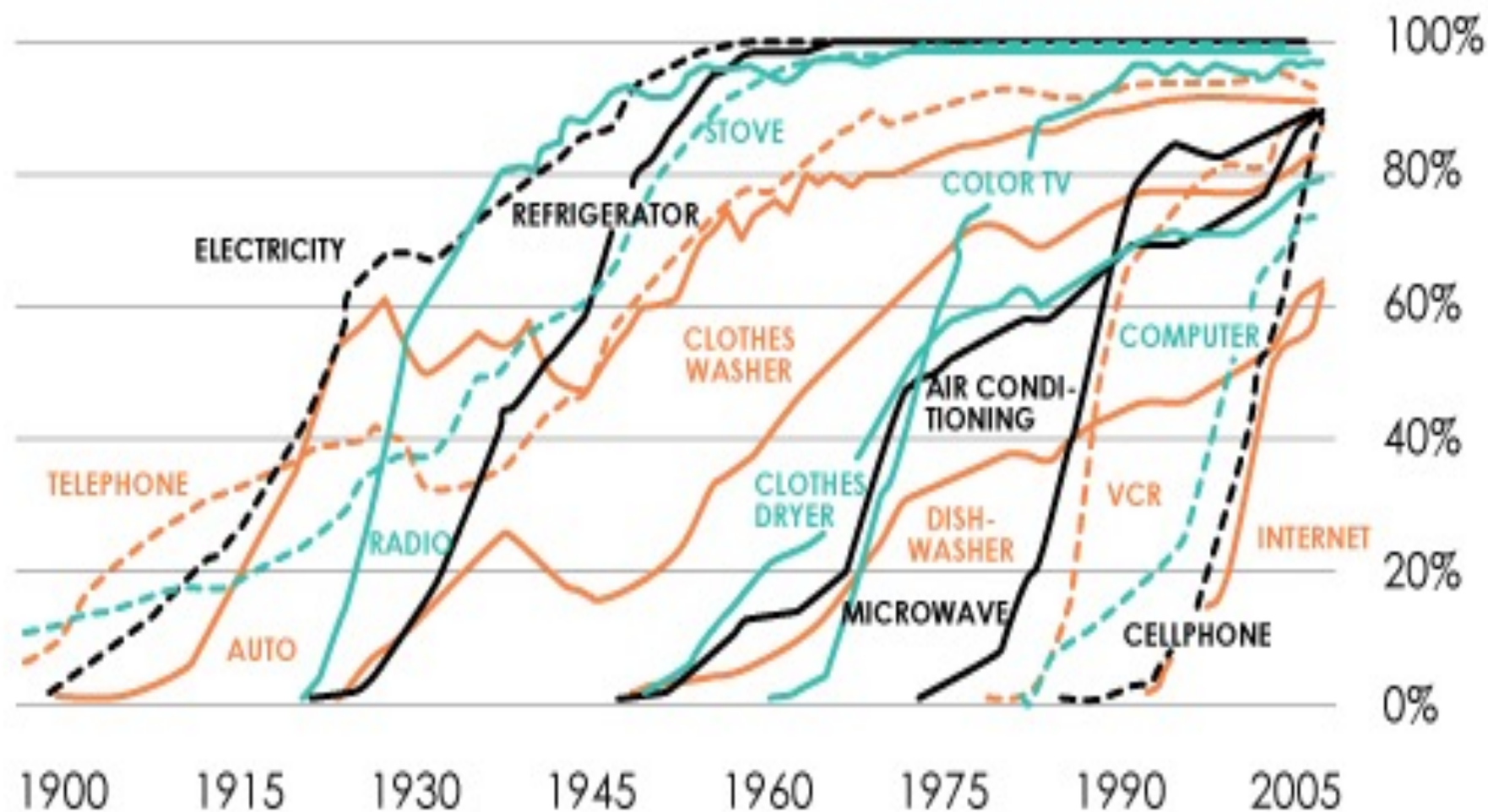
	ICE (Internal Combustion Engine)	Electric Vehicle
Fuel @ 10,000 miles	\$1,400 (25 mpg @ \$3.50/gal)	\$285 (3.5 miles/Kwh @\$0.10/kwh)
Total Fuel \$ at 100,000 mi.	\$14,000	\$2,850
Oil Changes	\$60 every 5,000 miles	\$0
Brakes	\$500 to \$800 every 50k	\$0 (over 200k+)
Radiator Flush	\$100 every 100k	\$0
Timing Belt	\$1000 every 60k	\$0
Alternator	\$500 every 100k	\$0
Water pump	\$500 every 70k	\$0
Transmission service	\$200 every 60k	\$0
Battery Coolant Flush	-	\$300 Once every 10 yrs or 100k
Spark plugs, spark plug wires, fuel filters, ...	??\$? Repairs ?\$?\$	
Total fuel & maint. @100k	<u>~ \$17,700+</u>	VS <u>~ \$3,150</u>

