Why all the excitement about Electric Vehicles?

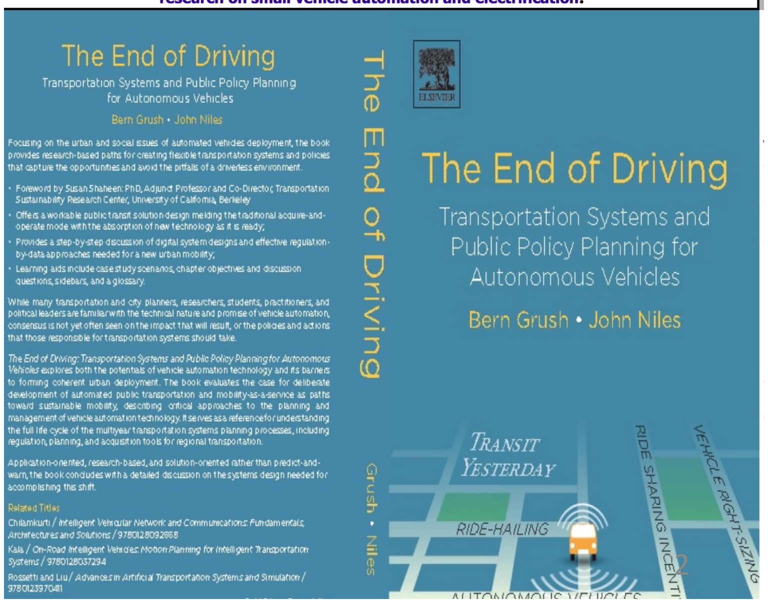
Presenter info

- 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.

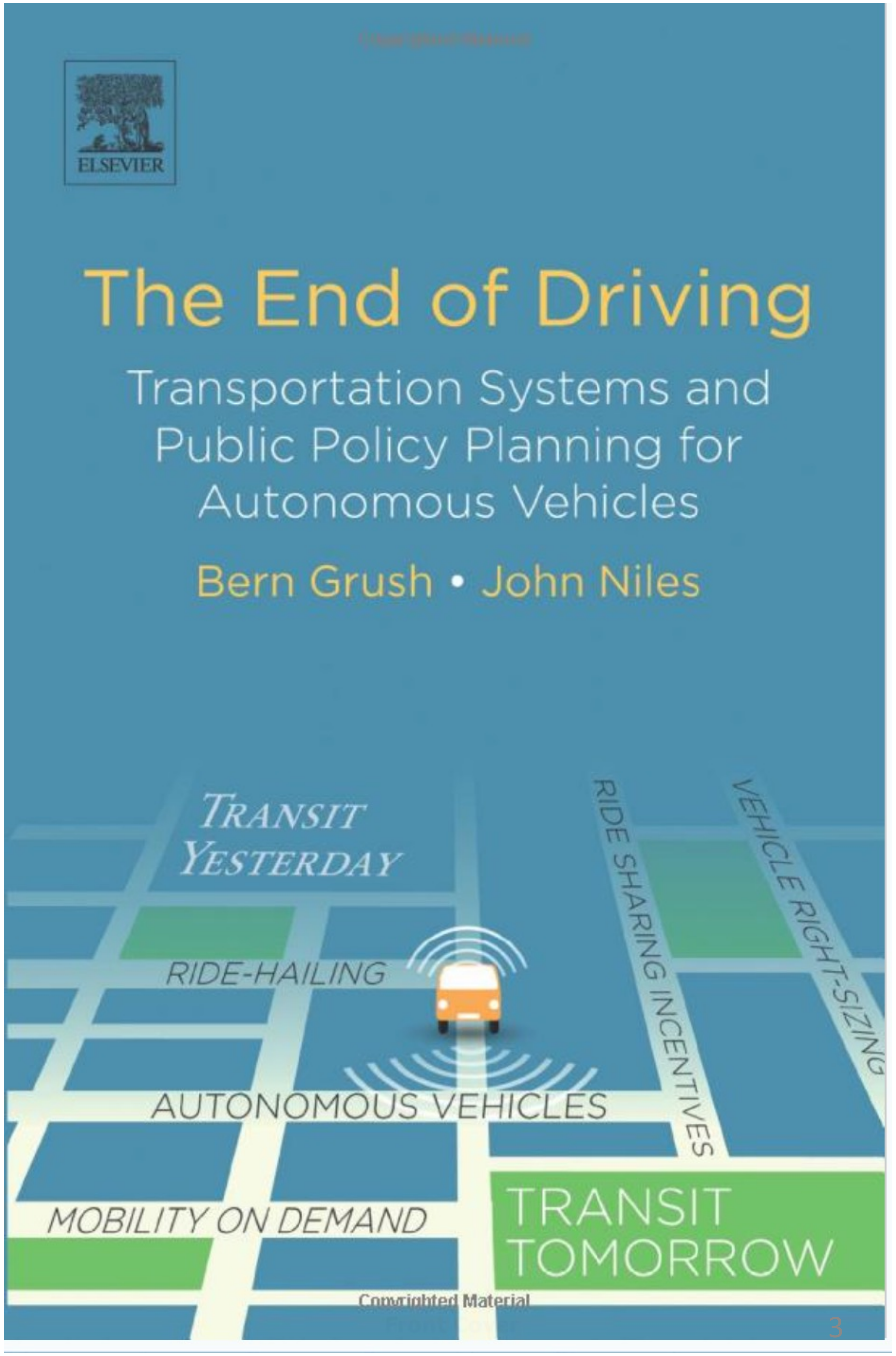


The End of Driving: Transportation Systems and Public Policy Planning for Autonomous Vehicles

- explores the potential of **<u>vehicle automation technology</u>**

- the barriers to urban deployment

- evaluates the case of automated public transportation and **<u>mobility-as-a-service</u>** as paths toward sustainable mobility



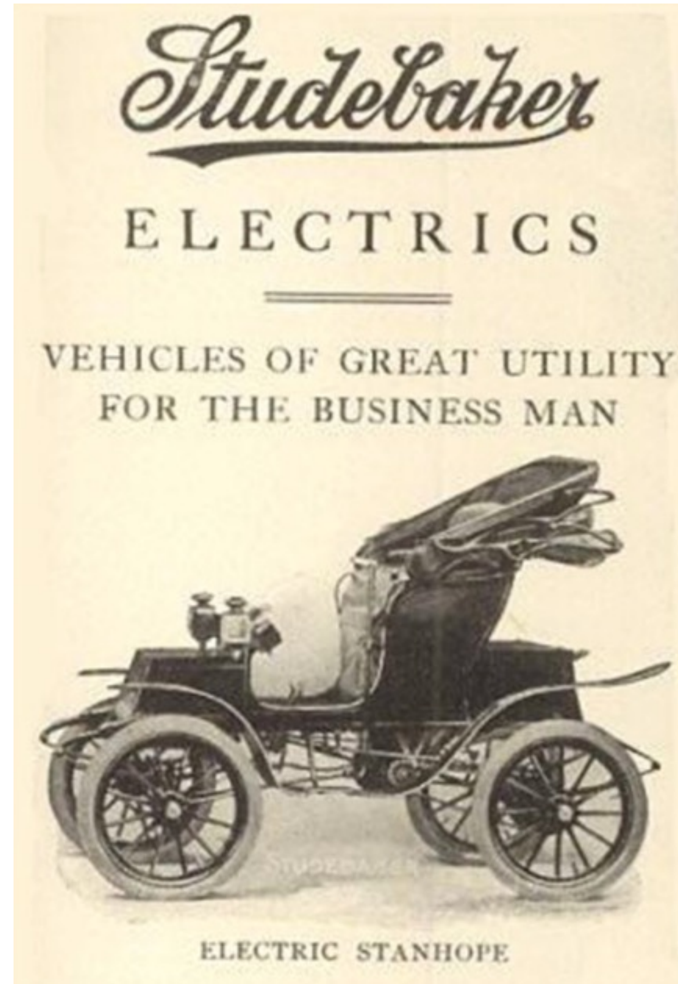
Why all the excitement about EVs?

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



GM EV1 2,300 built 1996 - 1999

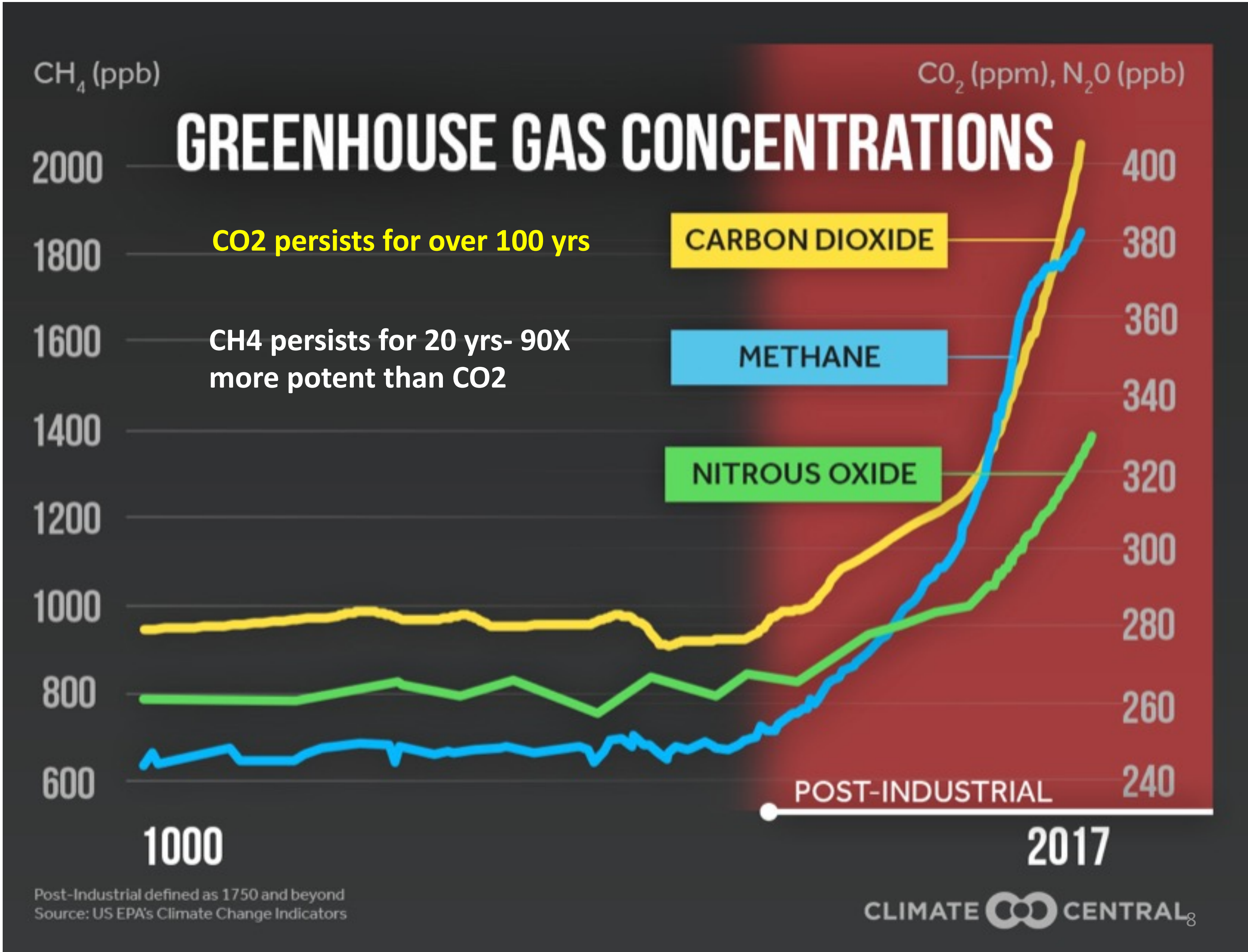
Movie : “Who killed the electric car?”

Why all the excitement today?

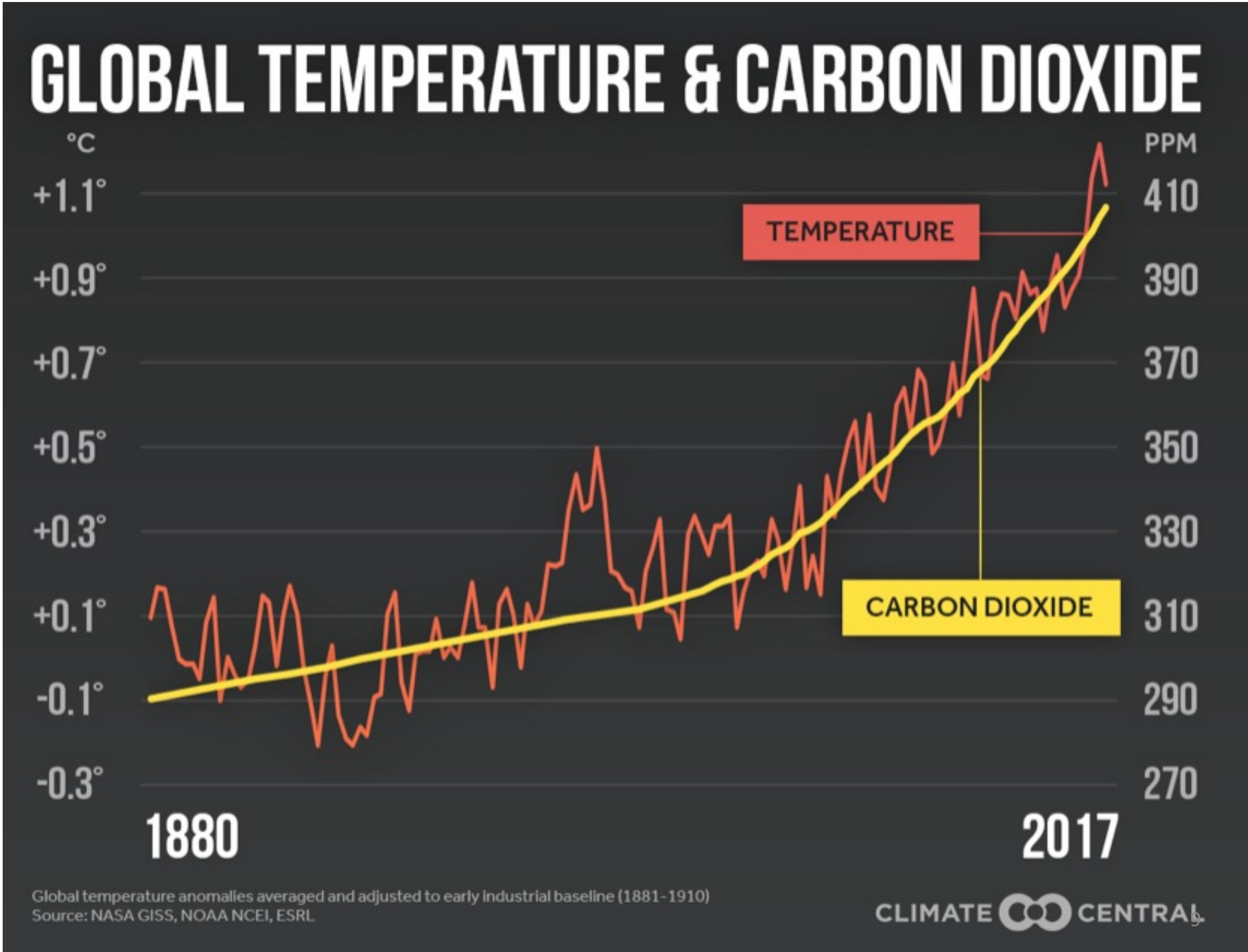
- Impacts of GHG emissions are recognized thru the climate science research and evidence, driving the urgent need to rapidly reduce anthropogenic co2 emissions
  - Transportation sector is largest share of U.S. co2 emissions at 29%
  - One gallon of gas or diesel emits about 21 lbs of co2

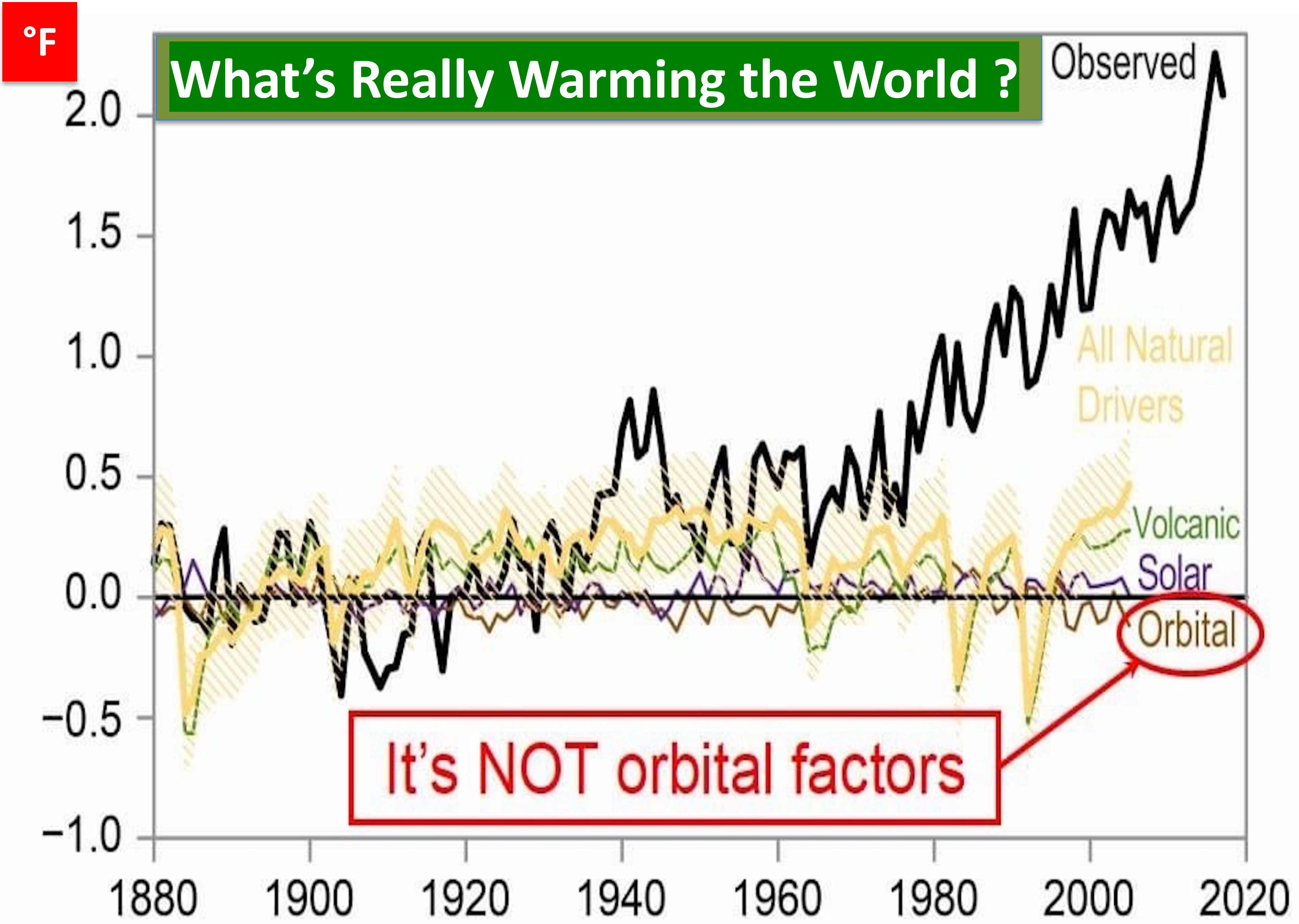
- Advanced Battery Technology
  - Lighter
  - Denser
  - Reliable

- Battery costs are falling thru mass production economies of scale and making electric vehicles more affordable and life cycle costs very compelling



GREENHOUSE GAS CONCENTRATIONS
CH4 (ppb)
CO2 (ppm), N2O (ppb)
CO2 persists for over 100 yrs
CH4 persists for 20 yrs- 90X more potent than CO2
CARBON DIOXIDE
METHANE
NITROUS OXIDE
2000
1800
1600
1400
1200
1000
800
600
400
380
360
340
320
300
280
260
240
POST-INDUSTRIAL
1000
2017
Post-Industrial defined as 1750 and beyond
Source: US EPA's Climate Change Indicators
CLIMATE CENTRAL

