

Electric Vehicles in 2022

Presented to

SIR #51

Los Altos Hills

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Presentation Overview

- **Misconceptions And Propaganda**
- **Jargon and EV Lingo**
- **Charging And Connectors**
- **Home Environment**
- **Workplace / MFH / Rentals**
- **DC Fast Charging And Range**
- **Marketplace offerings**
- **The Future**

MISCONCEPTIONS AND PROPAGANDA

- **Slow, ugly, not good for long trips**
- **Too expensive**
- **No place to charge them**
- **Range anxiety**



Jargon and EV Lingo

- ICE - only petroleum power
- Hybrid - petroleum power w/ electric assist
- BEV - full battery power (no pistons)
- PHEV - plug-in E-drive w/ fueled generator
- FCEV - H₂ sourced energy w/ battery

EVSE, Renewable Energy, DC-FC

Background reading: “Internal Combustion” by Edwin Black, 2006 See notes below slide.

What's a Hybrid Vehicle? 1/2

Parallel Hybrid:

Both gas engine and electric motor can drive a transmission at the same time

Series Hybrid:

Gas engine turns generator; generator charges batteries or powers electric motor to drive wheels

Gas engine never *directly* powers the vehicle

→ Batteries recharged from ICE & regen braking

→ Gasoline is the (single) source of energy

Wouldn't it be better to have multiple sources?

What's a Hybrid Vehicle? 2/2

Hybrid vs Conventional ICE:

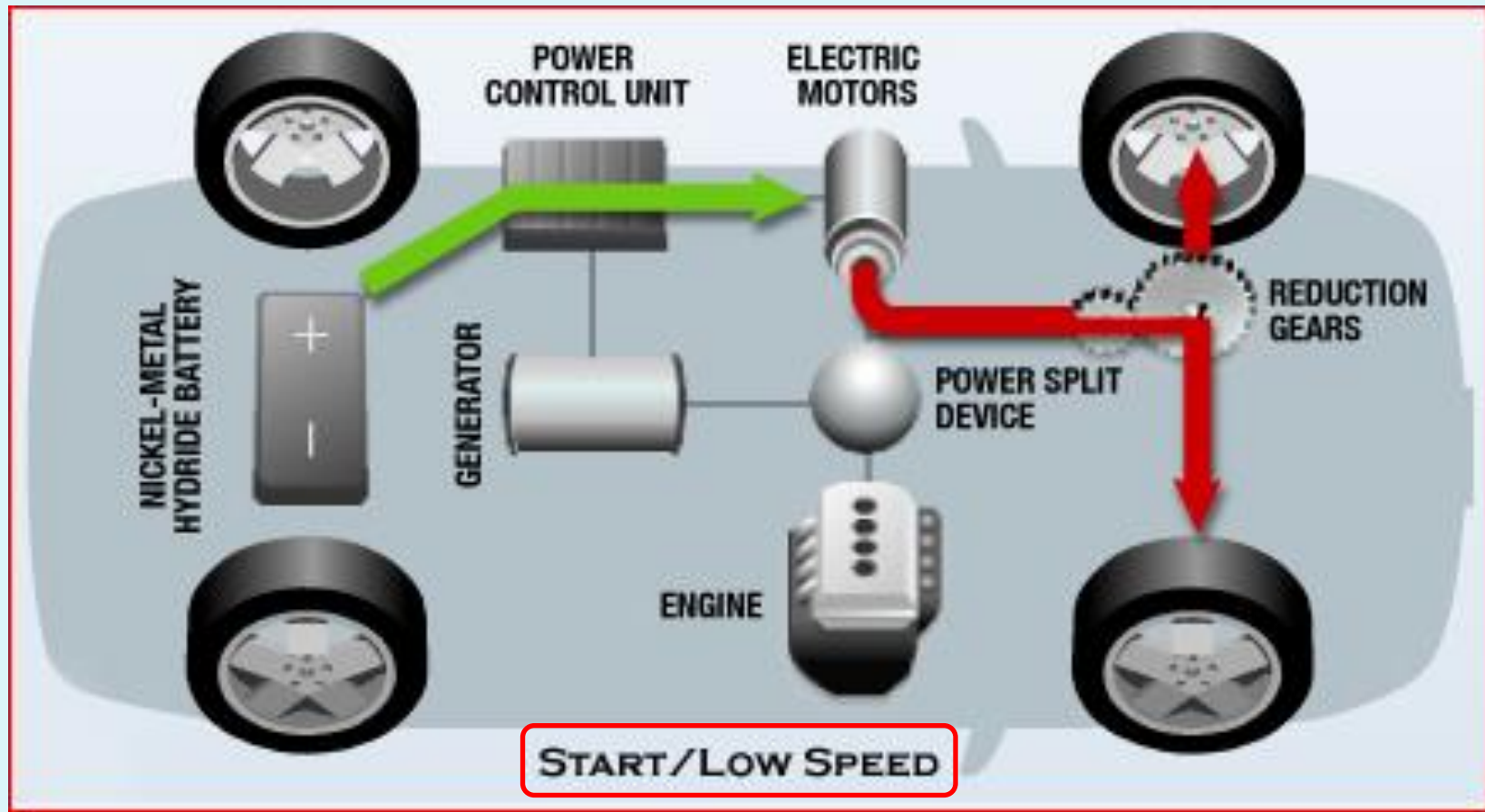
ICE: Historically had mostly belt driven accessories;
peak power but used <1% of the time

HEV: gas engine sized for average power plus electric motor for extra power (acceleration, steep hills, etc.)