**Decreasing Battery \$
& Low Operating Costs**



Market Transition

New Technologies and Mainstream Adoption



Source: Michael Felton, *The New York Times*

www.earlyinvesting.com

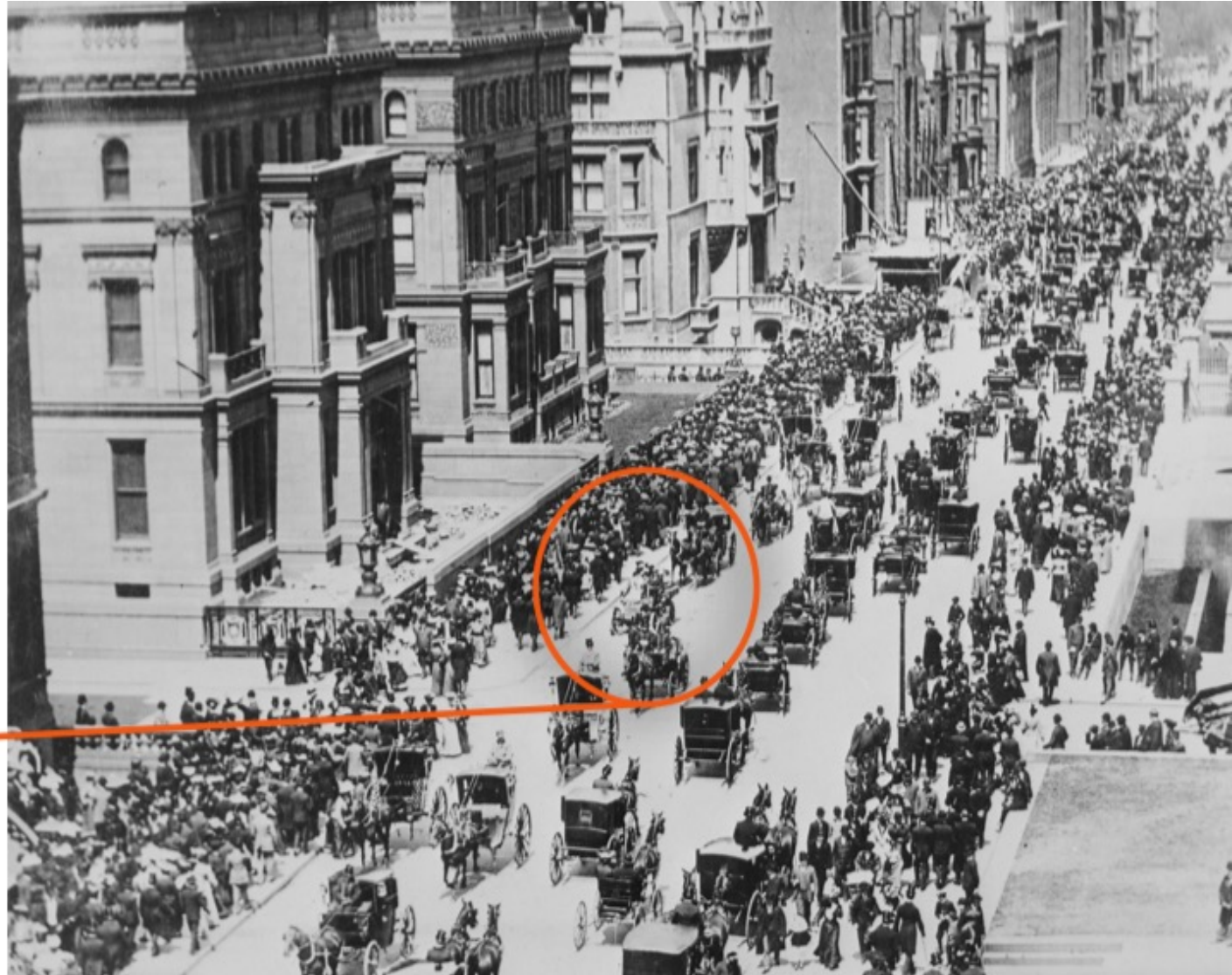
Speed of Disruption

5th AVE NYC

1900

Where is

the
car?



Speed of Disruption

5th AVE NYC

1913

Where is
the
horse?