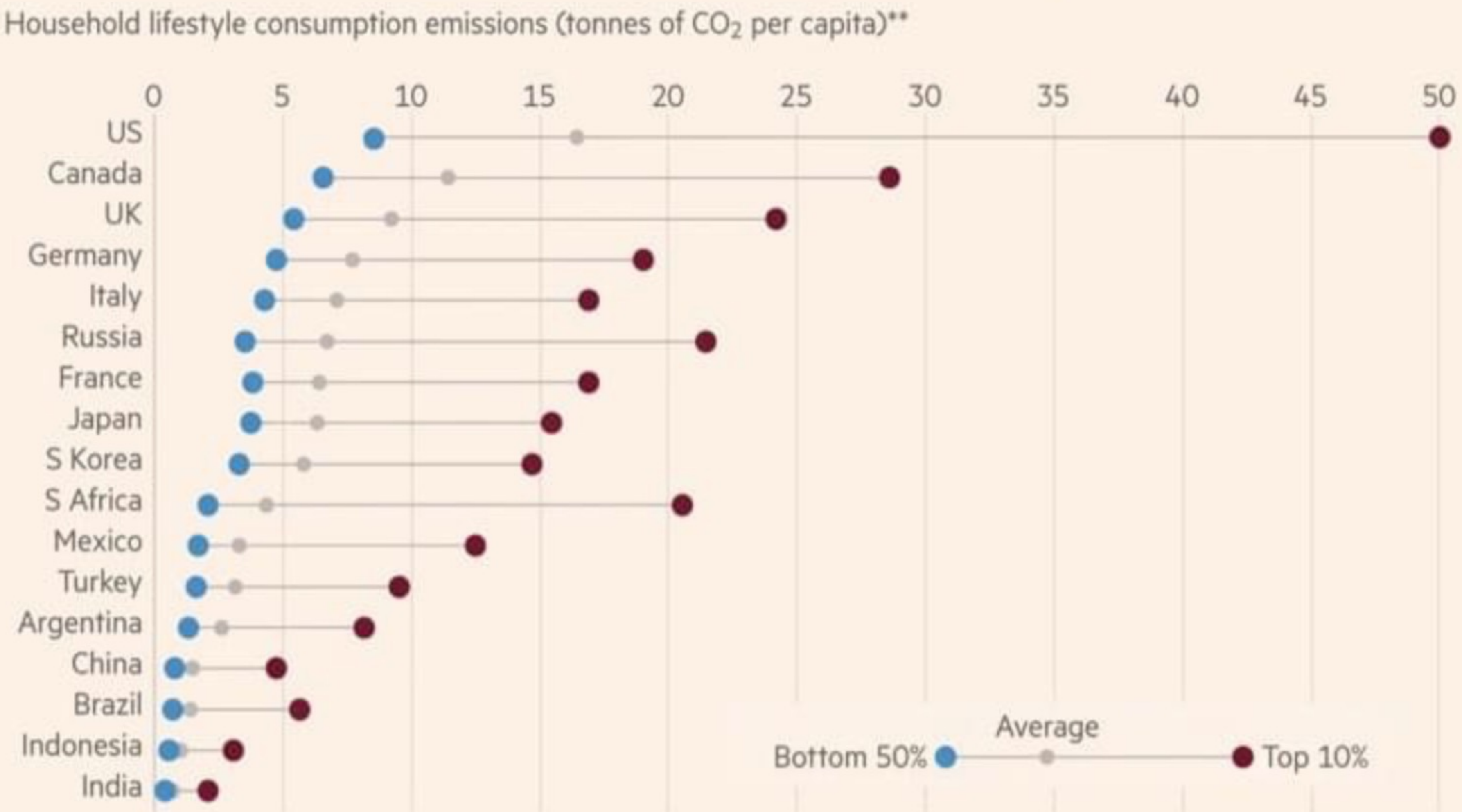

GLOBAL TEMPERATURE & CARBON DIOXIDE
°C
PPM
+1.1°
+0.9°
+0.7°
+0.5°
+0.3°
+0.1°
-0.1°
-0.3°
410
390
370
350
330
310
290
270
TEMPERATURE
CARBON DIOXIDE
1880
2017
Global temperature anomalies averaged and adjusted to early industrial baseline (1881-1910)
Source: NASA GISS, NOAA NCEI, ESRL
CLIMATE CENTRAL


°F
What's Really Warming the World ?
Observed
All Natural Drivers
Volcanic
Solar
Orbital
It's NOT orbital factors
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
1880
1900
1920
1940
1960
1980
2000
2020

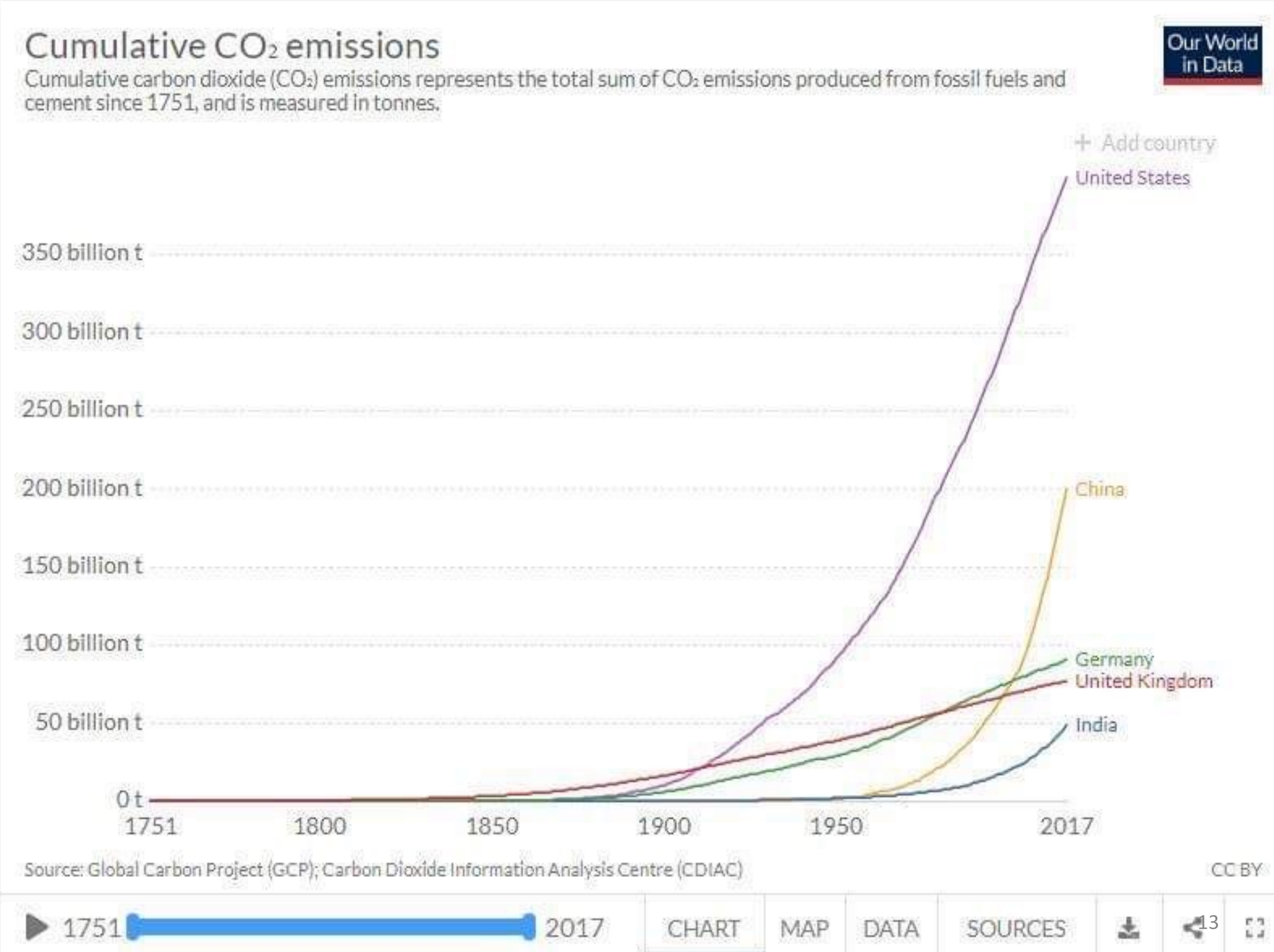
- WHATS REALLY WARMING THE WORLD?

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

Emissions per capita

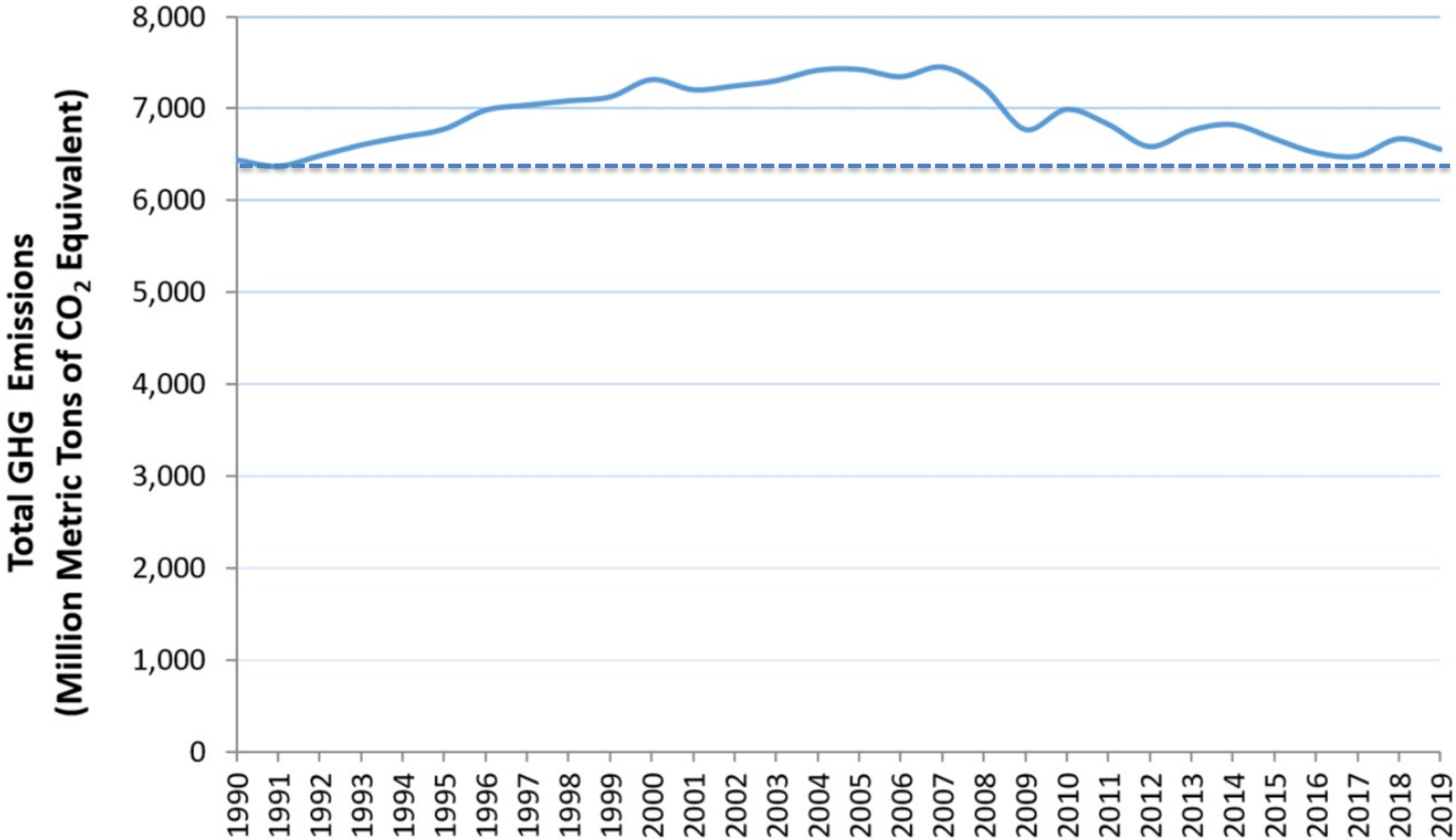


** In G20 countries for which data is available
Visual journalism: Steven Bernard/@sdbernard and Chelsea Bruce-Lockhart/@C_BruceLockhart
Source: Oxfam
© FT



Cumulative CO_2 emissions
Cumulative carbon dioxide (CO_2) emissions represents the total sum of CO_2 emissions produced from fossil fuels and cement since 1751, and is measured in tonnes.
Our World in Data
+ Add country
United States
China
Germany
United Kingdom
India
350 billion t
300 billion t
250 billion t
200 billion t
150 billion t
100 billion t
50 billion t
0 t
1751
1800
1850
1900
1950
2017
Source: Global Carbon Project (GCP); Carbon Dioxide Information Analysis Centre (CDIAC)
CC BY
1751
2017
CHART
MAP
DATA
SOURCES

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



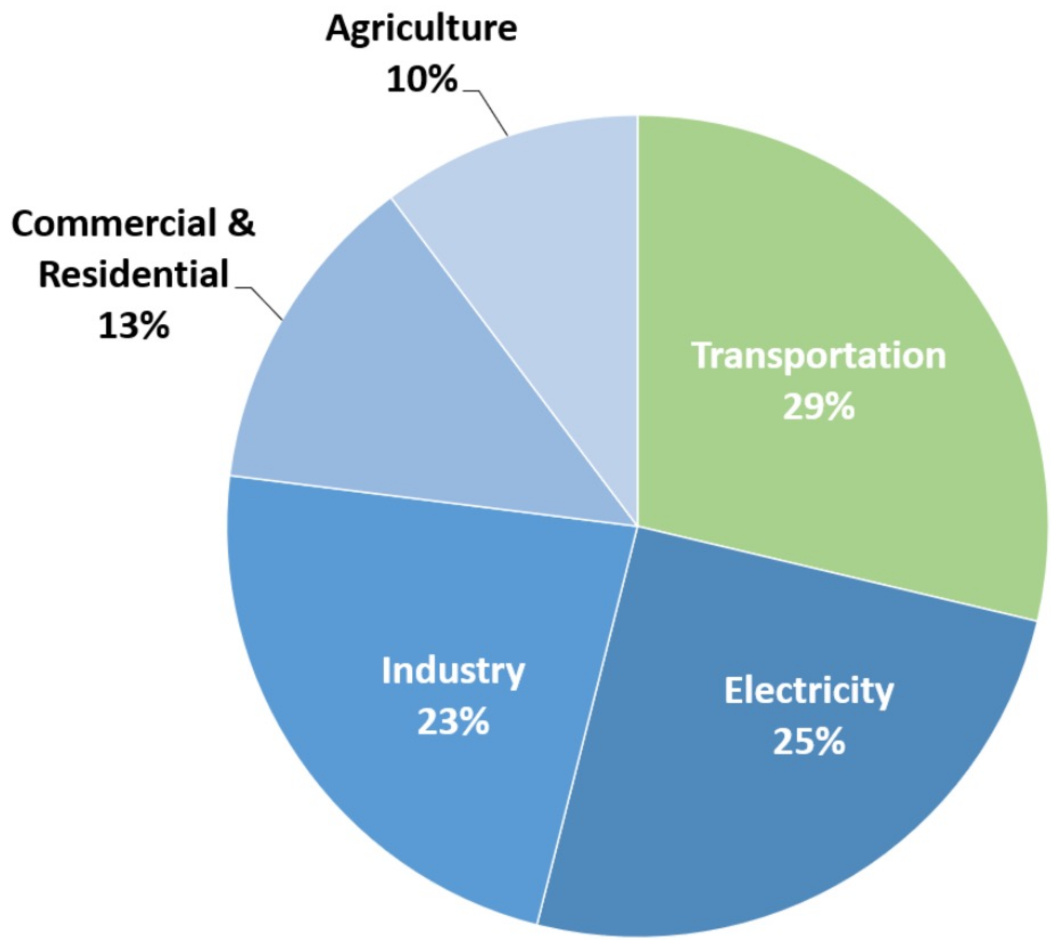
Note: All emission estimates from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2019*.

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

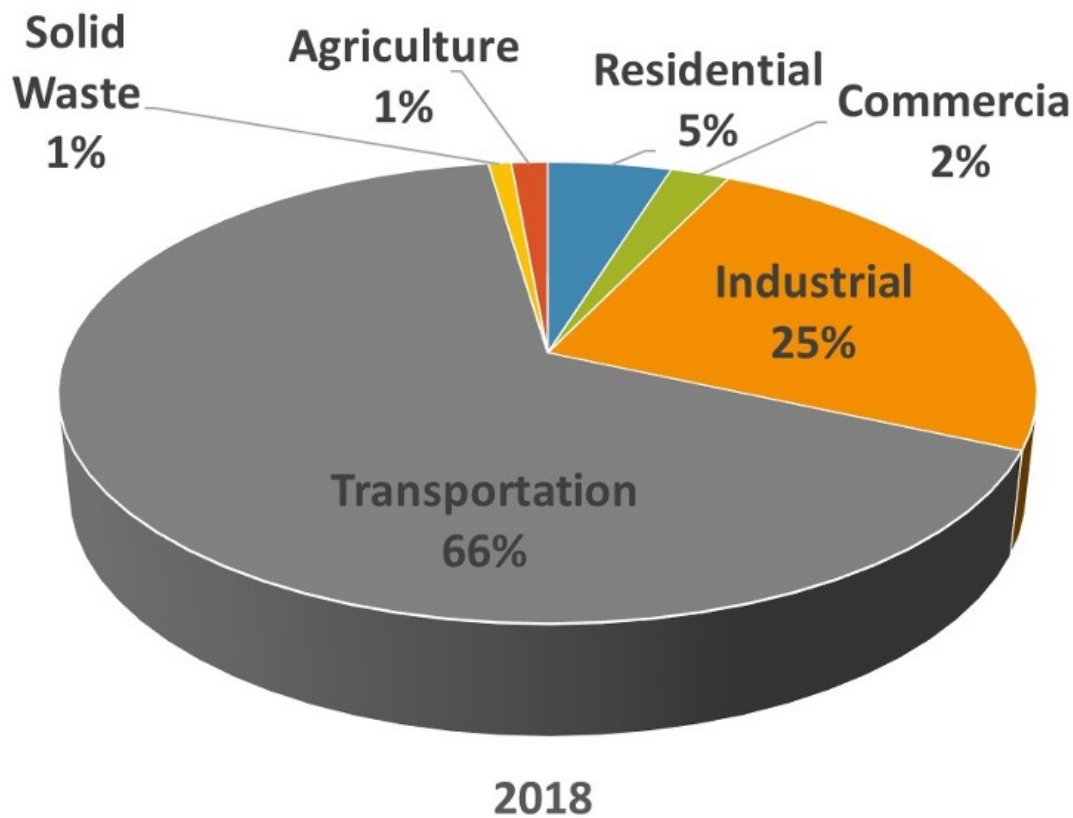
  - commercial aircraft, ships, boats, and trains, as well as pipelines and lubricants



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

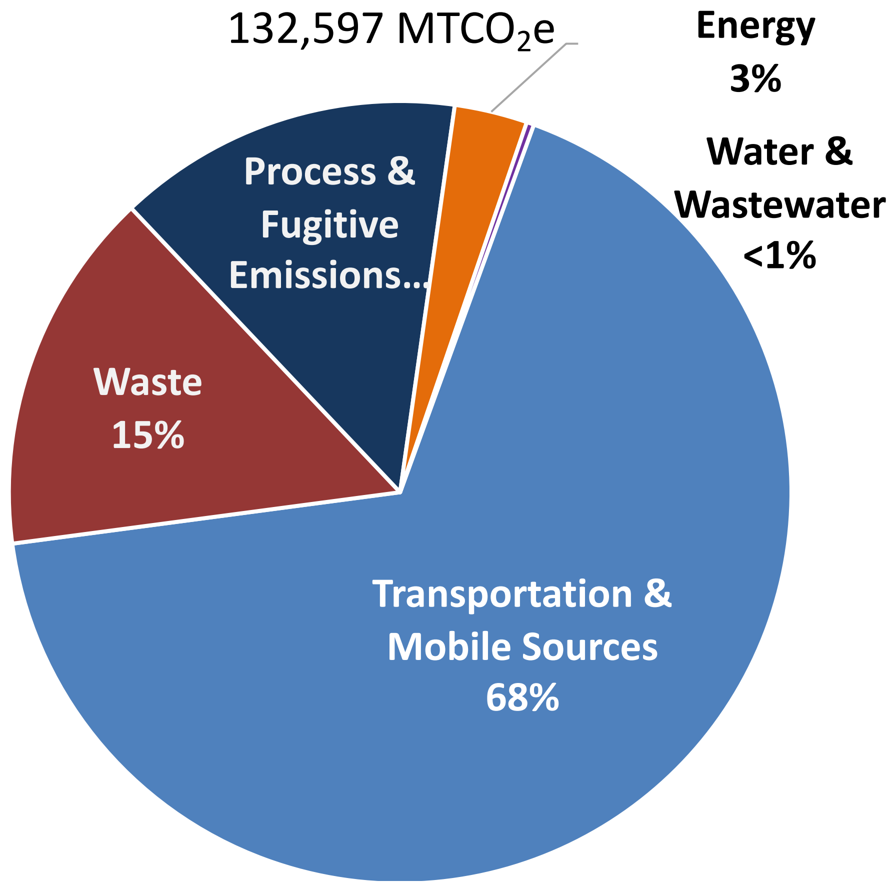


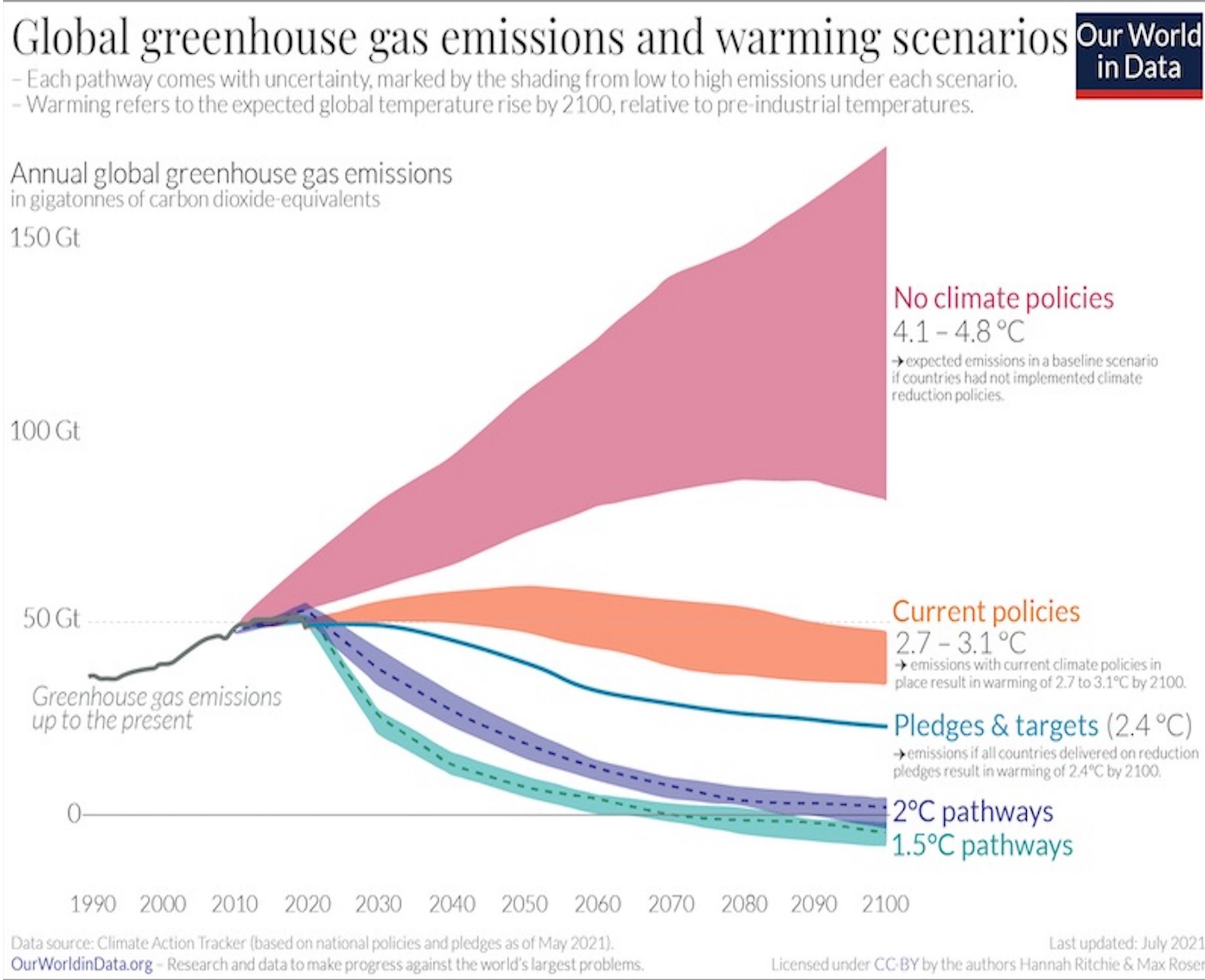
Inventory Results: 2019 Community Snapshot