The Rise of Electric Cars

BNEF sees more than 20 million sales by 2030

Millions

25

20

15

10

5

0

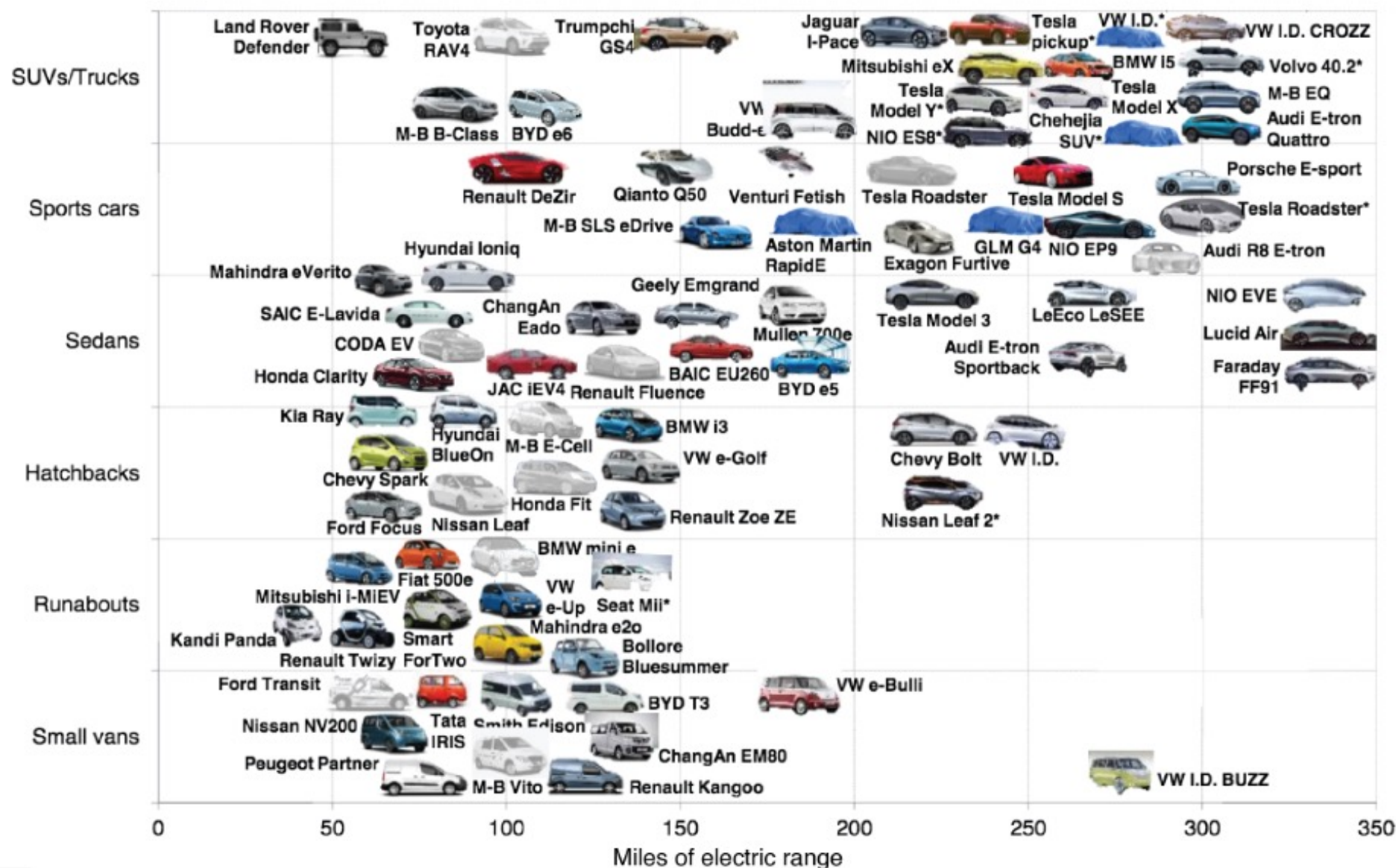
2016 2018 2020 2022 2024 2026 2028 2030



Source : Bloomberg New Energy Fund

➤ *By 2025 EVs projected to be priced equal to or less than gasoline vehicles*

EV Models by Style and Range – existing & coming



Cities & Municipalities



Trucking



Vehicle to Load (V2L)

- Worksite
- Camping
- Residential back up
- Christmas lights.....



Performance - Instant Torque!



Chevrolet Bolt

0-60 MPH

6.3 sec

QUARTER MILE

14.9 sec @ 93.1 mph



Electric Vehicles are Quick!

2021 Ford Mustang Mach-E Select SR AWD \$39,195	211	5.2
2021 Tesla Model 3 Standard Range Plus \$41,190	262	5.3
2021 Tesla Model 3 Standard Range Plus \$41,190	263	5.3
2021 Audi e-tron \$59,495	222	5.5
2021 Audi e-tron Sportback \$62,695	218	5.5
2021 Volkswagen ID.4 AWD Pro \$37,370	249	5.7
2021 Ford Mustang Mach-E Select SR RWD \$36,495	230	5.8
2021 Ford Mustang Mach-E Route 1 ER RWD \$44,000	305	6.1
2021 Ford Mustang Mach-E Premium ER RWD \$46,200	300	6.1
2022 Nissan LEAF e+ S (62 kWh) \$25,875	226	6.5
2022 Nissan LEAF e+ SV (62 kWh) \$30,875	215	6.5
2022 Chevrolet Bolt EV \$31,995	259	6.5
2021 BMW i3s \$41,145	153	6.8
2022 MINI Cooper SE \$23,250	114	6.9
2022 Chevrolet Bolt EUV \$33,995	247	7.0
2022 Polestar 2 Single Motor 19" \$39,700	265	7.0
2021 BMW i3 \$37,945	153	7.2
2022 Nissan LEAF S (40 kWh) \$20,875	149	7.4
2022 Kia Niro EV (e-Niro) \$33,665	239	7.5
2022 Hyundai Kona Electric \$27,685	258	7.9

Benefits - Driving an EV is Fun!

- **Instant Power**, 100% torque at 0 RPM! Bolt is 0 – 60mph in 6.3 Seconds!
- Low Center of Gravity – **handles curves better**
- **Silent** – no transmission – direct drive
- **Pre-heat or Pre-air condition** while charging & before leaving home
- Heating and Cooling sitting in ferry line – no “idling”
- **Leave home with a “full tank”**
 - – no gas station stops or oil checks (no drips)
- **Regenerative Braking** - “One Pedal Driving” – **Minimal brake pad wear!**

Regenerative Braking – “one pedal driving”

- Electric motor acts like a generator when decelerating
- Greatly reduces brake wear

Regular Car



Brakes applied. Brake lights on. Friction of pads on disc slows car. Brakes wear.



Model S



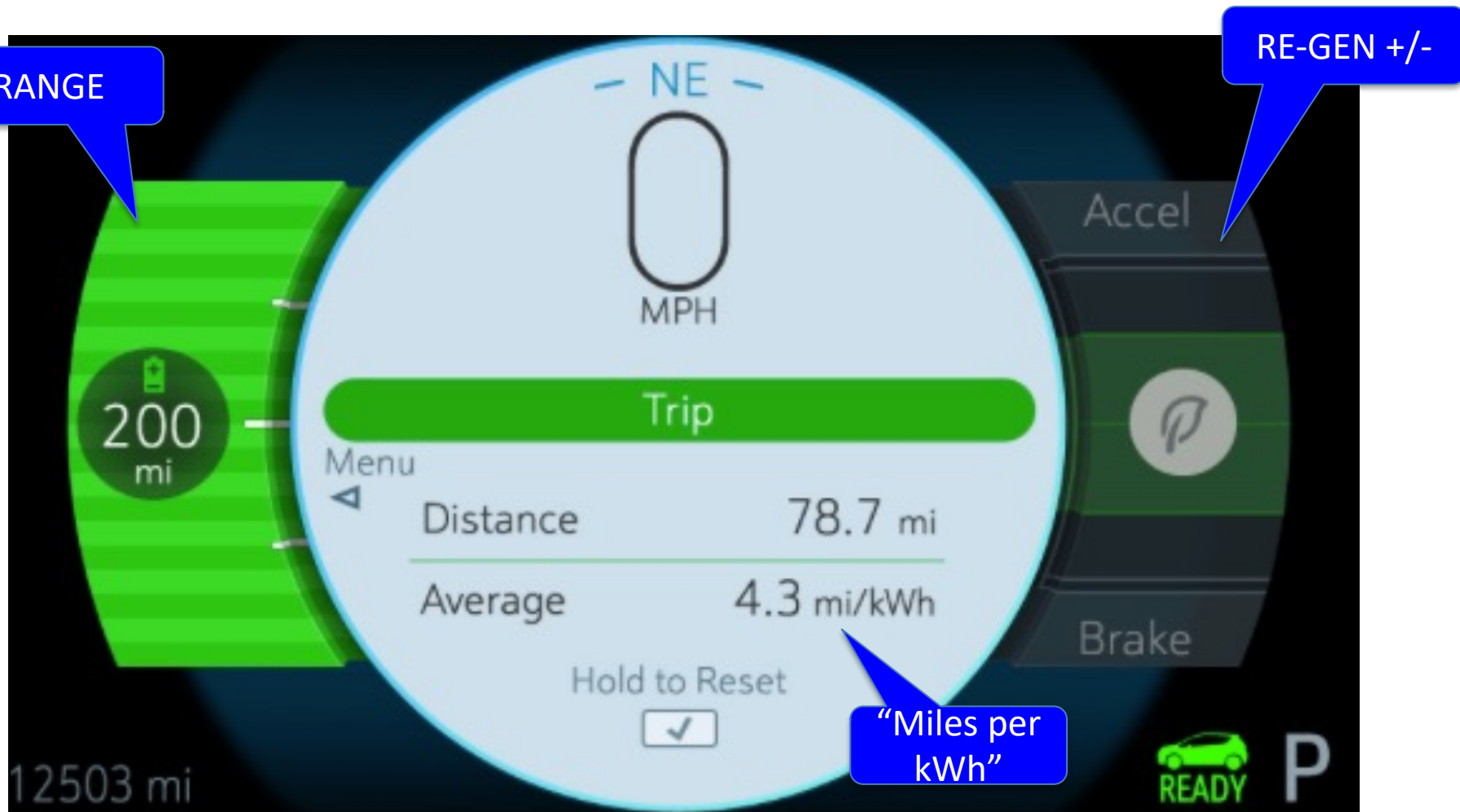
Brakes applied

Accelerator released. Brake lights on. Car slows. Energy goes back into batteries