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

Total 2019 Community Emissions:
132,597 $MTCO_2e$





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

- NO_2 forms from emissions from cars, trucks and buses, power plants, and off-road equipment

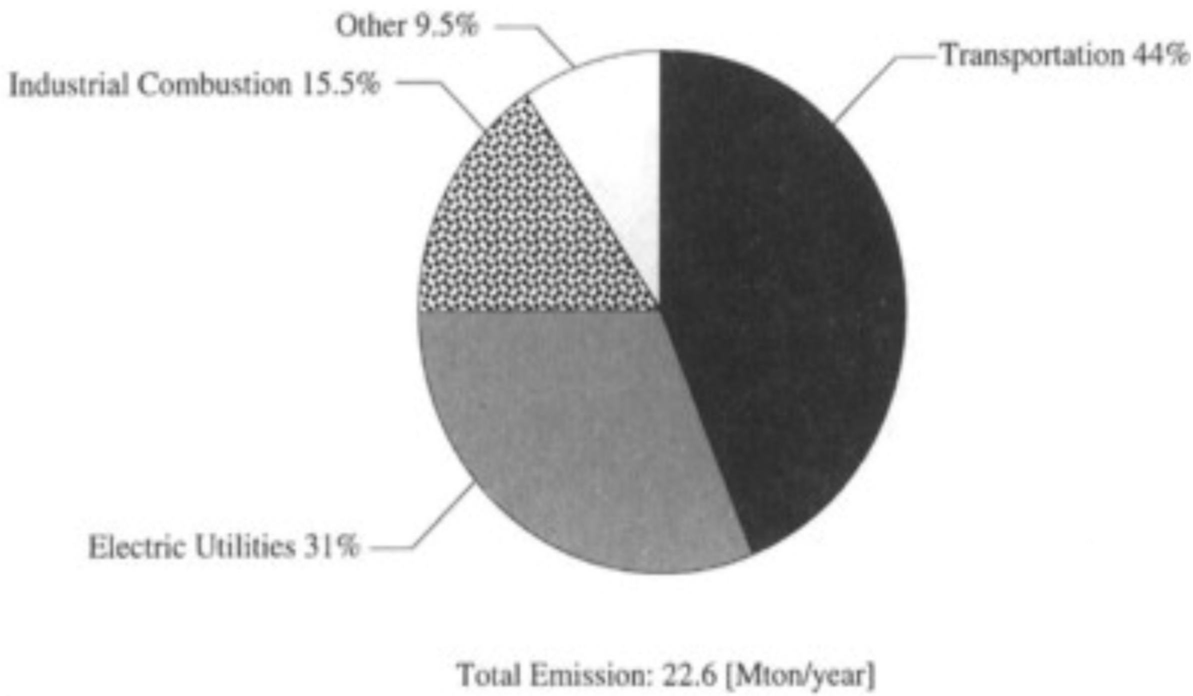
- contribute to the development of asthma

- increase susceptibility to respiratory illnesses

- Acid rain

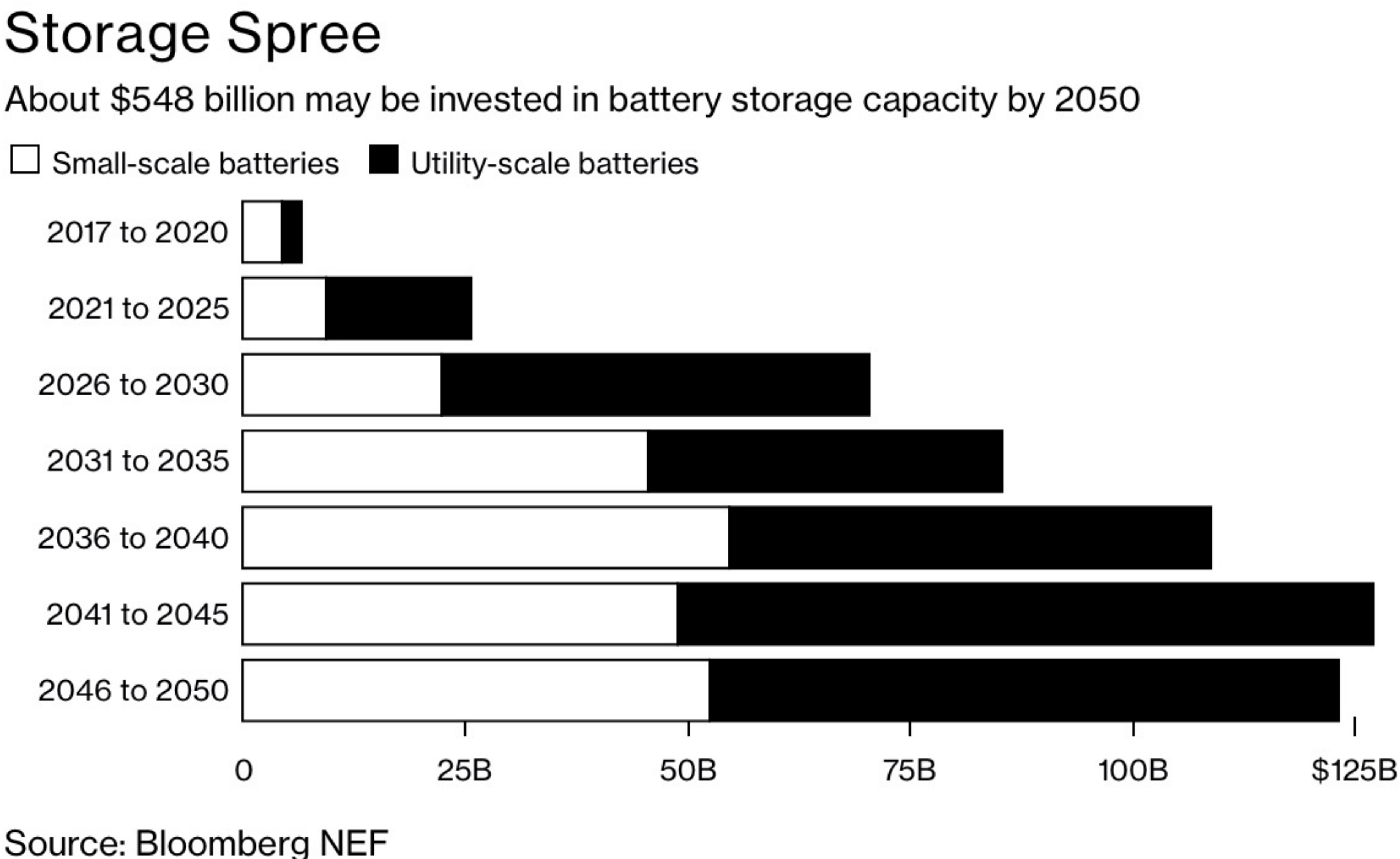
- Haze

- Nutrient pollution : algae blooms

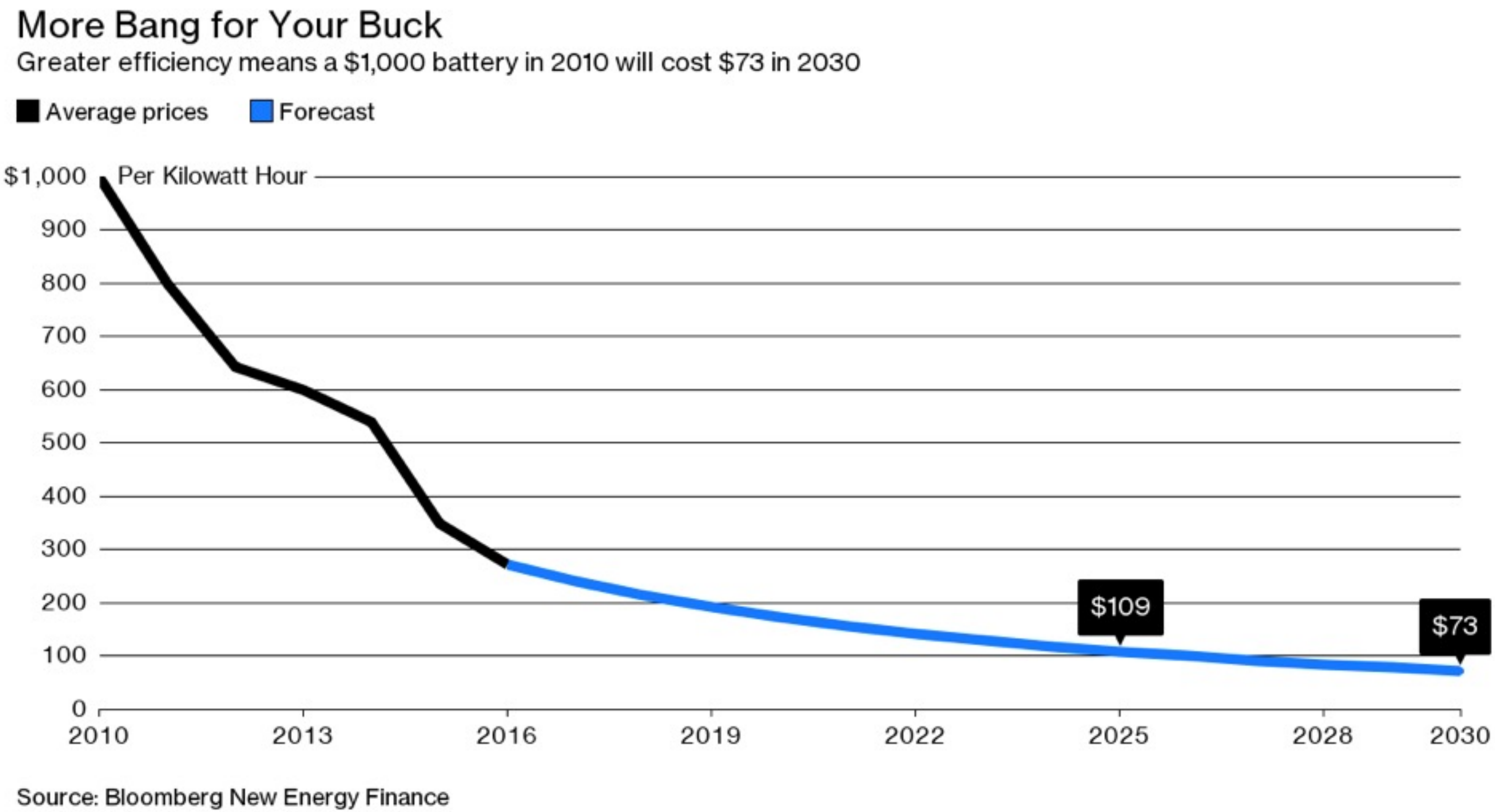


The Future of clean energy includes batteries

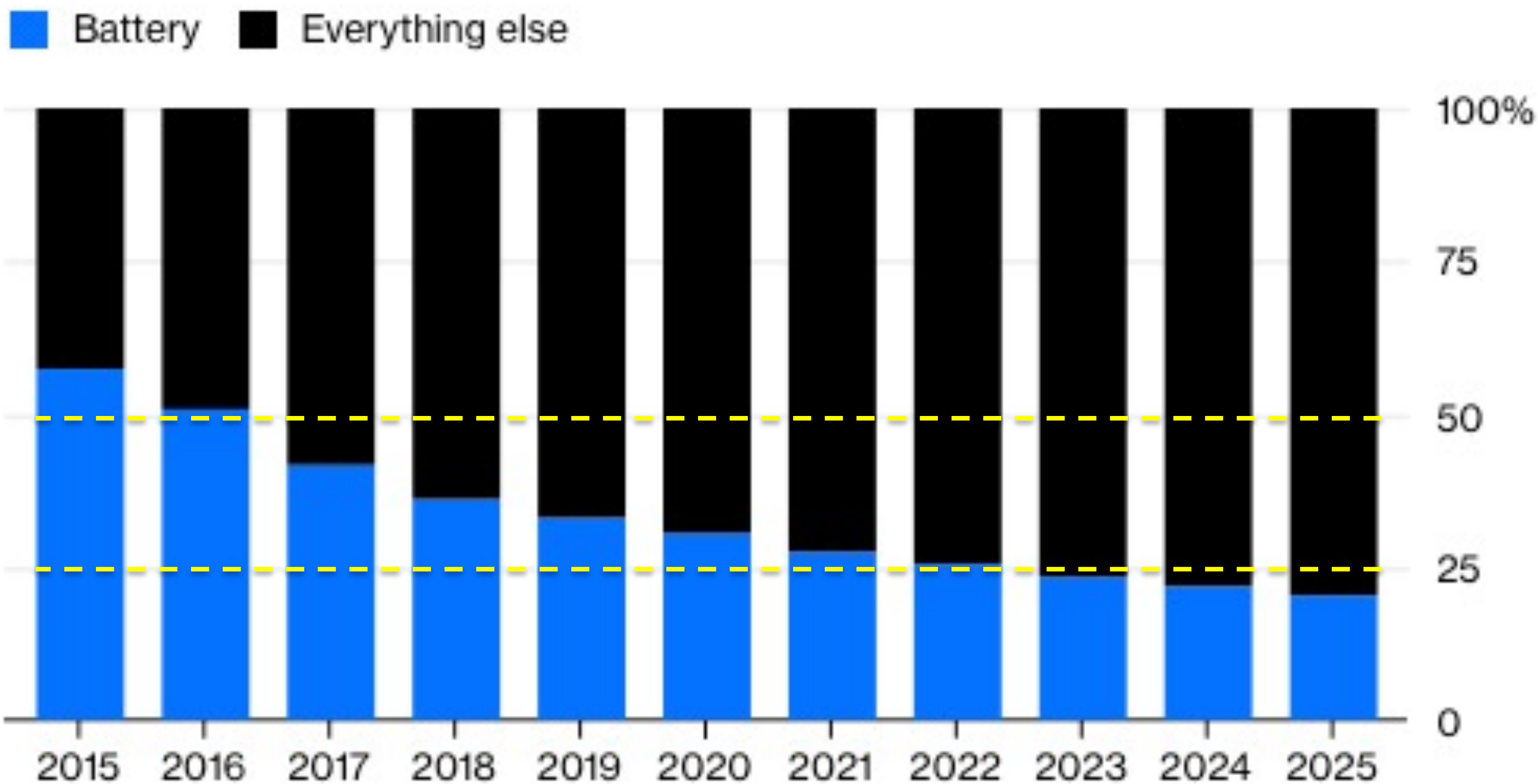
Battery Investments



Battery costs falling rapidly …….

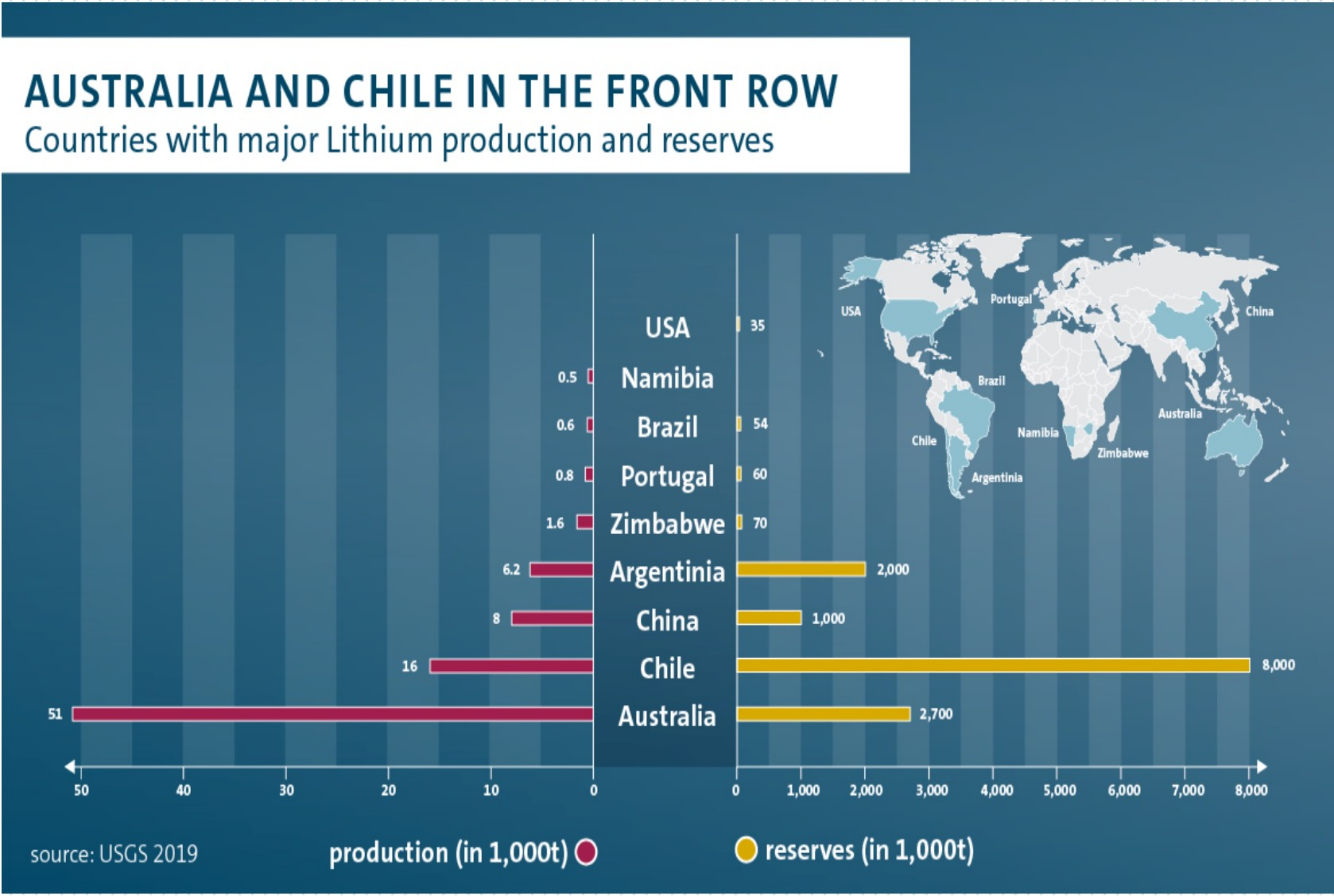


EV battery cost for U.S. medium-size car as a percentage of retail price



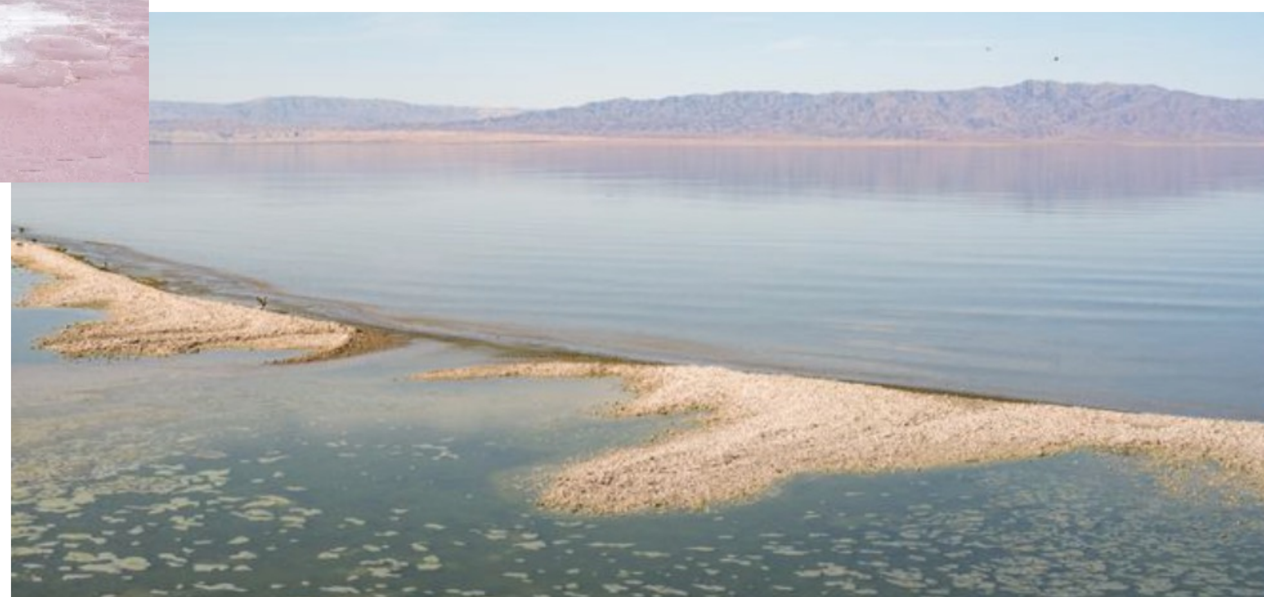
Source: BloombergNEF
Note: Includes profit margins and costs other than direct manufacturing costs.

Where will the Lithium come from ?