 = Distance brakes are being applied

Simple to operate

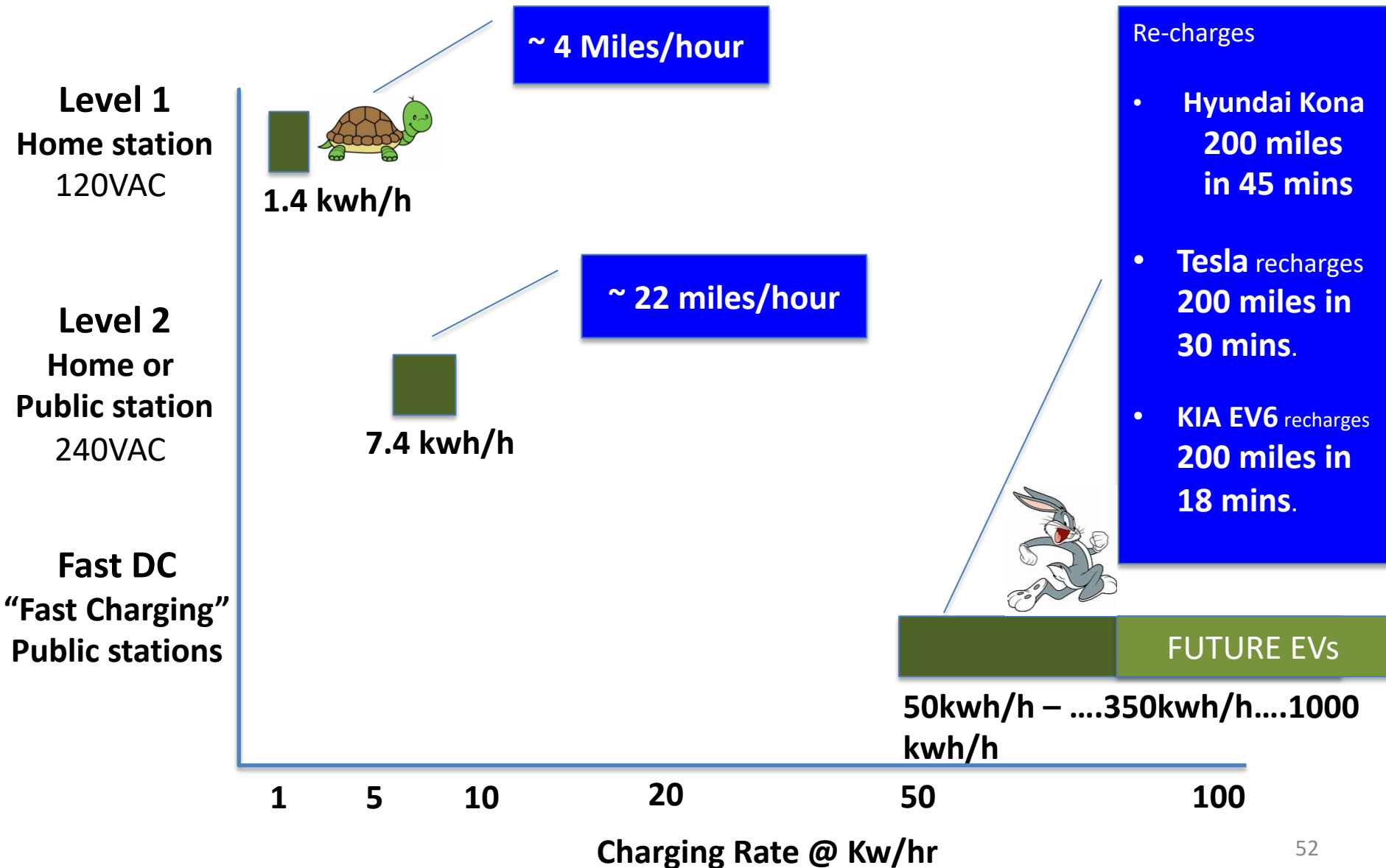


- No oil pressure
- No water temp
- No engine coolant
- No water pump or alternator
- No belts to adjust or replace
- No exhaust system to rust

Charging Networks



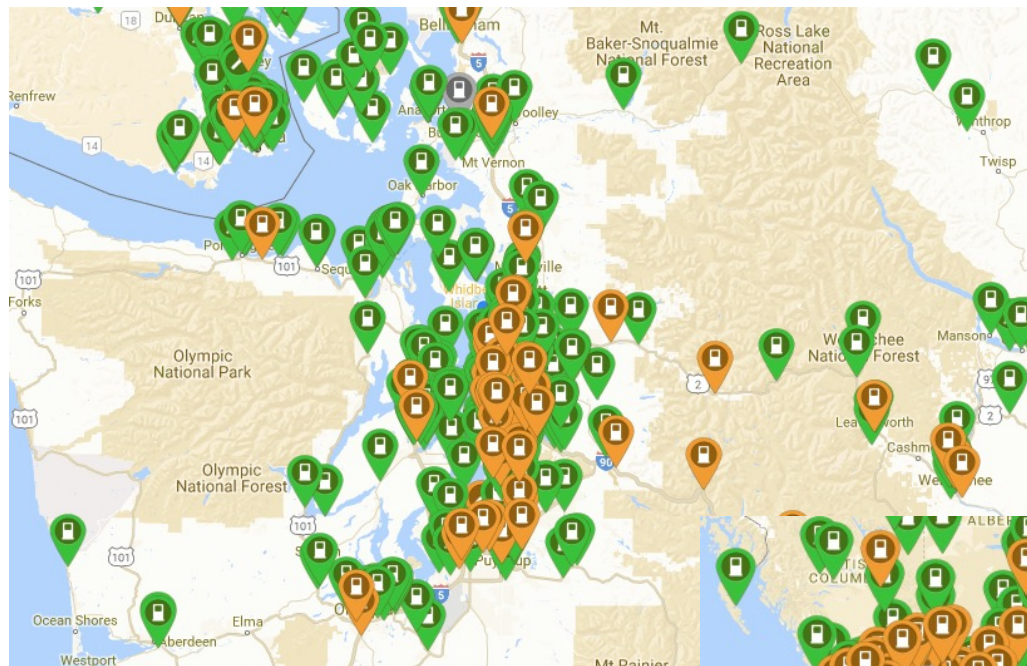
Charging Stations



Charging Stations

	Slow 	Faster	 Fast
Outlet	<div>Level 1 110VAC, 1.4 Kw</div> <div><ul style="list-style-type: none">• Toaster• Stereo• TV• Lamps</div> <div> Wall</div>	<div>Level 2 220VAC, 3.3 - 7.4 Kw,</div> <div><ul style="list-style-type: none">• Ovens, ranges, and cooktops• Clothes dryers• Furnaces• Electric Water heaters</div> <div> NEMA 14-50</div>	<div>Fast DC “Fast Charge”</div> <div><ul style="list-style-type: none">• CCS• CHAdeMO• Tesla</div> <div>High Voltage DC 50 kw – 350kw</div>
Vehicle Connection	 J-1772	 J-1772	<div> CCS/SAE</div> <div> CHAdeMO</div> <div> Tesla</div>
Charging Equipment		 	
	Home	Public	