GM Will Suck Lithium from the Salton Sea to Make Batteries

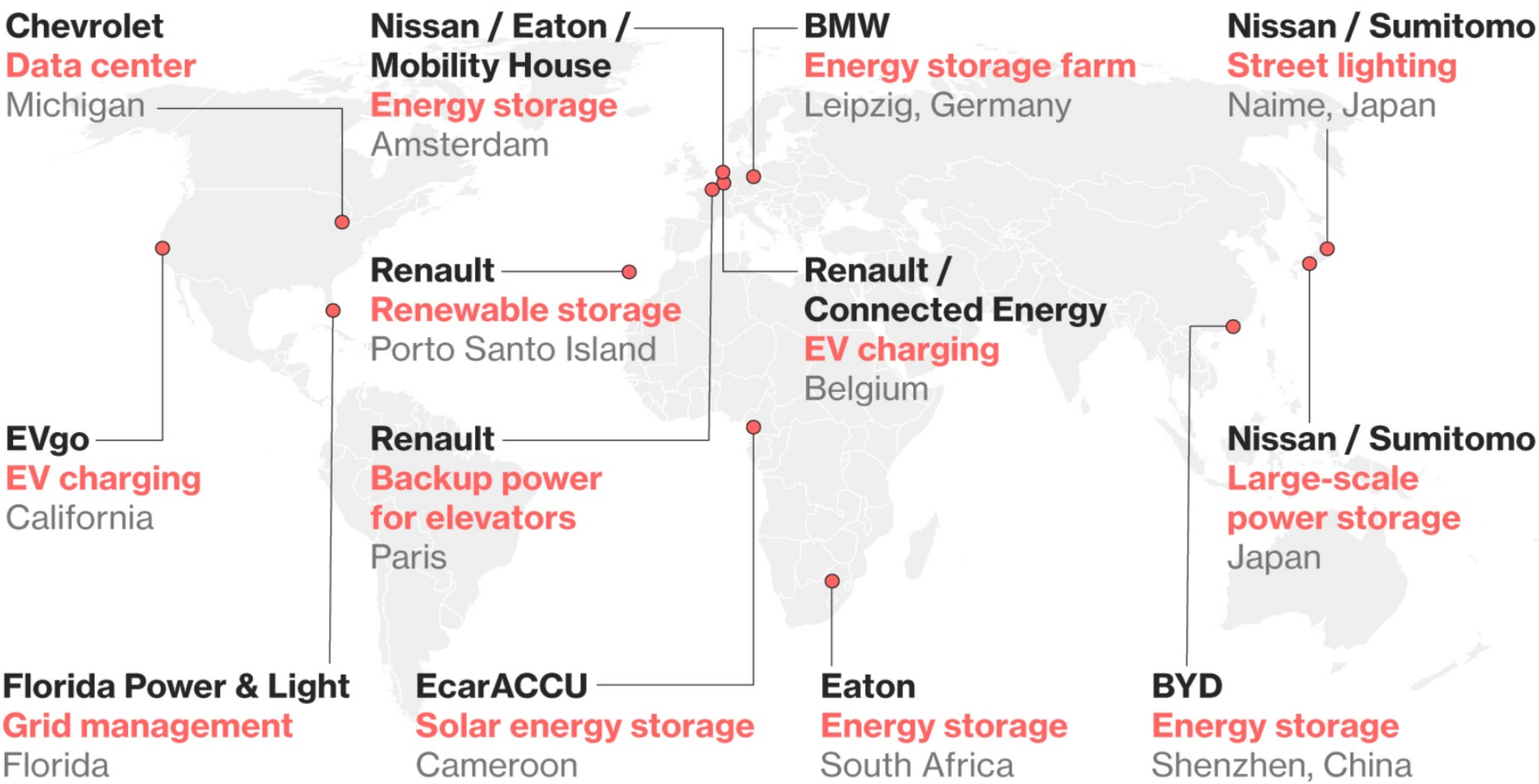
"California Energy Commission's estimate that the **Salton Sea area could produce 600,000 tons of lithium per year**, which is amazing **since the entire world's industry produced a mere 85,000 tons of lithium in all of 2019.."**
Source: AutoWeek July 2021



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

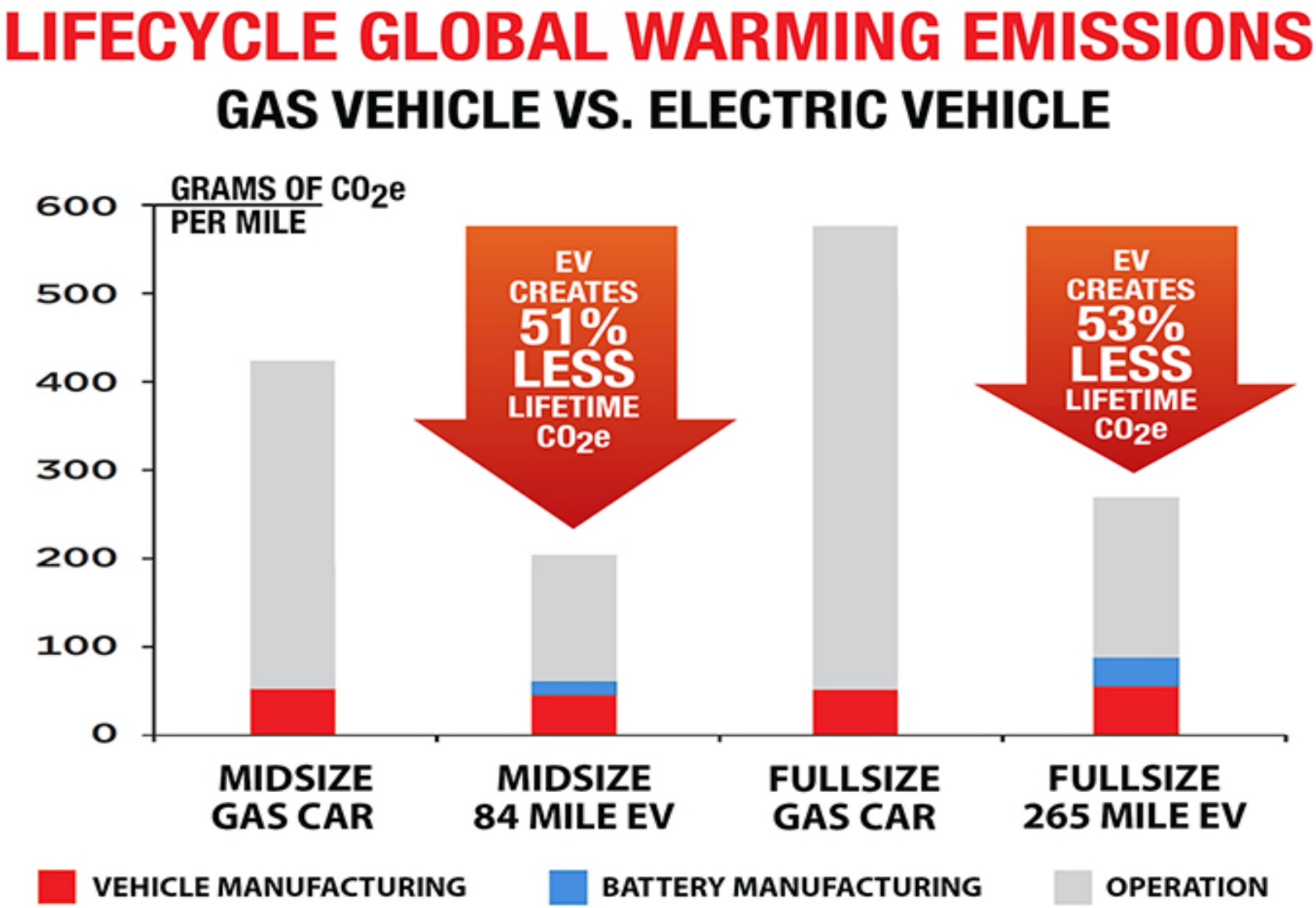
Li-Cycle, Northvolt, and Ganfeng Lithium are among those building recycling plants, spurred by environmental and supply-chain concerns

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.

Source : IEEE Spectrum

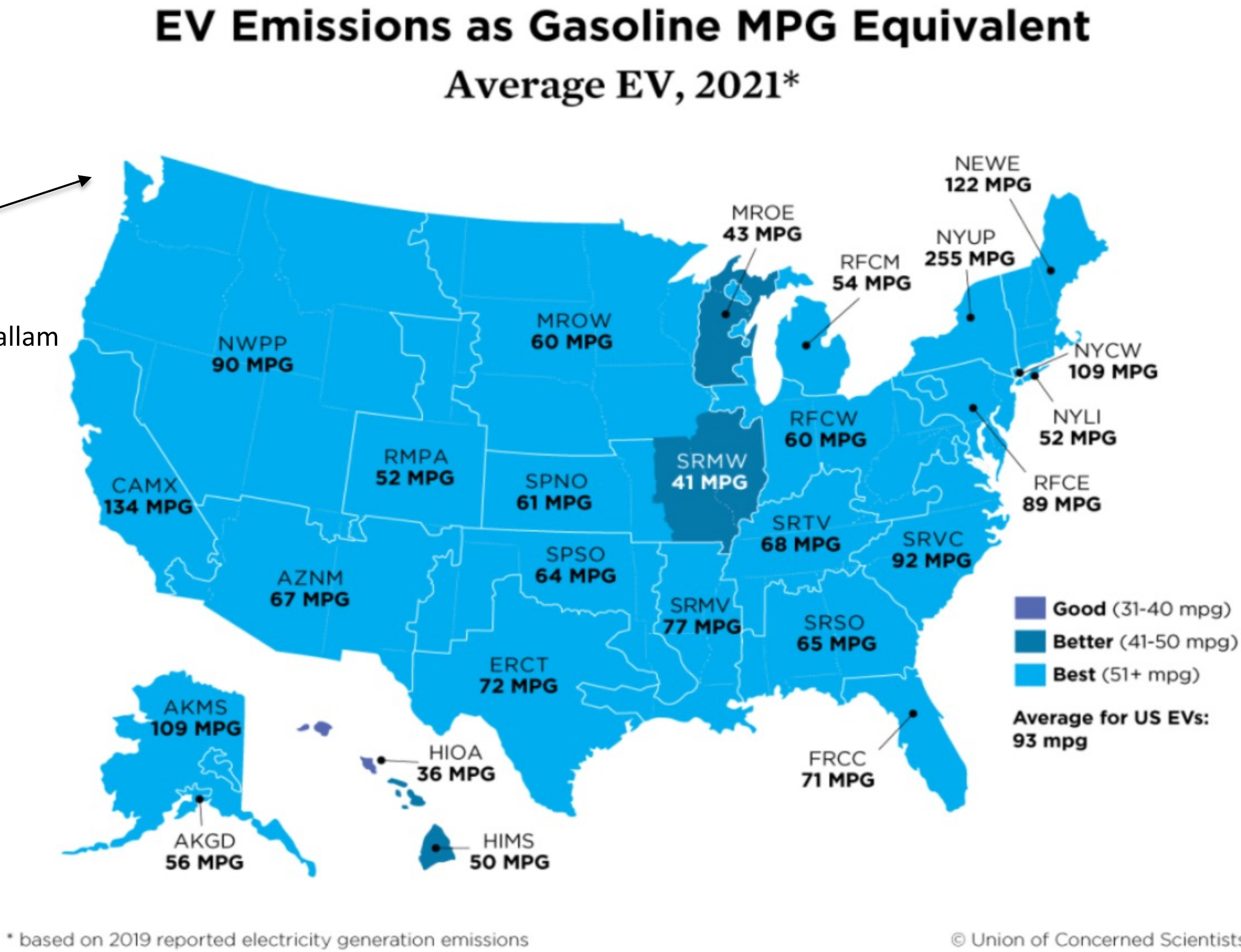
CO2 Footprint of EV



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 driving.

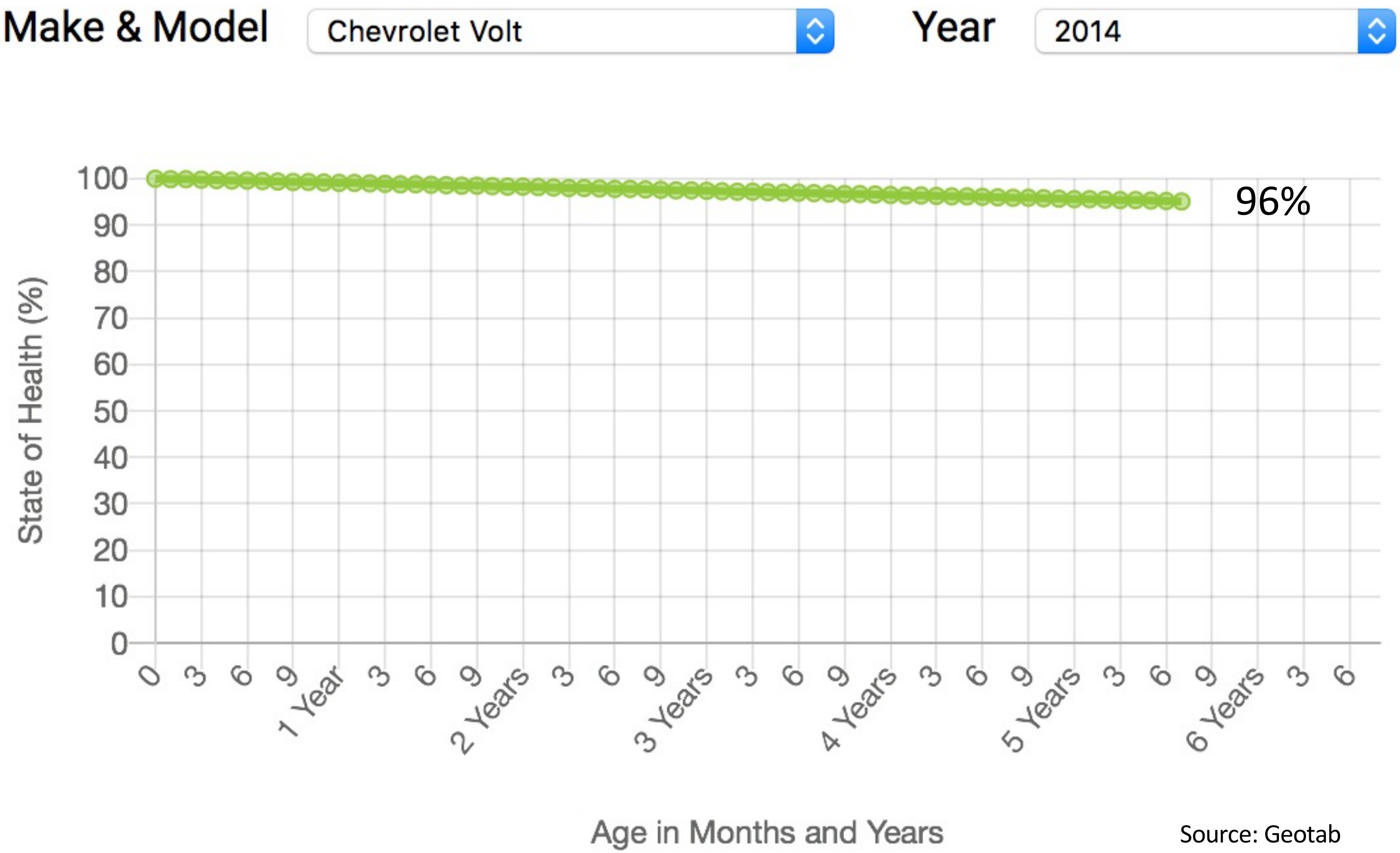
Where you live makes a difference

> 2,000 MPG Equivalent in Port Angeles, Clallam & Jeff Co.



Source: Union of Concerned Scientists, 2021

What about Degradation?



Source: Geotab

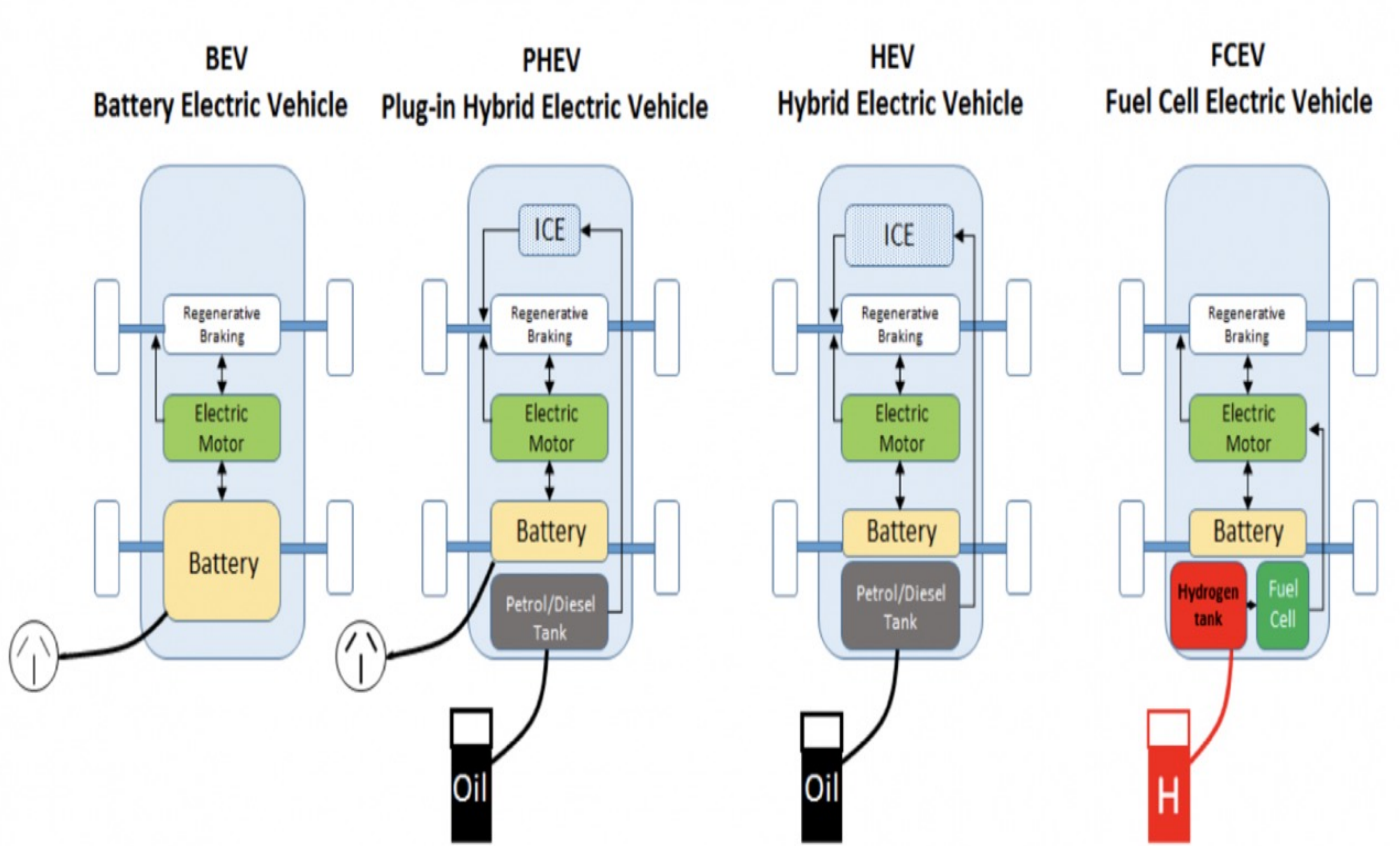
Causes:

- **Degradation increases if using DCFC frequently (DC fast charging)**
- **Avoid operating much below 10%**

- Battery Mgt Systems differ between vehicles

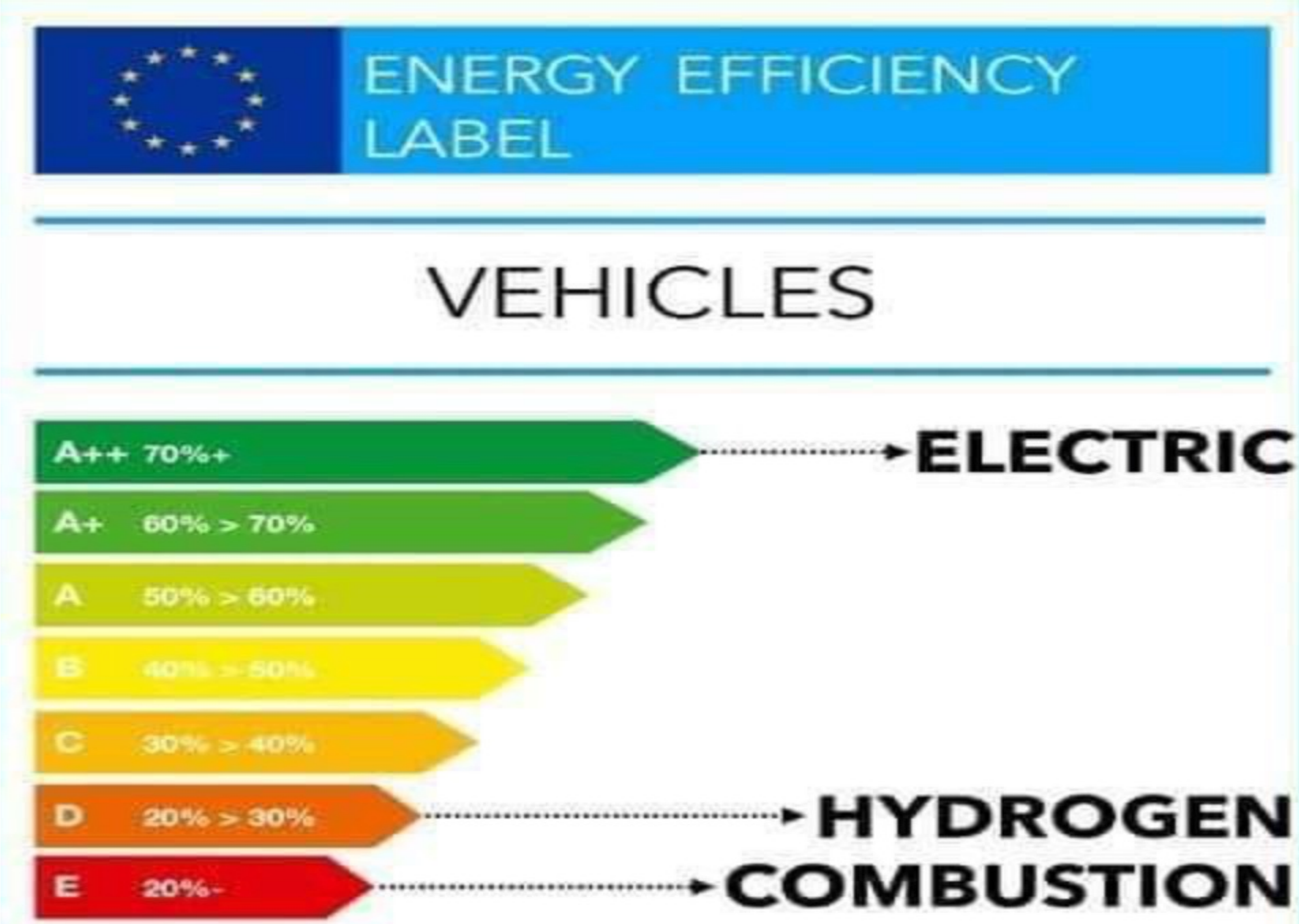
Passive Thermal management systems (ex. Leaf) vs Active liquid cooled & heated (preferred)

Types of Electrified Vehicles Today



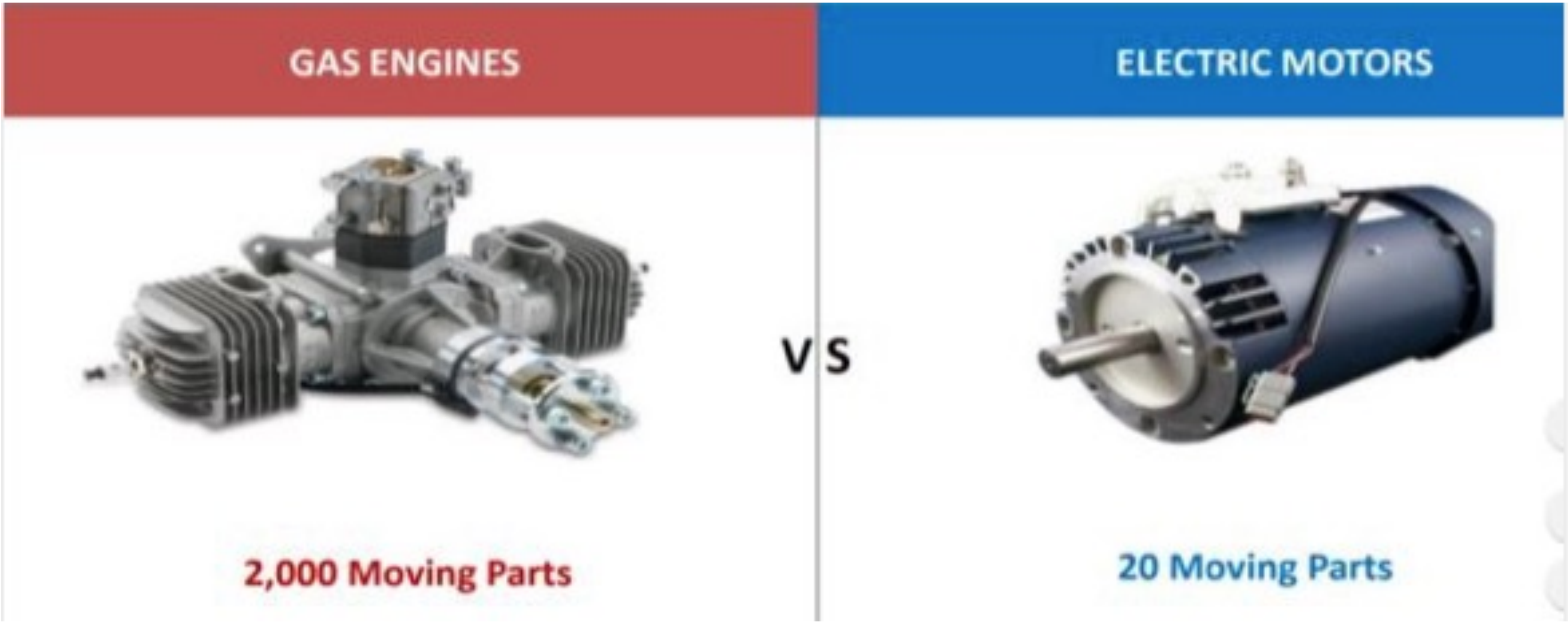
- *Series* or *parallel* ?

Source: Thedriven.io, **The ICE age is over: Why battery cars will beat hybrids and fuel cells** [NOVEMBER 14, 2018]

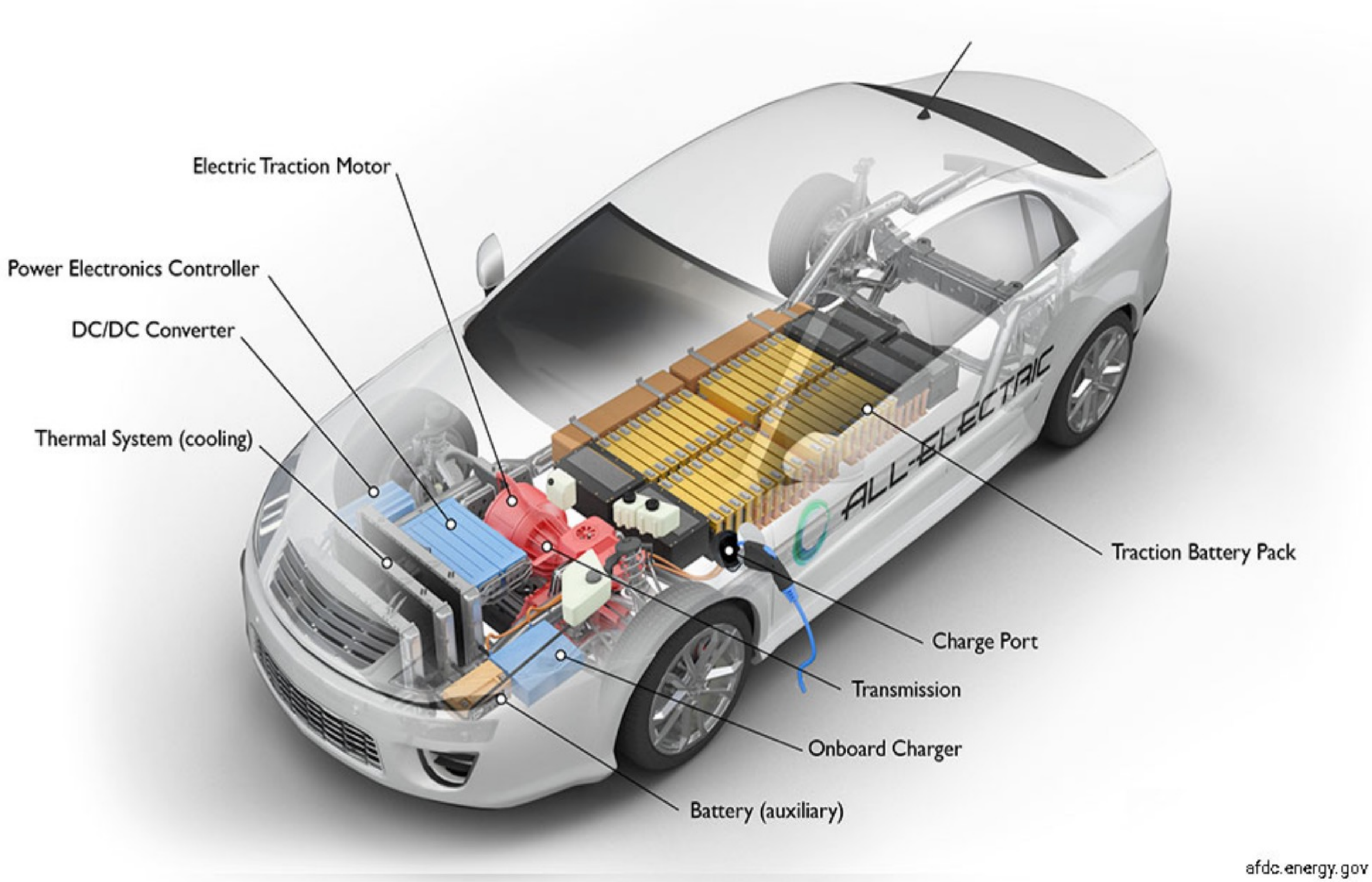


The World requires your Leadership and contribution in order to better use the energy and ensure the transition from fossil sources to renewable sources. Hence, it is important to realize 30% of the energy contained in the fuel of a conventional vehicle (know as 'ICE' Internal Combustion Engine) is actually 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



100% Battery Electric Simple Design



afdc.energy.gov

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.																				✓

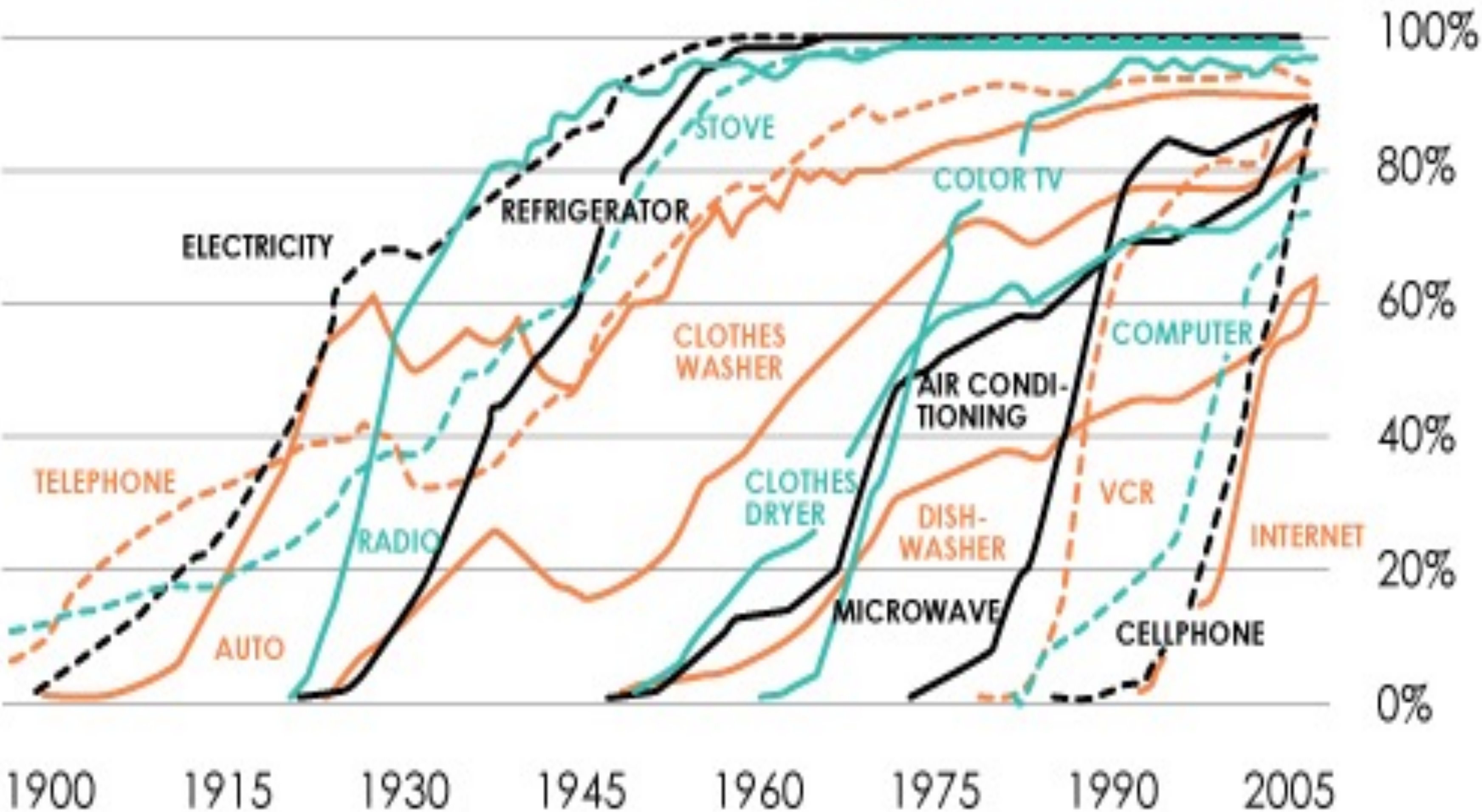
Owning an EV

	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	**~ $17,700+** VS	**~ $3,150**

Decreasing Battery $
& Low Operating Costs

Market Transition

New Technologies and Mainstream Adoption



Source: Michael Felton, *The New York Times*

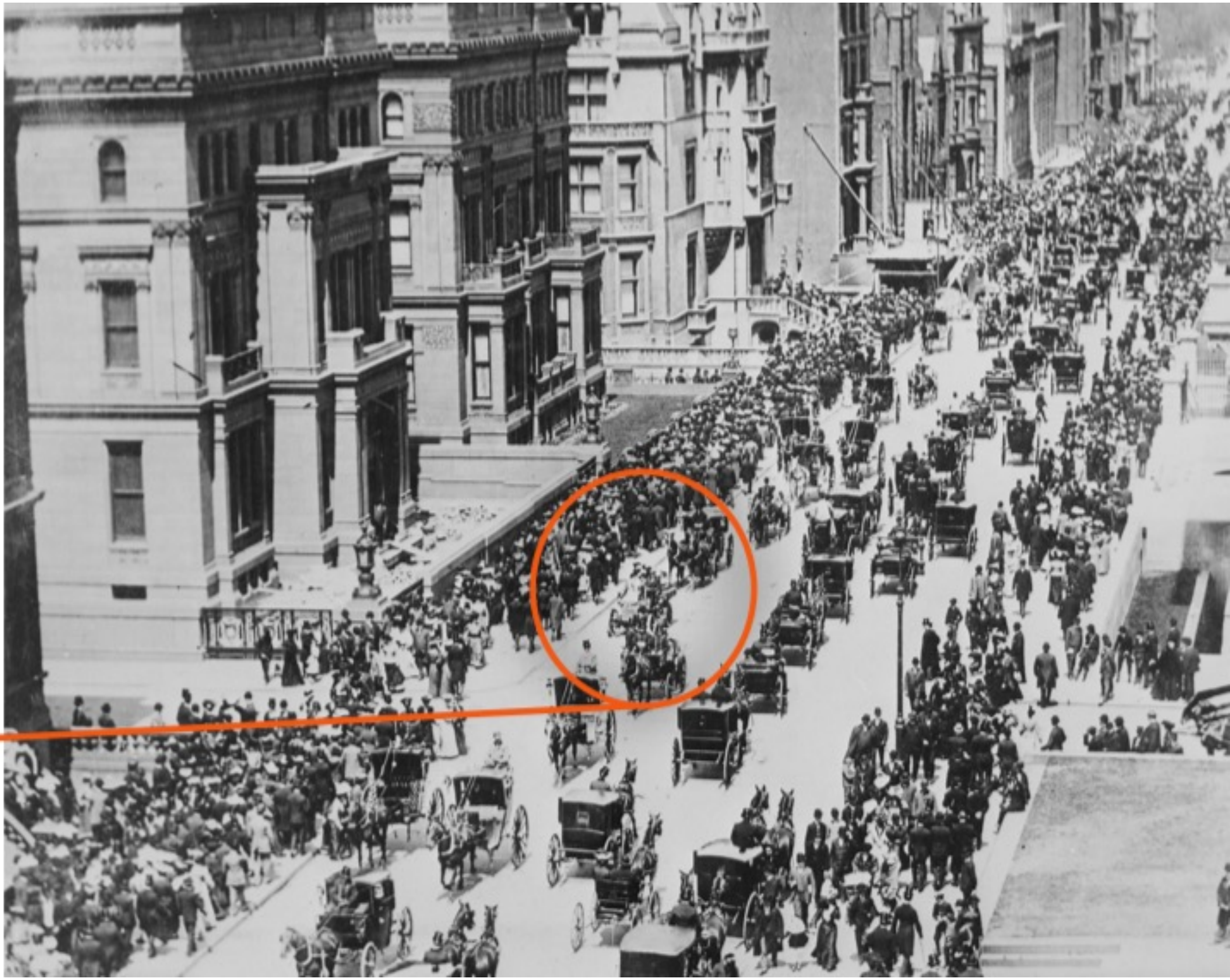
www.earlyinvesting.com

Speed of Disruption

5th AVE NYC

1900

Where is the car?