Public Charging Networks



—chargepoint+

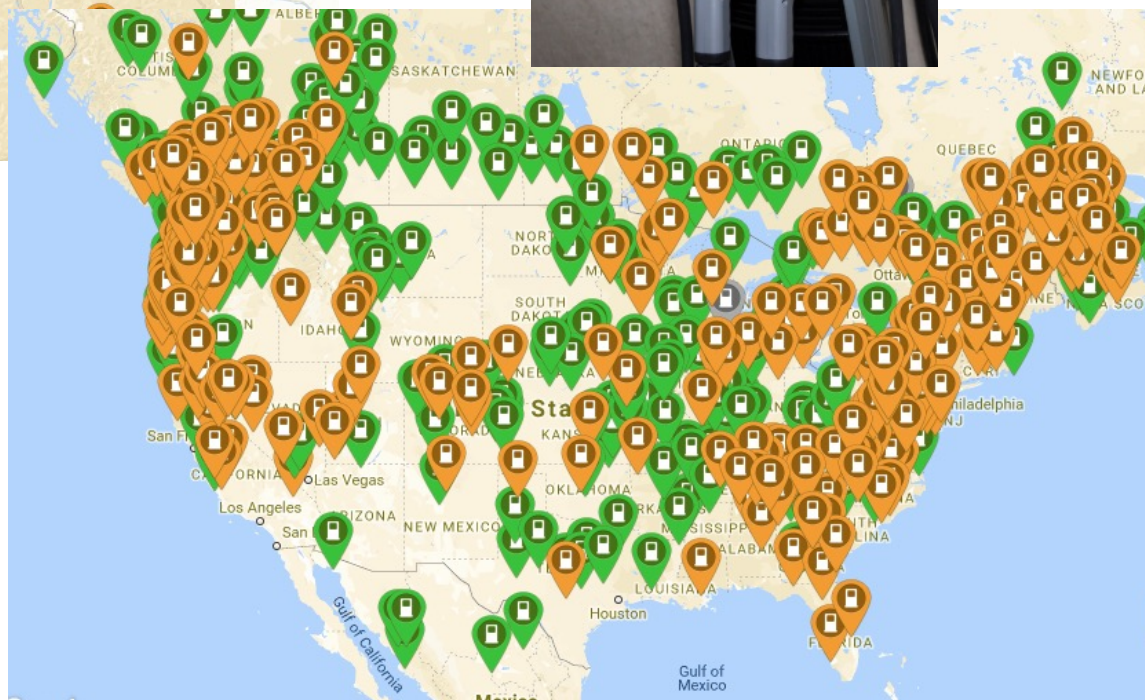
EVgo



SemaConnect


blink

electrify
america



Map images from  PlugShare App and Plugshare.com 54

Mobile apps & Networks – Fast DC & Level 2

 PlugShare

Search for a Charging Location


Filters

Showing Filters for


Use My Current Location

Plugs (2 of 8)


Toggle All




Supercharger




CCS/SAE




CHAdeMO




J-1772




Tesla



Tesla (Roadster)



NEMA 14-50



Wall

Location Filters (2 of 5)