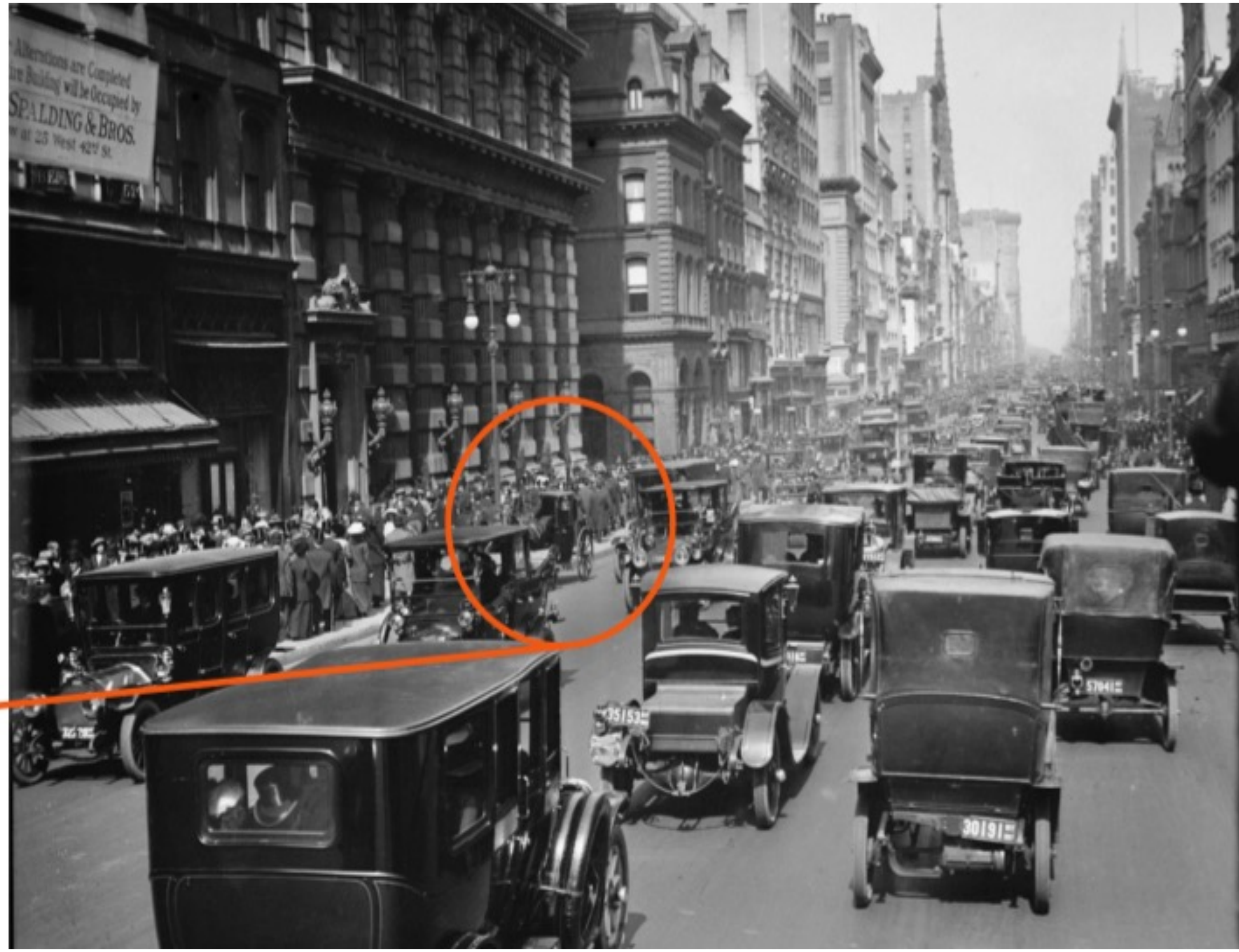


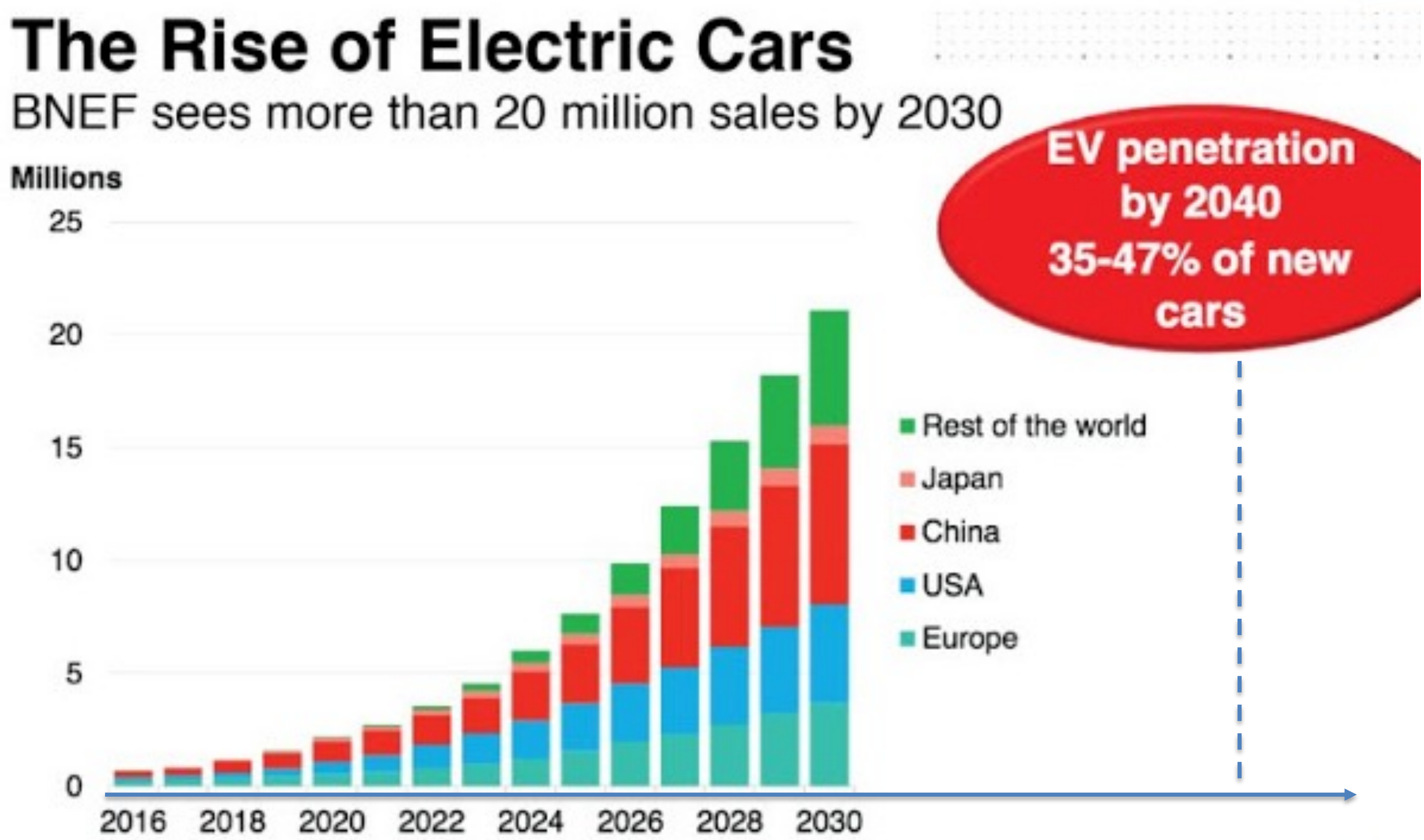
Speed of Disruption

5th AVE NYC

1913

Where is **the horse?**

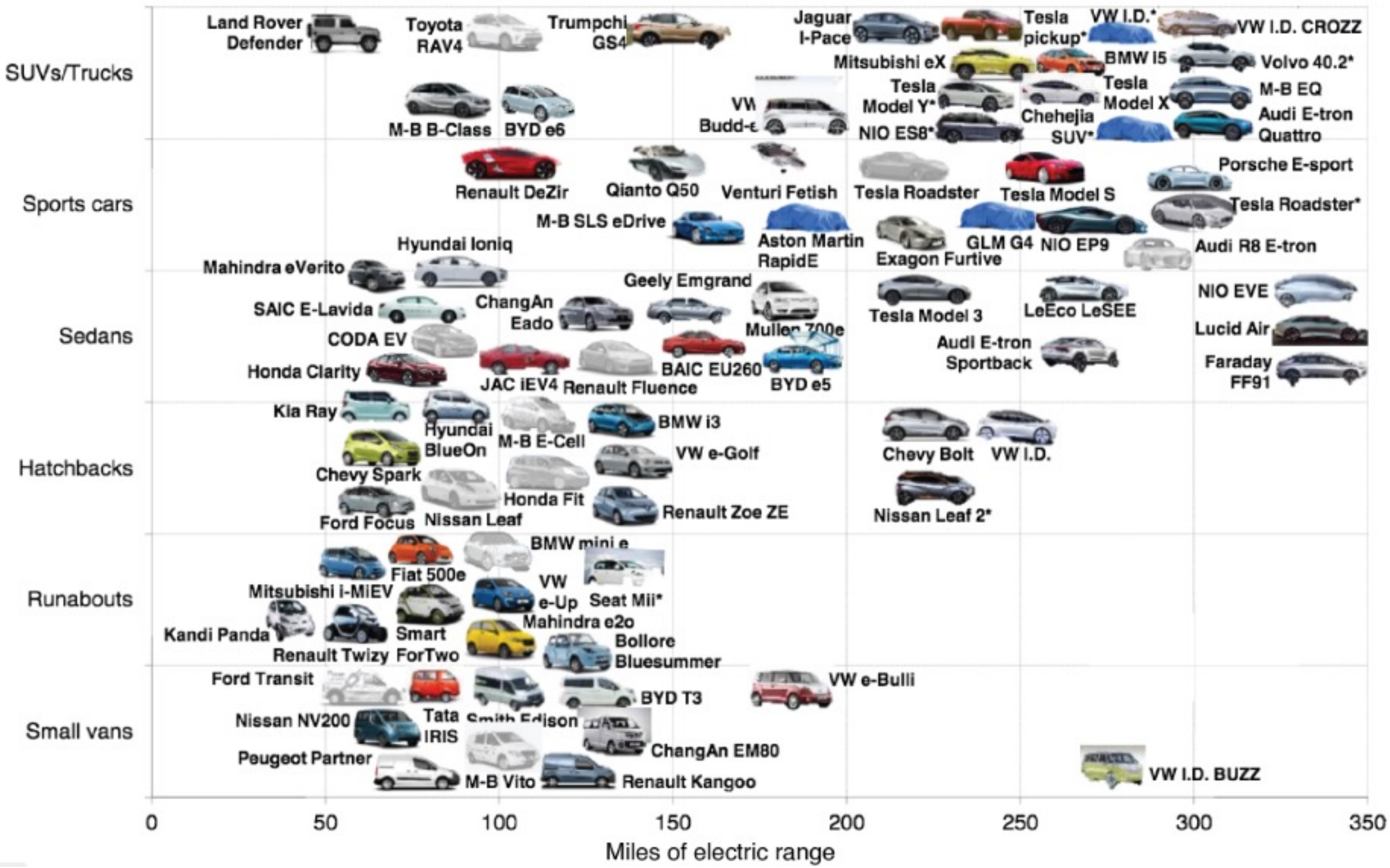




Source : Bloomberg New Energy Fund

- ***By <u>2025</u> EVs projected to be priced <u>equal to or less</u> than gasoline vehicles***

EV Models by Style and Range – existing & coming



Cities & Municipalities

CITY OF SEATTLE

Trucking


ups
Worldwide Services
Electric Vehicle


prime
prime


XP24261


100% electric.


ORDER DEPT. 1-800-BEER-INC
T730
VOLVO

Vehicle to Load (V2L)

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

FORD F150 LIGHTNING REAR V2L SOCKET POSITION. IMAGE: FORD.

Performance - Instant Torque!

Chevrolet Bolt

0-60 MPH	6.3 sec
QUARTER MILE	14.9 sec @ 93.1 mph

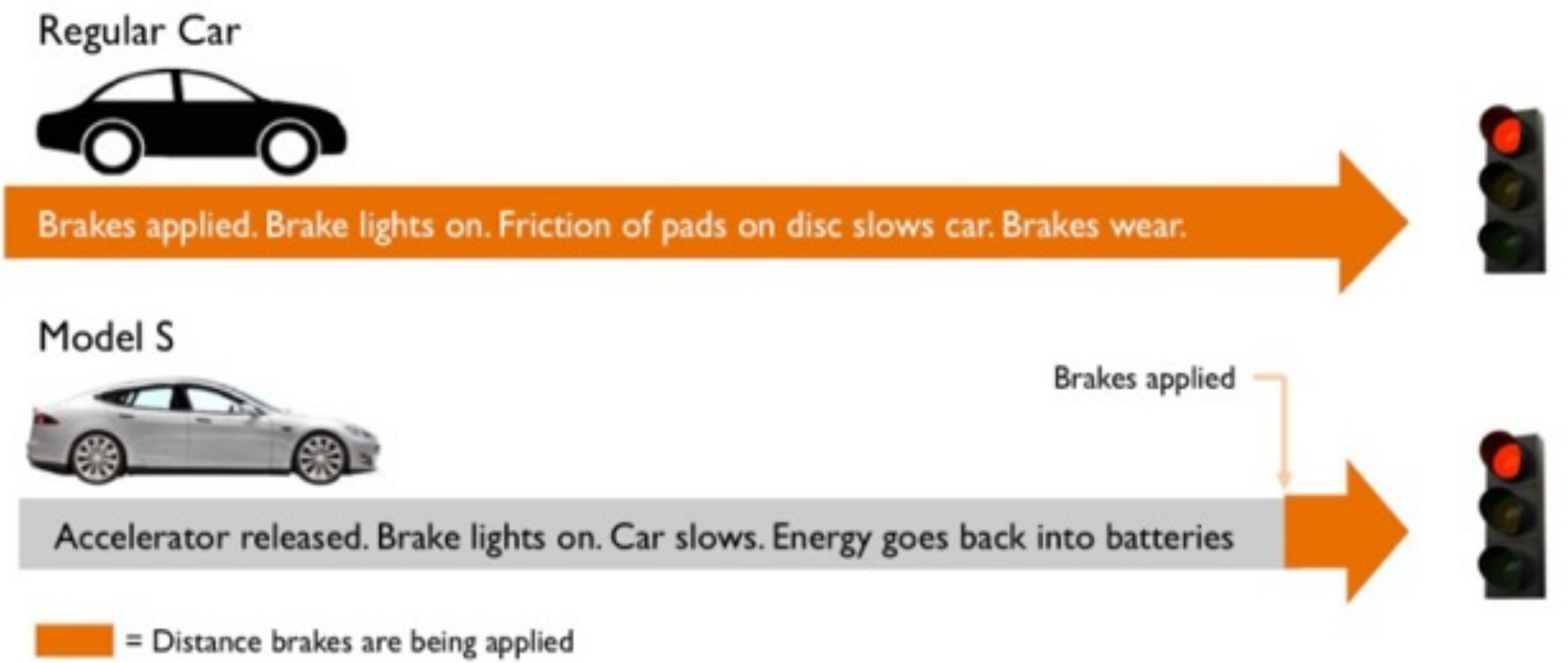
Electric Vehicles are Quick!

Benefits - Driving an EV is Fun!

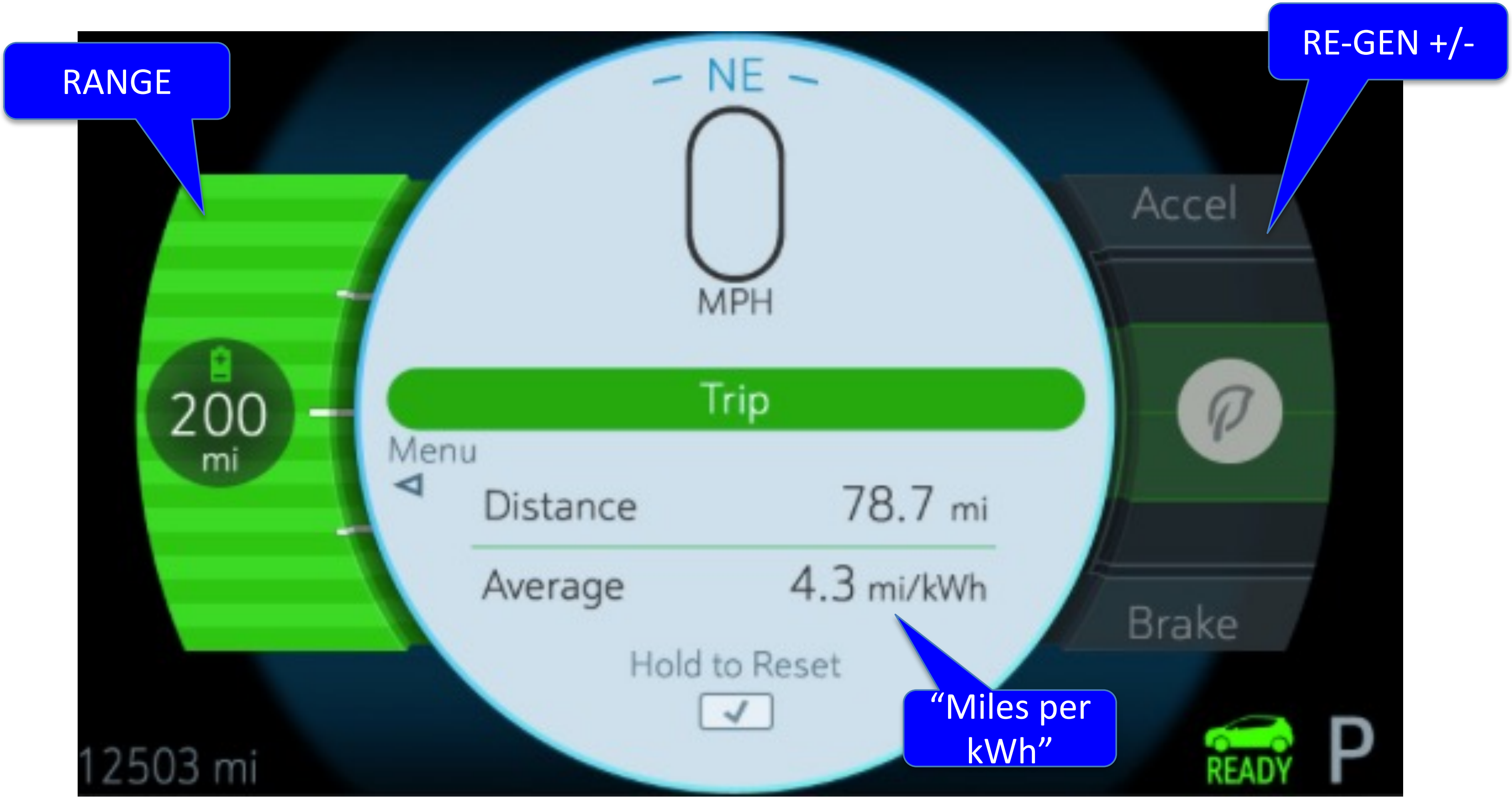
- **Instant Power**, 100% torque at 0 RPM! Bolt is 0 – 60mph in 6.3 Seconds!
- Low Center of Gravity – **handles curves better**
- **Silent** – no transmission – direct drive
- **Pre-heat or Pre-air condition** while charging & before leaving home
- Heating and Cooling sitting in ferry line – no “idling”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

Regenerative Braking – "one pedal driving"

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



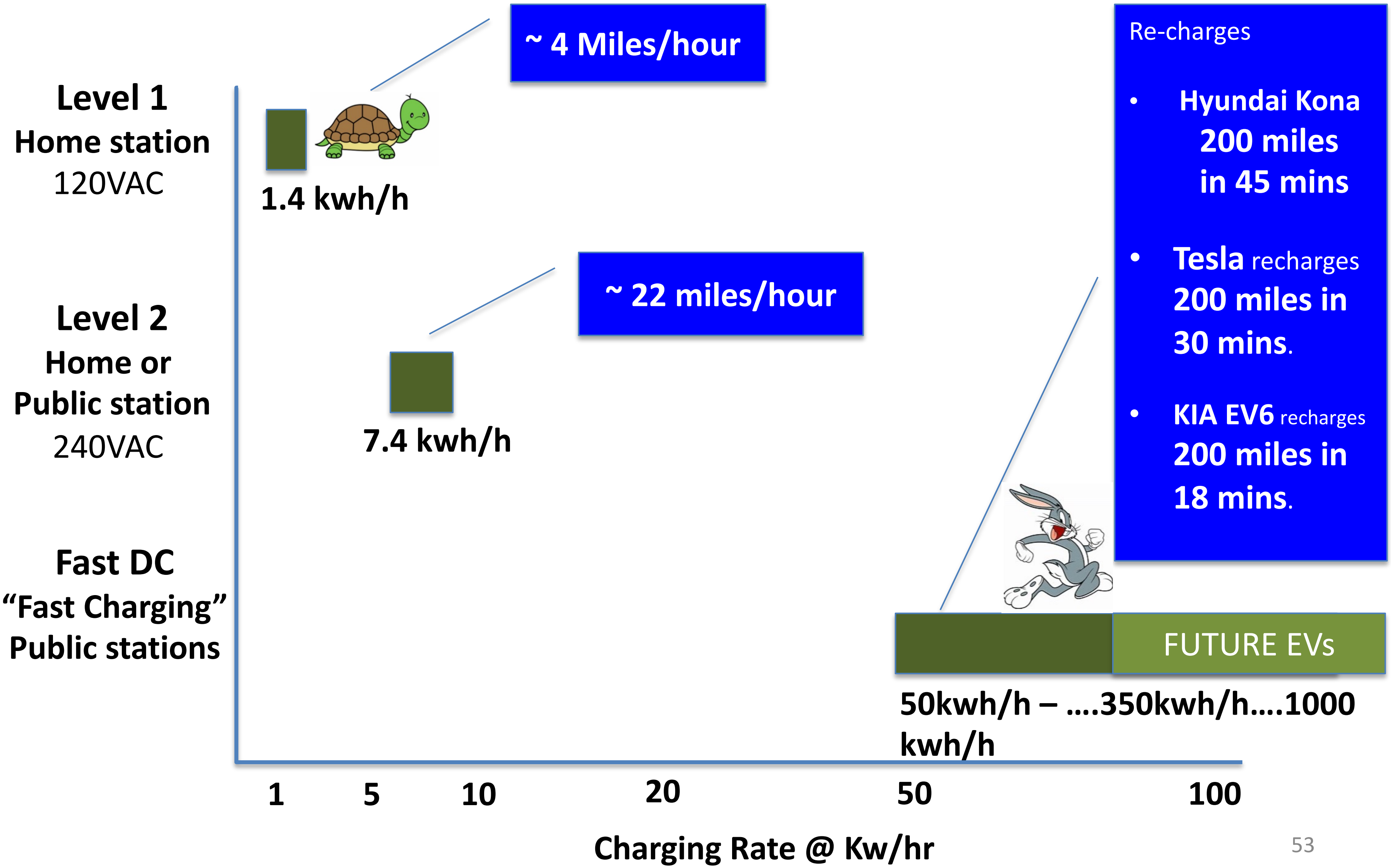
Simple to operate



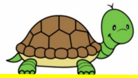
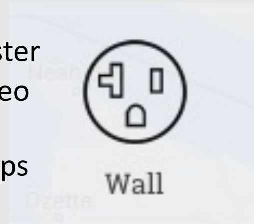
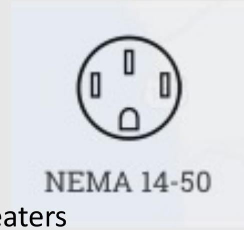
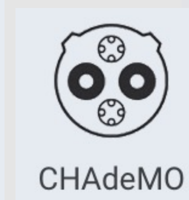
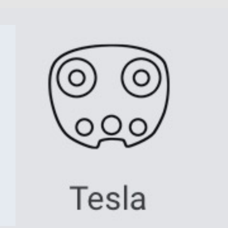
- **No oil pressure**
- **No water temp**
- **No engine coolant**
- **No water pump or alternator**
- **No belts to adjust or replace**
- **No exhaust system to rust**

Charging Networks

Charging Stations

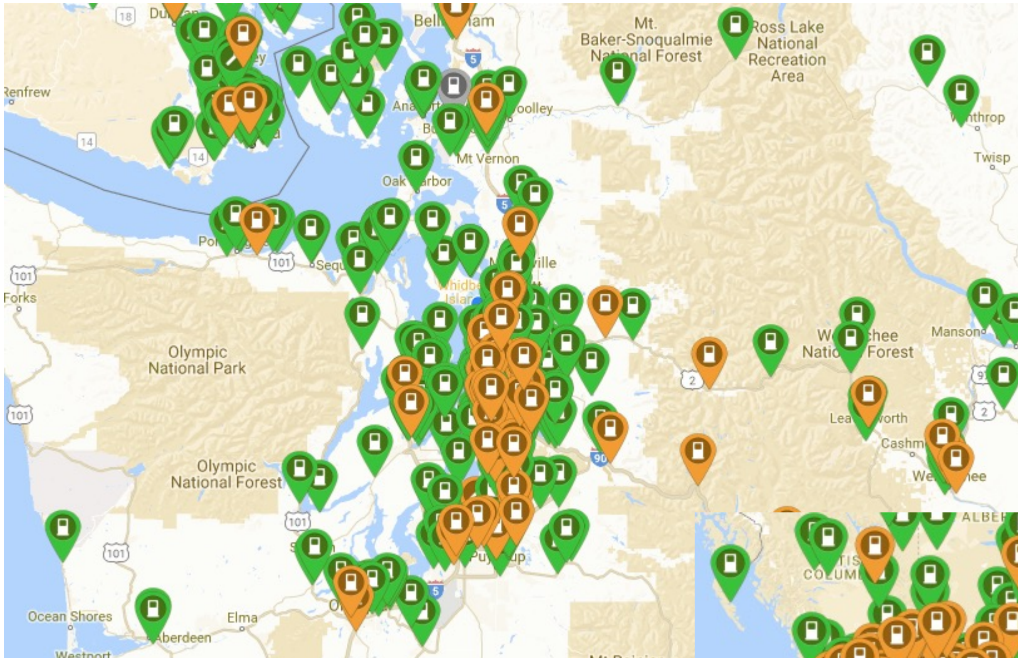


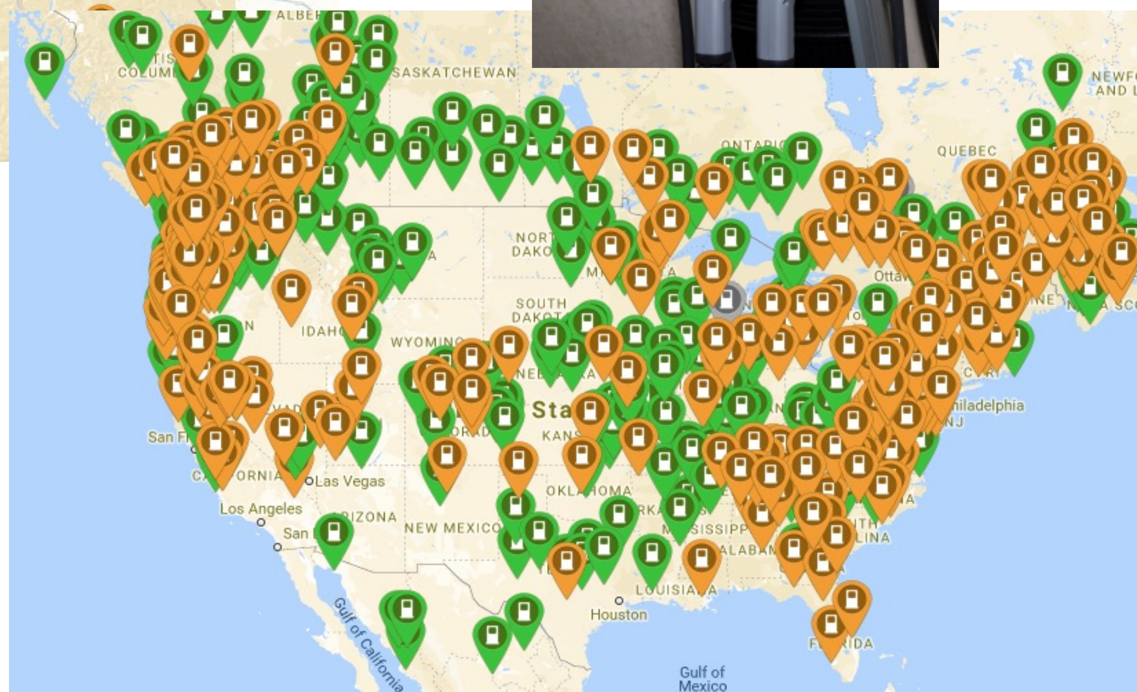
Charging Stations

	Slow 	Faster	 Fast
Outlet	**Level 1** 110VAC, 1.4 Kw • Toaster • Stereo • TV • Lamps 	**Level 2** 220VAC, 3.3 - 7.4 Kw, • Ovens, ranges, and cooktops • Clothes dryers • Furnaces • Electric Water heaters 	**Fast DC** "Fast Charge" • CCS • CHAdeMO • Tesla High Voltage DC 50 kw – 350kw
Vehicle Connection			  
Charging Equipment		 	