Show Locations That Require Payment

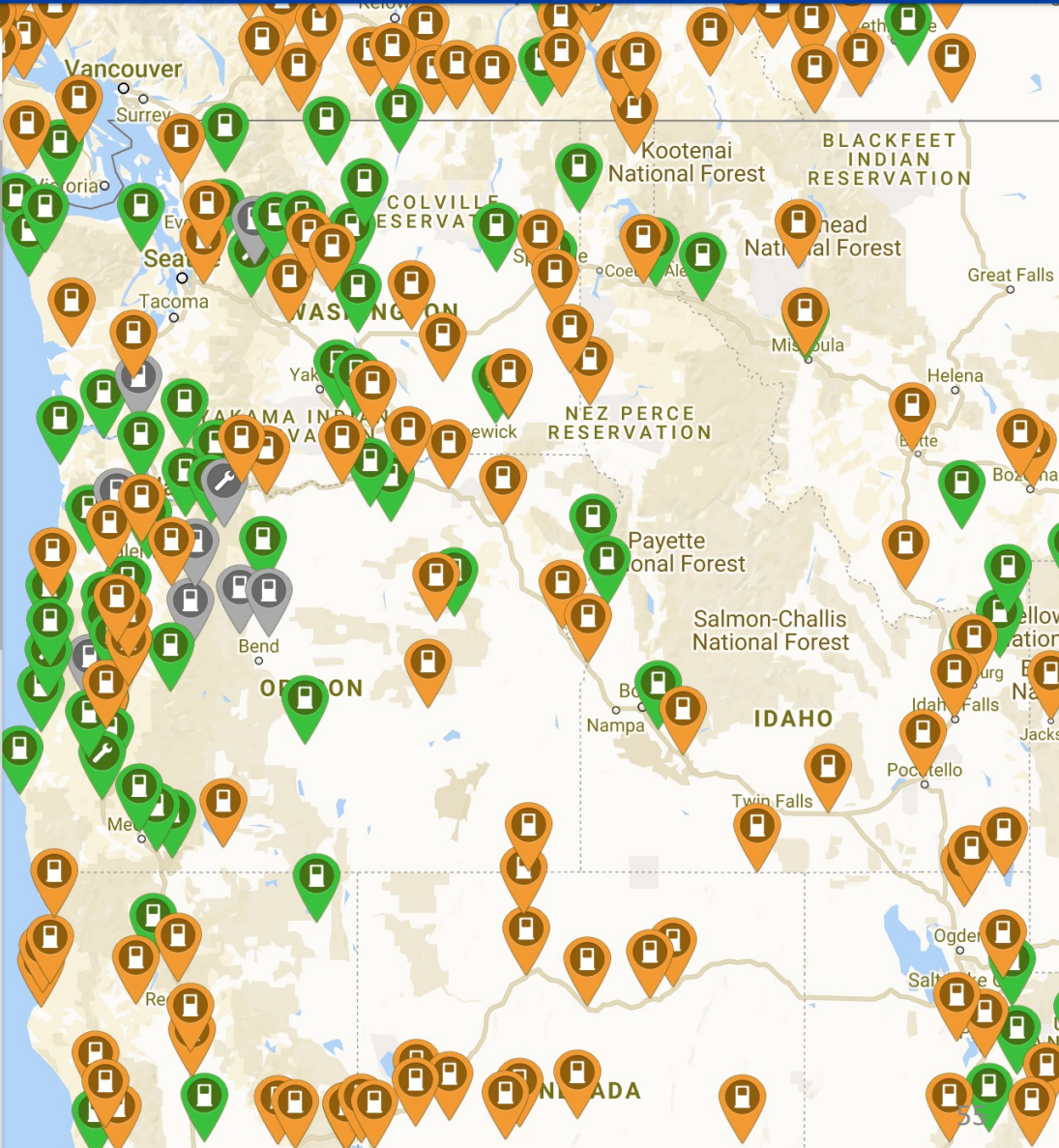
Show In-Use Locations

Show Restricted Locations

Show Residential Locations

Show Coming Soon Locations

Minimum Power (0 kW)



Using a Public Charging Station with Smartphone

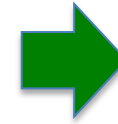
Find a
charging
station



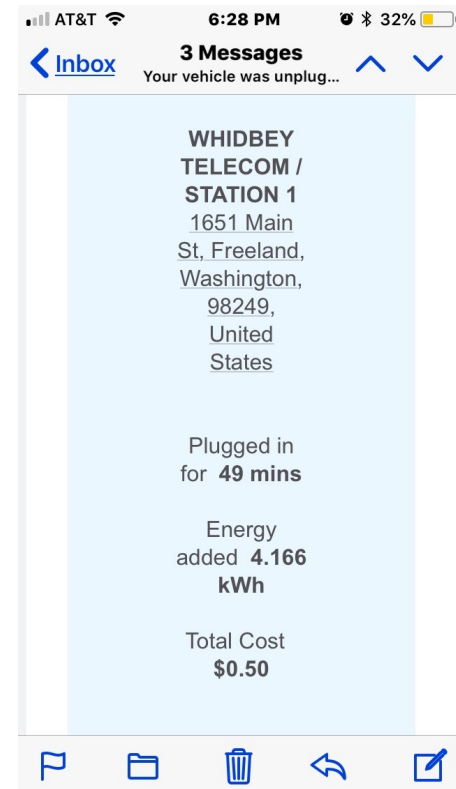
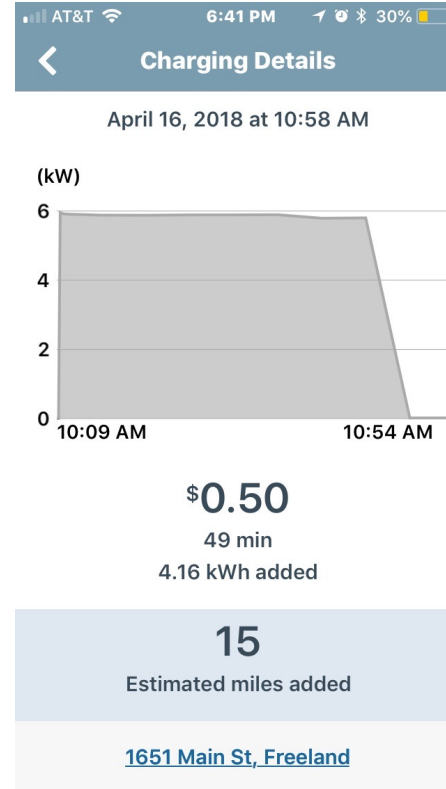
Connect,
Activate, &
Pay
(App, RFID,
Credit Card)



Monitor
charging &
Notify
complete



Payment
confirmation



Are they affordable ?