Home **Public**

Public Charging Networks





chargepoint

EVgo

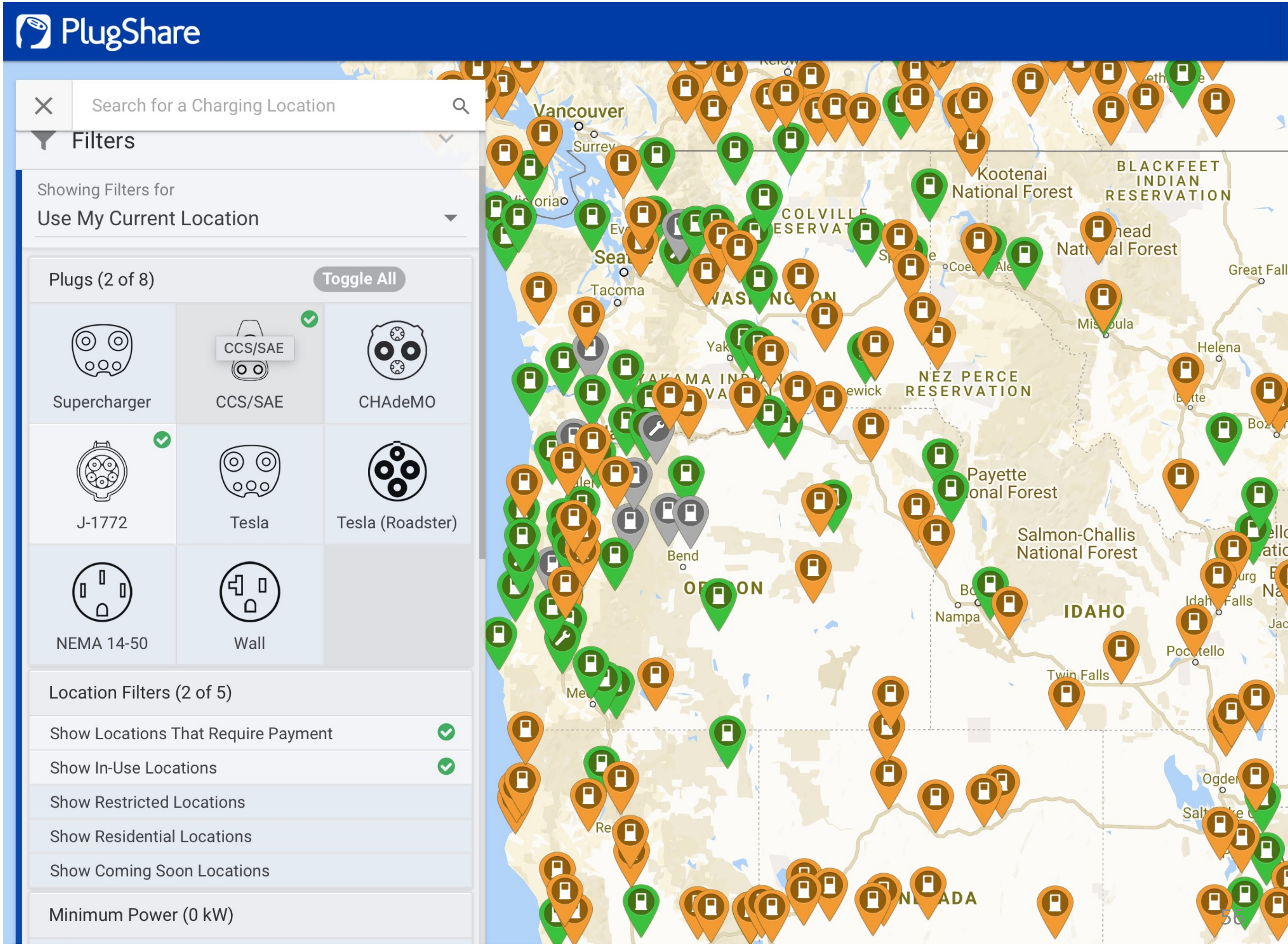
SemaConnect

blink

electrify america

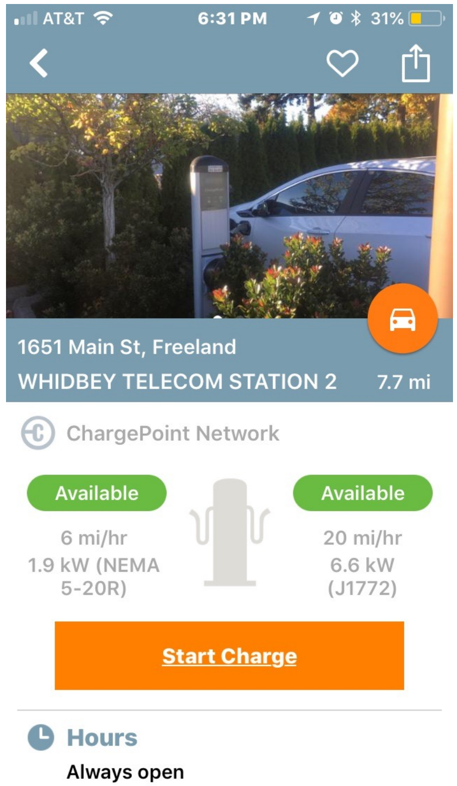
Map images from PlugShare App and Plugshare.com

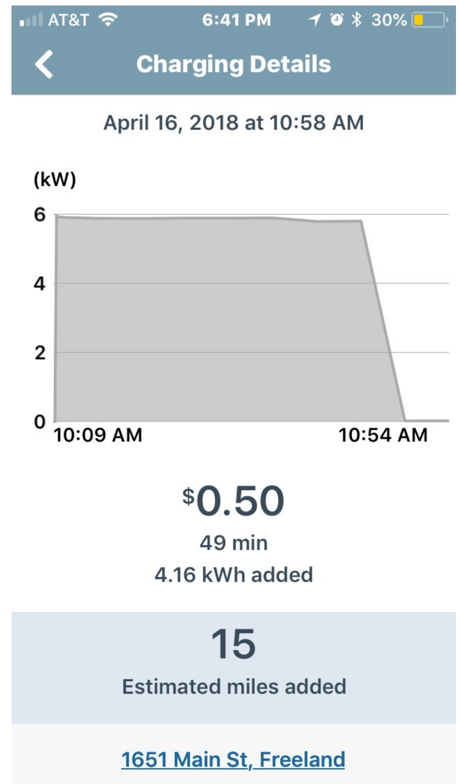
Mobile apps & Networks – Fast DC & Level 2

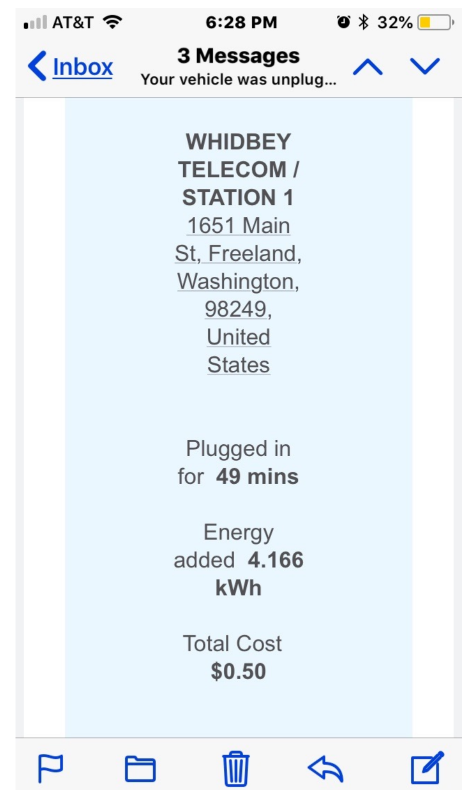


Using a Public Charging Station with Smartphone

Find a charging station → Connect, Activate, & Pay (App, RFID, Credit Card) → Monitor charging & Notify complete → Payment confirmation







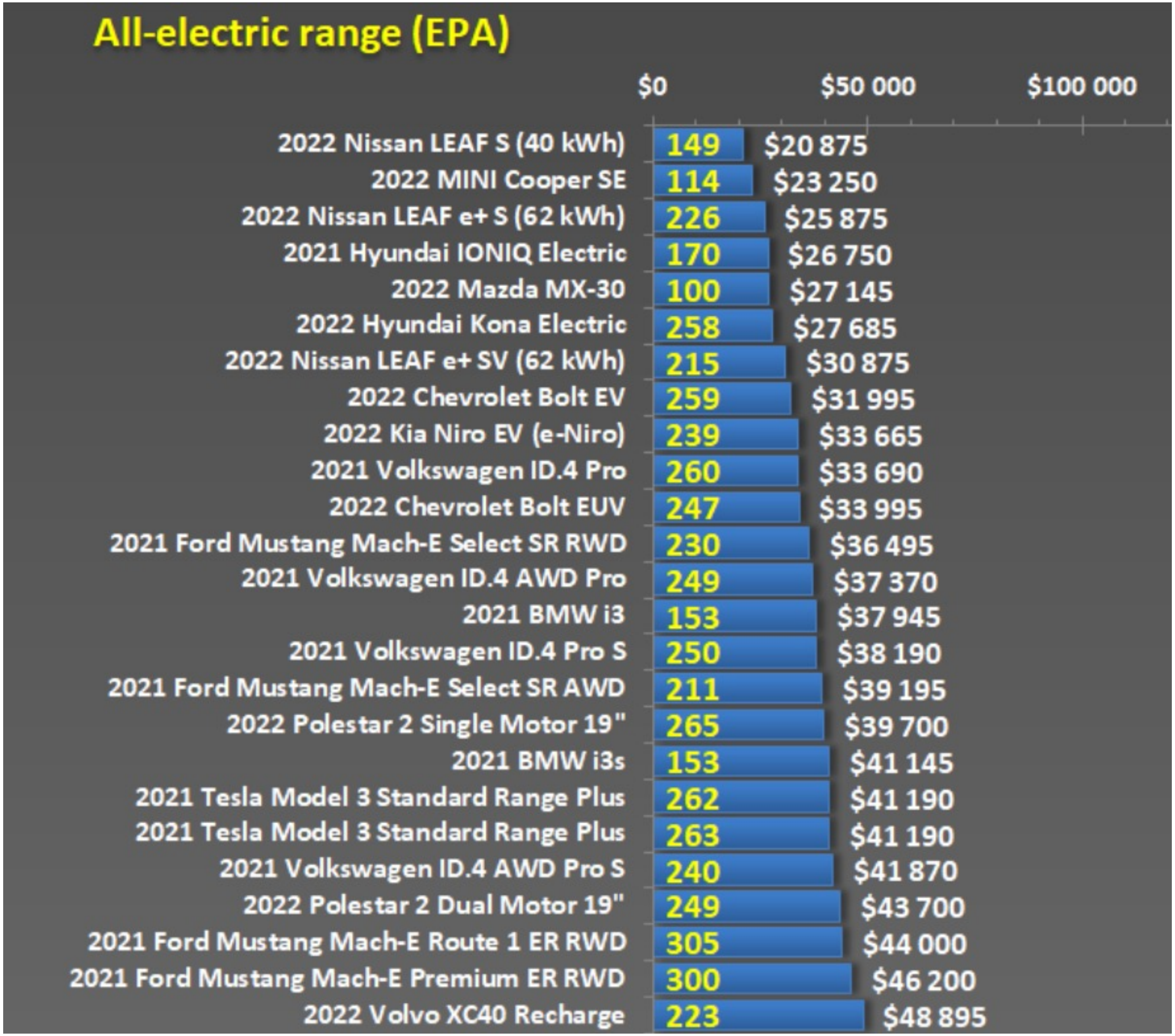
EV Charging Stations & Convenience Stores

2022 Shell Fulham London EV station

- Shell converts UK gas stations to EV charging, featuring nine 175-kW chargers, demonstrating a way for stations to adapt to the EV age.
- The 175-kW chargers can charge most EVs from 0% to 80% state of charge in 10 minutes.

Are they affordable ?

Base price (MSRP + DST and after Tax Credit)



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

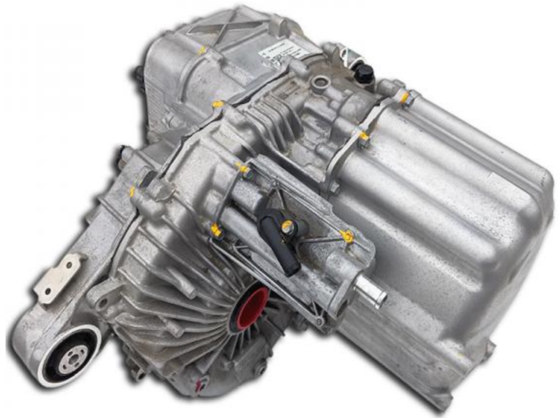
- Sales tax exemption
- **New light vehicles are subject to a 6.8 % sales tax in Washington.**
  - up to $2,500 tax reduction for <u>new</u> vehicles < $45,000
  - up to $1,600 tax reduction for <u>used</u> vehicles < $30,000

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.)

https://data.wa.gov/Transportation/Vehicle-Models-Eligible-for-the-Washington-State-T/aug9-4a7g

Drive Electric

- Performance



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

Thank you !

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olydriveelectric@gmail.com

Favorite Links :

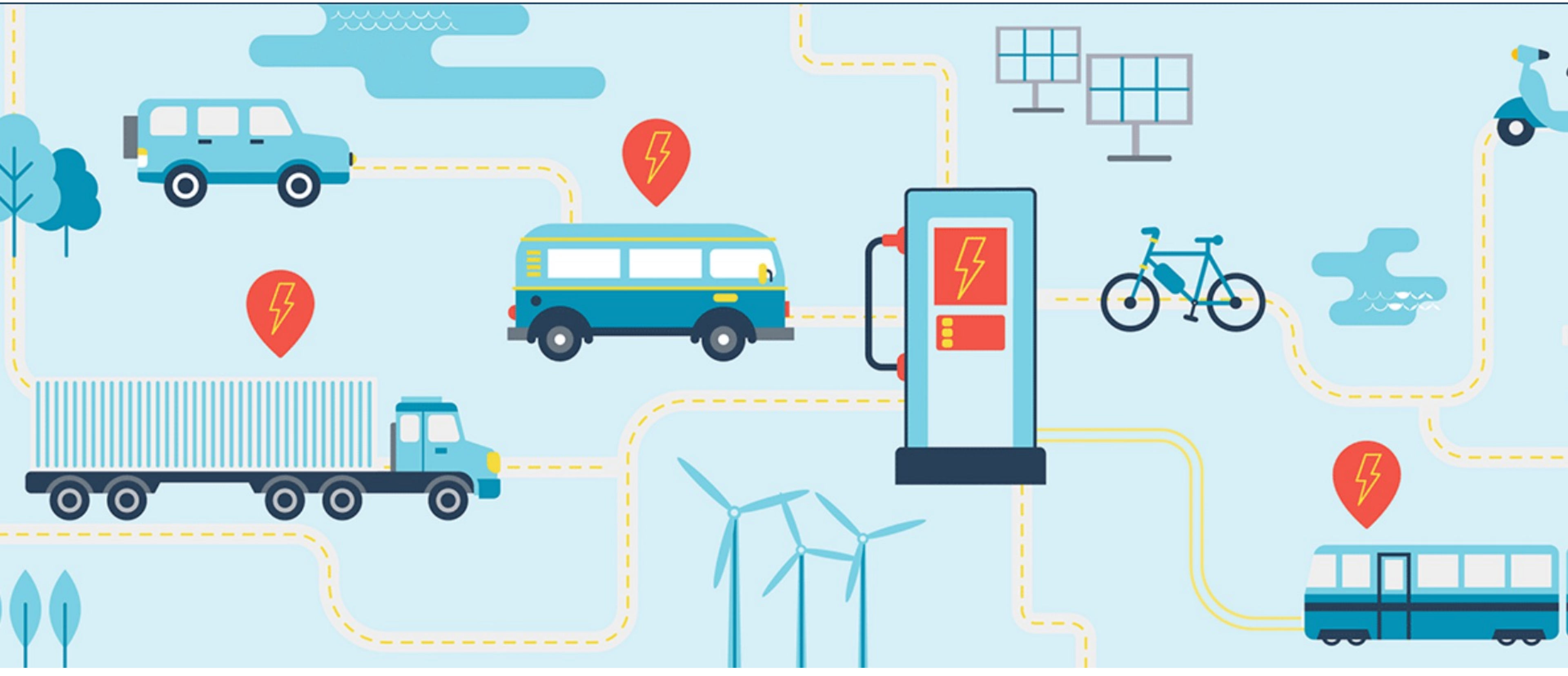
jeffersoncan.org

coltura.org

cityofpa.us/1010/Climate-Resiliency-Plan

Olyclimate.org

www.aboutCATES.org

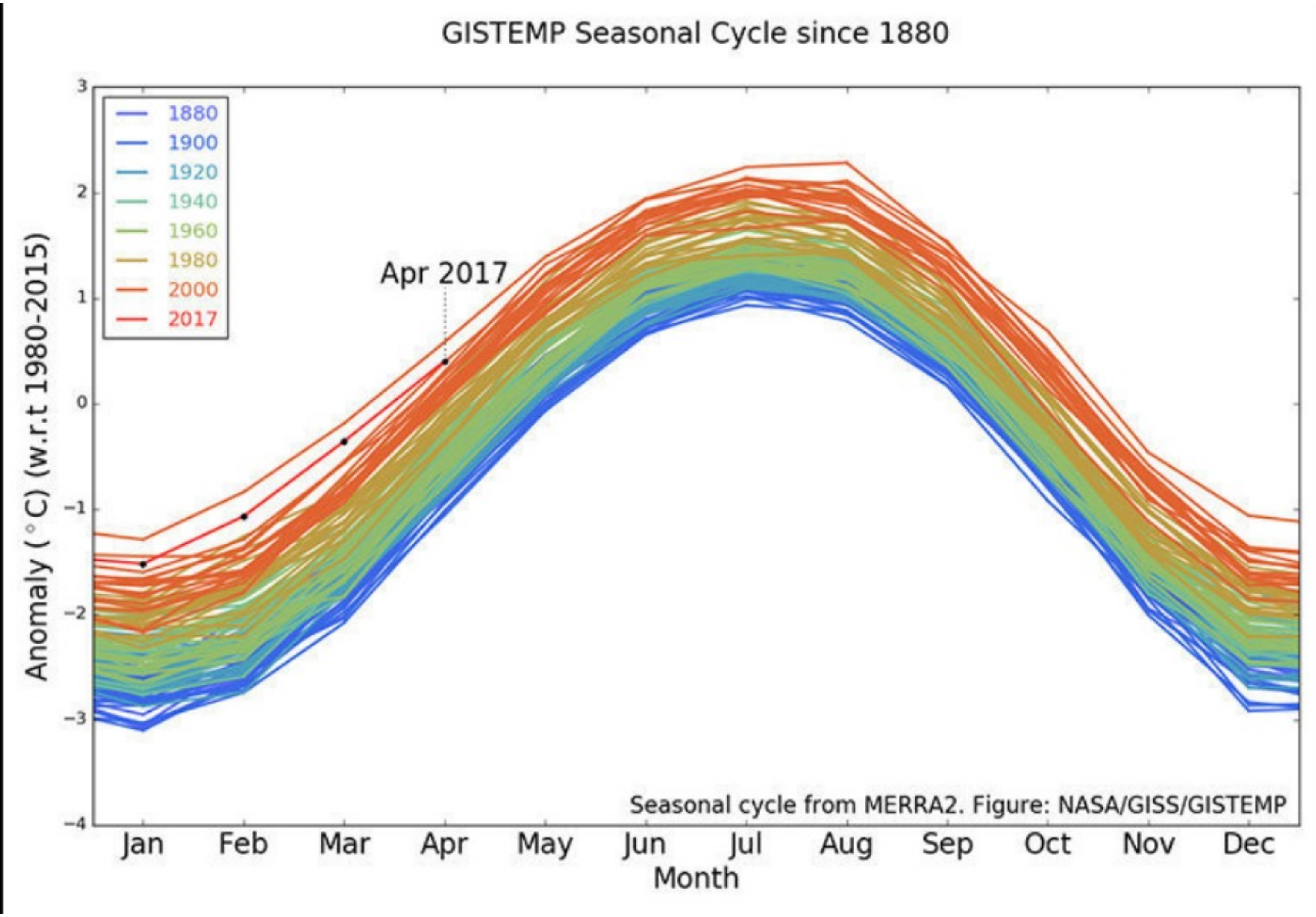


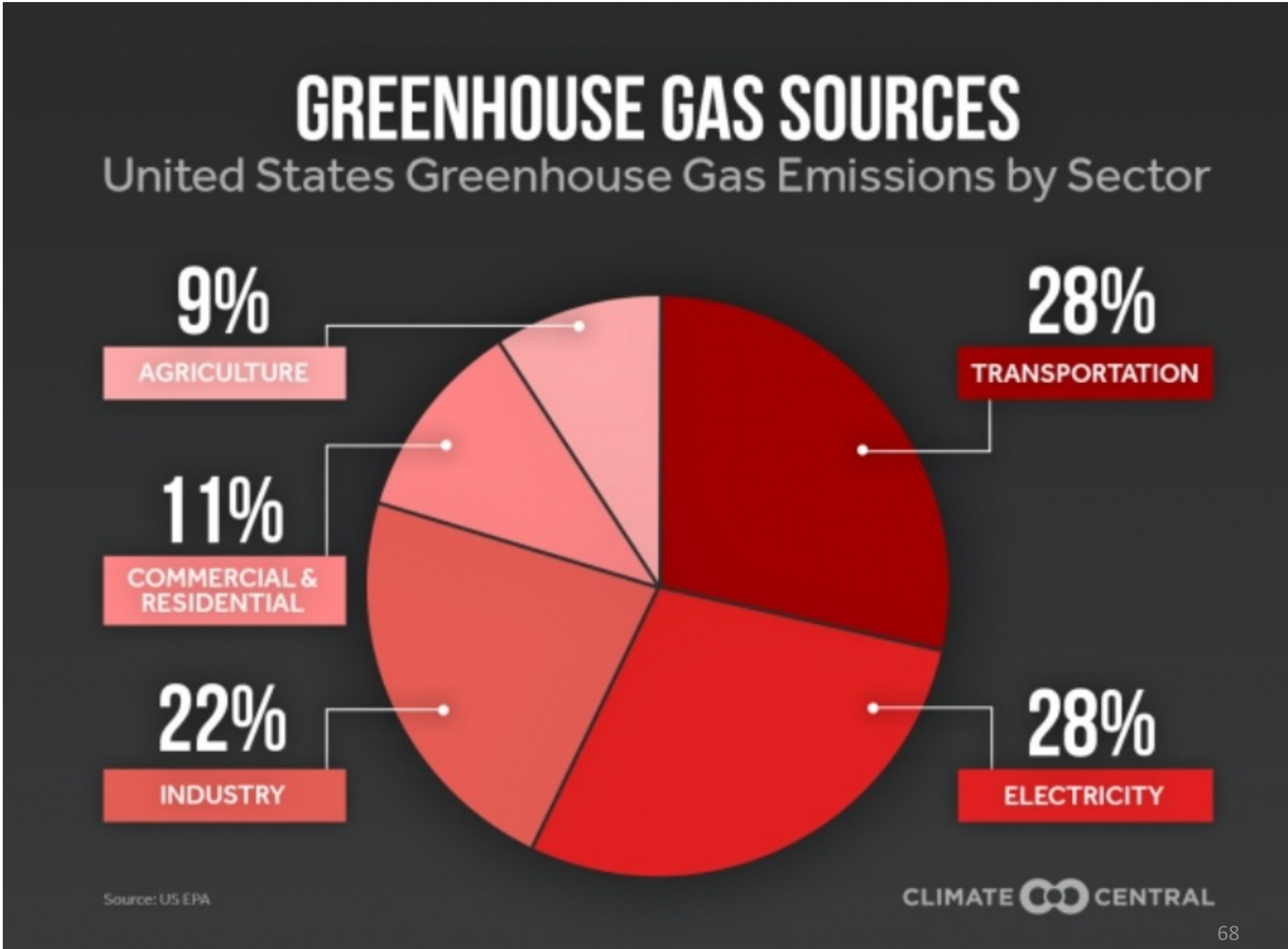
Appendix

- WHATS REALLY WARMING THE WORLD?

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

Increasing temperatures




GREENHOUSE GAS SOURCES
United States Greenhouse Gas Emissions by Sector
9%
AGRICULTURE
28%
TRANSPORTATION
11%
COMMERCIAL & RESIDENTIAL
22%
INDUSTRY
28%
ELECTRICITY
Source: US EPA
CLIMATE CENTRAL

Inventory Results: 2019 Community Snapshot

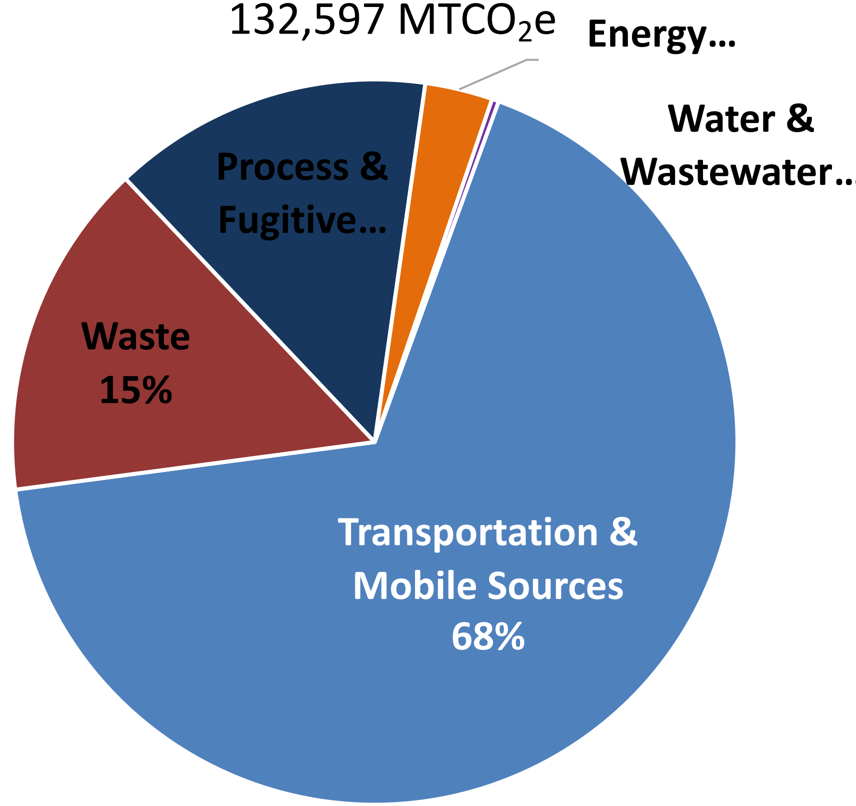
Main Sources of Emissions (in order):
1. Transportation & mobile sources
2. Solid waste generation & landfill operations
3. Process & fugitive emissions (e.g., refrigerants)

Major Data Sources
- City of Port Angeles Public Works & Utilities (Energy, Solid Waste, Water & Wastewater)
- Port of Port Angeles & Black Ball Ferry
- Washington State Department of Transportation (WSDOT)
- U.S. Energy Information Administration

Key Considerations
- Propane data downscaled from state-level usage data; scaled based on households
- No commercial/industrial propane estimates available -
- Vehicle mileage data was downscaled from annual county-level data from WSDOT

Total 2019 Community Emissions:

132,597 $MTCO_2e$



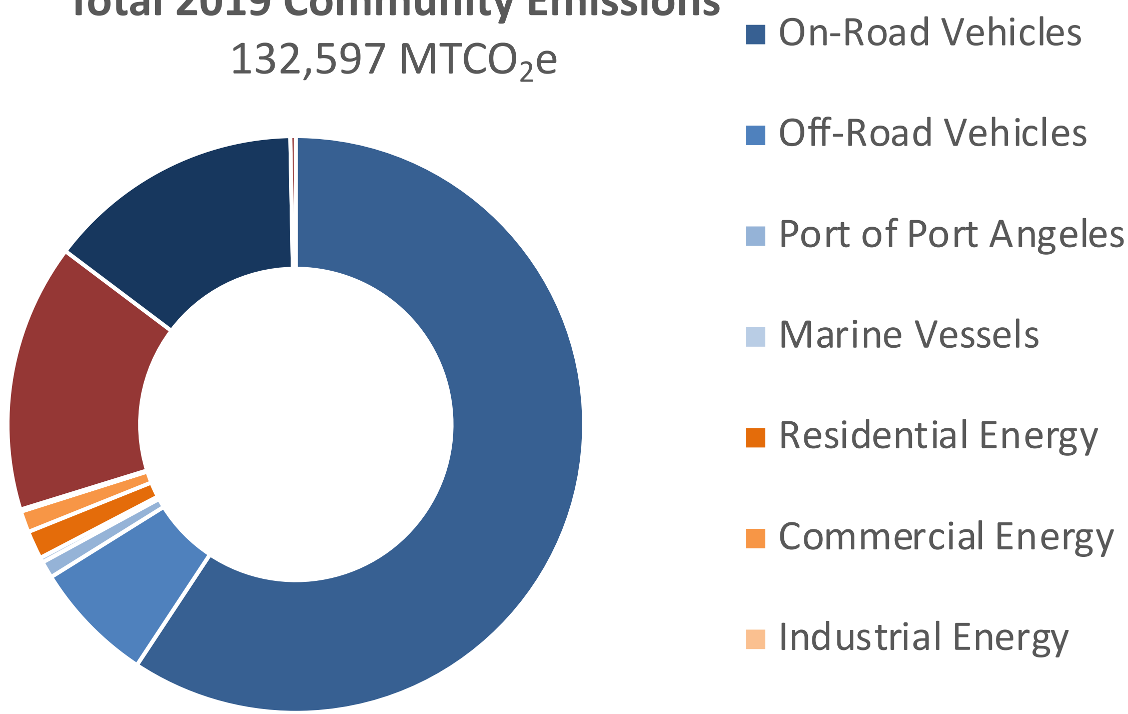
Inventory Results: Detailed Community Findings

Major Drivers of Emissions:

- On-road cars, motorcycles, SUVs, and trucks (59%)
- Solid waste generation & landfill operations (15%)
- Refrigerant leakage & electricity losses (14%)

Government operations make up **~1% of total emissions***

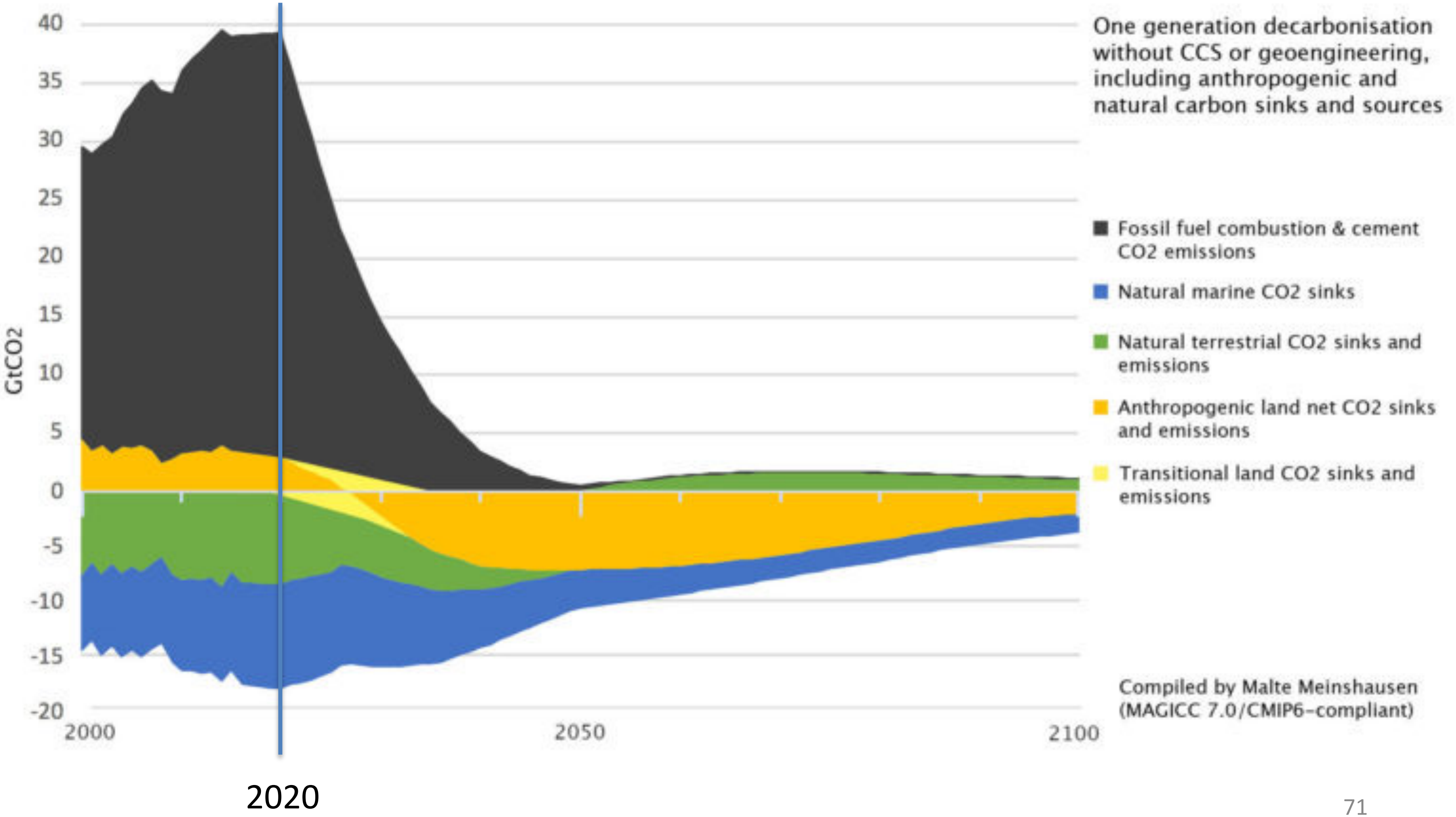
Total 2019 Community Emissions
132,597 $MTCO_2e$



**The government operations inventory is still being finalized to include results from an upcoming employee commute survey*

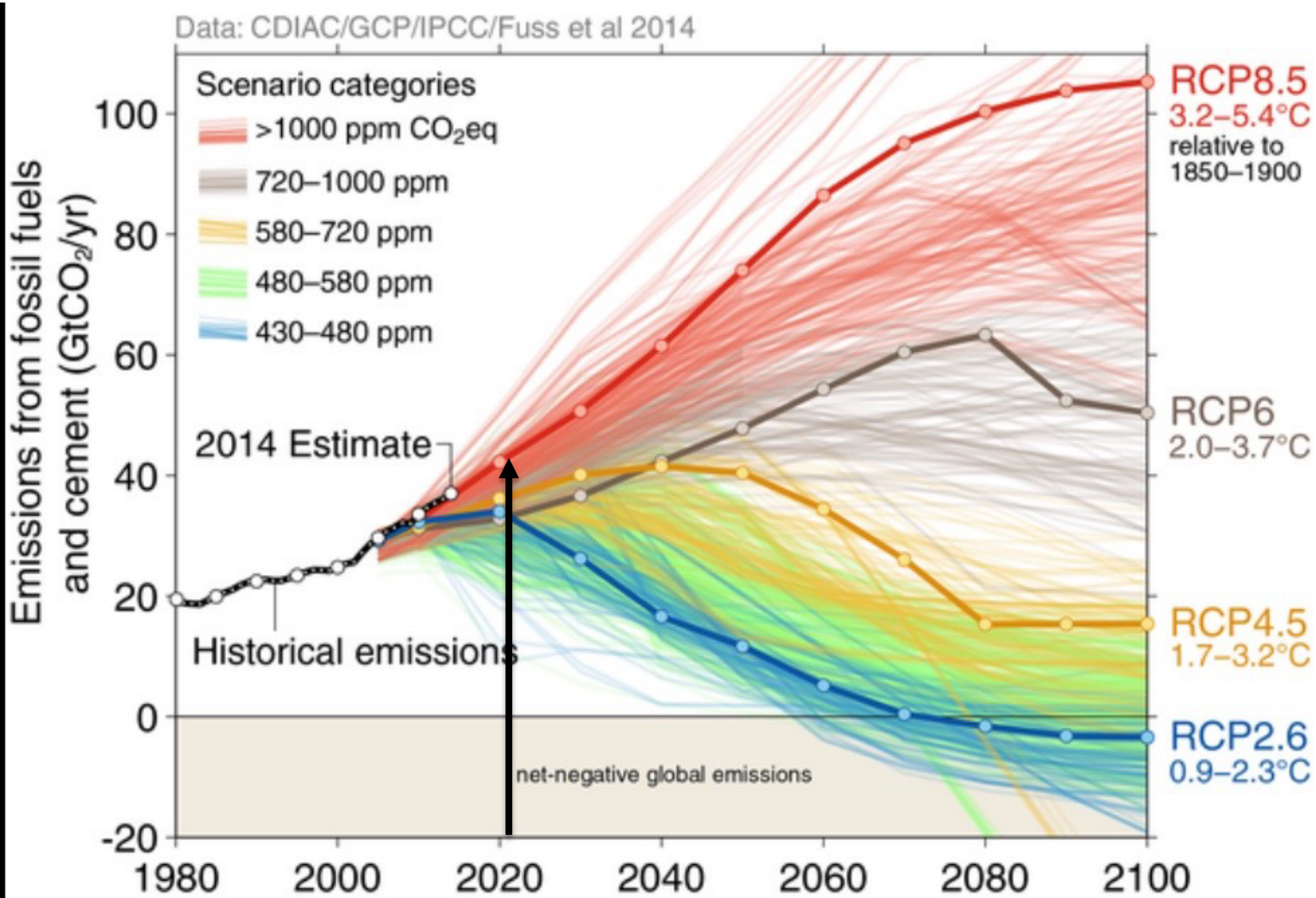
Decarbonization urgency

Best case still 2C - 3.5C (3.6 - 6F) by 2100
Assuming no GHG extraction CCS tech
or geoengineering



Climate Models

- **Representative Concentration Pathways (RCP)**



5.7 - 9.7F

3.6 - 6.6F

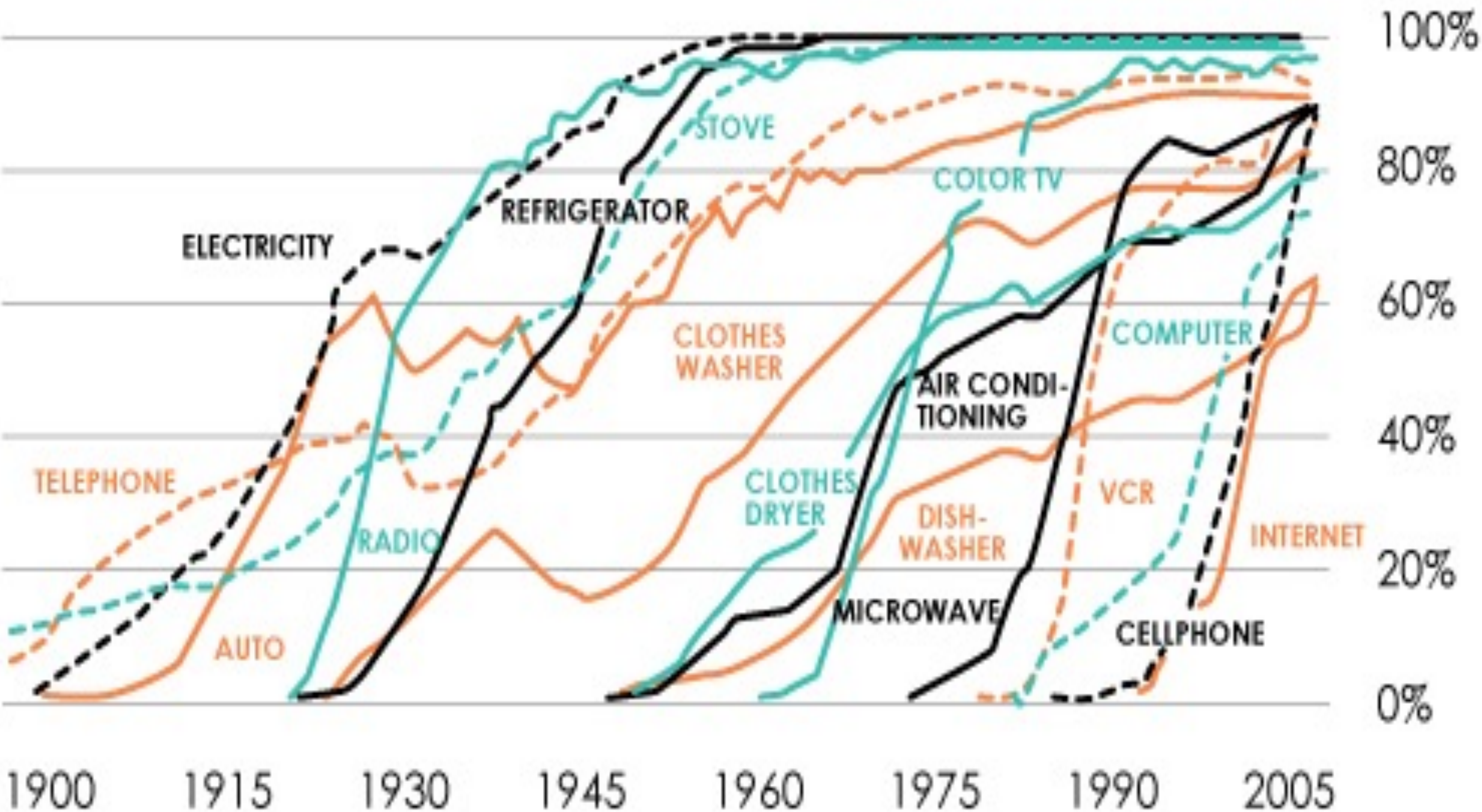
3.0 - 5.7F

1.6 - 4.1F

Quickest Production Cars (0—60)

Car[1]	Model Year	Test Results		Noted specs
Porsche 918 Spyder	2015	2.1 sec		naturally aspirated
Tesla Model S P100D	2017[x]	2.28 sec		All-electric, with 5 seats
Lamborghini Huracán Performante[viii]	2018	2.3 sec		Naturally aspirated
Porsche Taycan Turbo S[xii]	2020	2.4 sec		All-electric, with 4 seats
Tesla Model S Performance w/Ludicrous Model	2020	2.4 sec		All-electric, with 5 seats

New Technologies and Mainstream Adoption



Source: Michael Felton, *The New York Times*

www.earlyinvesting.com

Mobile apps & Networks – Fast DC