Base price (MSRP + DST and after Tax Credit)

All-electric range (EPA)

	\$0	\$50 000	\$100 000
2022 Nissan LEAF S (40 kWh)	149	\$20 875	
2022 MINI Cooper SE	114	\$23 250	
2022 Nissan LEAF e+ S (62 kWh)	226	\$25 875	
2021 Hyundai IONIQ Electric	170	\$26 750	
2022 Mazda MX-30	100	\$27 145	
2022 Hyundai Kona Electric	258	\$27 685	
2022 Nissan LEAF e+ SV (62 kWh)	215	\$30 875	
2022 Chevrolet Bolt EV	259	\$31 995	
2022 Kia Niro EV (e-Niro)	239	\$33 665	
2021 Volkswagen ID.4 Pro	260	\$33 690	
2022 Chevrolet Bolt EUV	247	\$33 995	
2021 Ford Mustang Mach-E Select SR RWD	230	\$36 495	
2021 Volkswagen ID.4 AWD Pro	249	\$37 370	
2021 BMW i3	153	\$37 945	
2021 Volkswagen ID.4 Pro S	250	\$38 190	
2021 Ford Mustang Mach-E Select SR AWD	211	\$39 195	
2022 Polestar 2 Single Motor 19"	265	\$39 700	
2021 BMW i3s	153	\$41 145	
2021 Tesla Model 3 Standard Range Plus	262	\$41 190	
2021 Tesla Model 3 Standard Range Plus	263	\$41 190	
2021 Volkswagen ID.4 AWD Pro S	240	\$41 870	
2022 Polestar 2 Dual Motor 19"	249	\$43 700	
2021 Ford Mustang Mach-E Route 1 ER RWD	305	\$44 000	
2021 Ford Mustang Mach-E Premium ER RWD	300	\$46 200	
2022 Volvo XC40 Recharge	223	\$48 895	

Are they affordable? - Used EV prices - Ads from Paramount Motors Seattle

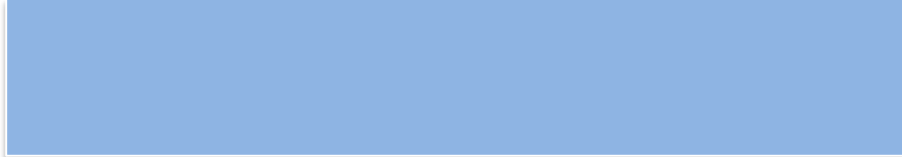


2012 NISSAN LEAF SL

\$6,995

Mileage:

57,482 miles

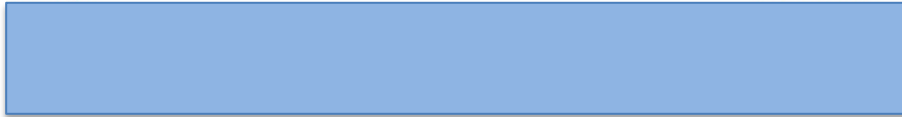


2014 FORD FOCUS ELECTRIC

\$6,995

Mileage:

86,983 miles



2016 KIA SOUL EV

\$11,995

Mileage:

31,248 miles

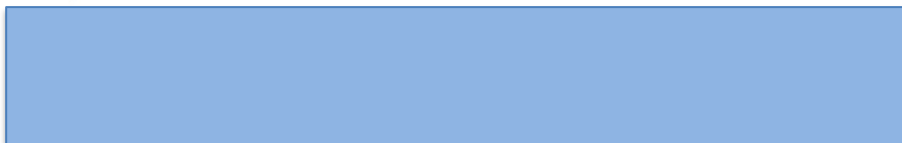


2017 CHEVROLET BOLT EV LT

\$22,500

Mileage:

41,077 miles



Federal Tax Incentives

Qualified Plug-in Electric Drive Motor Vehicle Credit

- purchase of a new electric vehicle is eligible for an income tax credit worth between **\$2,500 to \$7,500**
 - Purchased after December 31, 2009
 - Battery has at least 5 kilowatt hours (kWh) of capacity
 - Uses an external plug-in source to recharge
 - Has a vehicle weight rating of up to 14,000 pounds
- *This tax credit has a “phase out” built into the program. The phase out will kick in at the beginning of the second calendar quarter after a manufacturer has sold 200,000 eligible BEVs and/or PHEVs*

Washington State EV Incentive

- Sales tax exemption
- New light vehicles are subject to a 6.8 % sales tax in Washington.
 - up to \$2,500 tax reduction for new vehicles < \$45,000
 - up to \$1,600 tax reduction for used vehicles < \$30,000

- 1 (Electric vehicles that are able to travel at least 30 miles using only battery power.
- 2 OR vehicles exclusively powered by a clean alternative fuel (electricity, dimethyl ether, hydrogen, methane, natural gas, liquefied natural gas, compressed natural gas, or propane)
- 3 OR vehicles that use at least one method of propulsion that is capable of being re-energized by an external source of electricity and are capable of traveling at least thirty miles using only battery power.)

Drive Electric

- Performance
- Fuel and Maintenance savings (\$0.03/mile @ \$0.09/kwh)
- Reduce climate disaster for children & grandchildren



Thank you !

Favorite Links :

jeffersoncan.org

coltura.org

cityofpa.us/1010/Climate-Resiliency-Plan

Olyclimate.org

www.aboutCATES.org

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