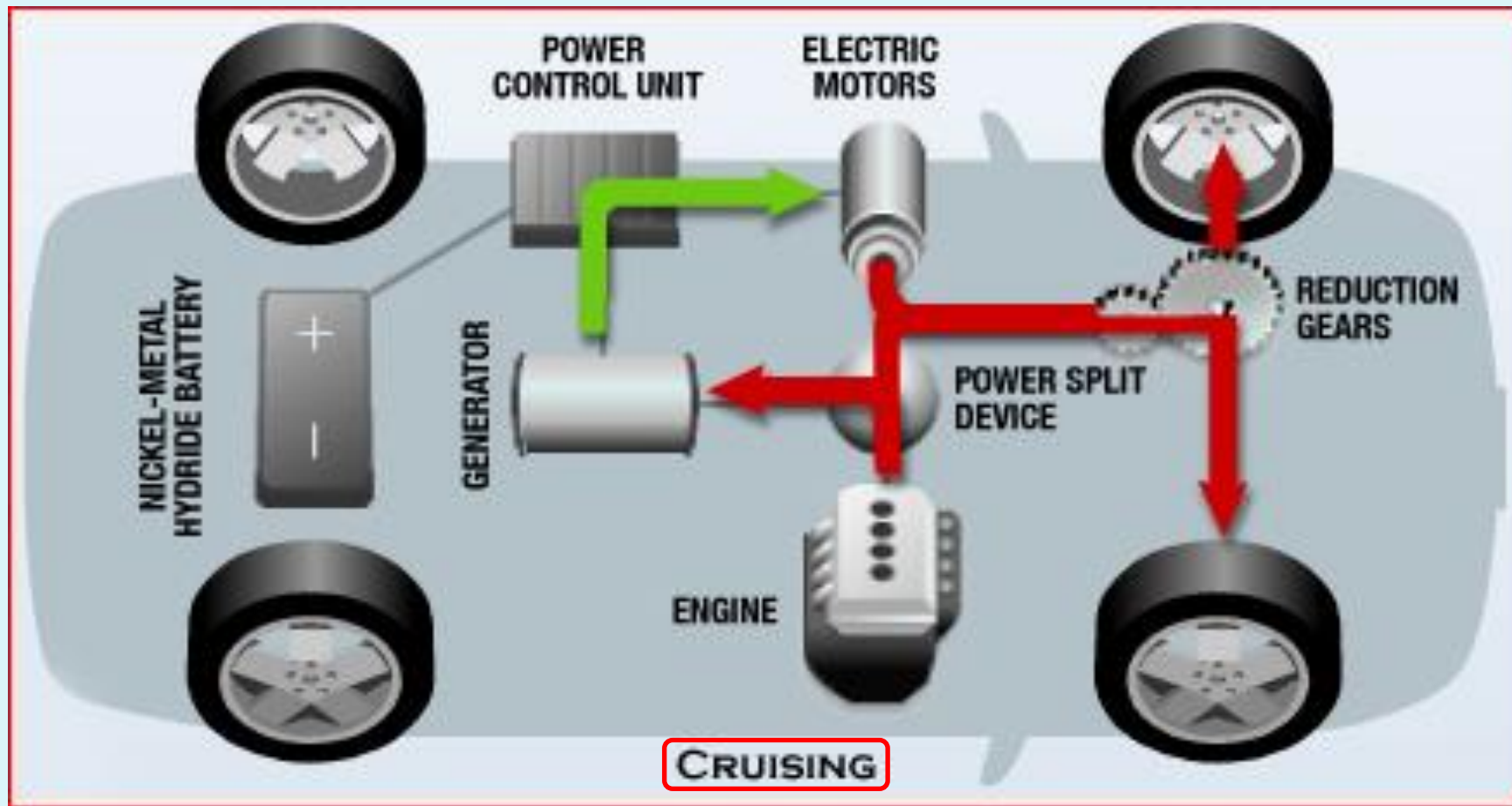
- Turn off ICE when vehicle stops (mild hybrid)
- Regenerative braking
- Aerodynamics
- Low rolling resistance tires
- Light weight materials

But early hybrids could not be plugged in! That changed in 2005 with CalCars.org promoting a new concept: PHEVs

Hybrid Power Transfer 1/2



Hybrid Power Transfer 2/2



Nearly Zero Maintenance









- Less consumables, less moving parts, less upkeep, less costs to owner
- NO OIL OR FILTERS NO BELTS NO FUEL PUMP
- NO TRANSMISSION NO TIMING BELT OR CHAINS
- NO SPARK PLUGS NO AIR CLEANER NO GLOW PLUGS
- NO DISTRIBUTOR NO SMOG CHECKS NO GAS STATION VISITS
- FILL UP WHILE YOU SLEEP A FULL “TANK” EVERY MORNING
- SAVE THOUSANDS ON YEARLY AUTO EXPENSES
- SAVE ON FUEL COSTS & BRAKES LAST LONGER
- **TIRES, INSURANCE, AND ELECTRICITY ARE ONLY ITEMS TO BUDGET**
- Total cost of ownership [studies](#) reveal long term benefits

2022 Electric Vehicles Summary

- **Comparable in every way with ICE + fun**
- **Dramatically reduced costs:
for operational and for maintenance**
- **Increased reliability (less moving parts)**
- **Ideal 2nd car for most situations**
- **Offered by major manufacturers today**
- **Home fueling – an unbeatable plus**

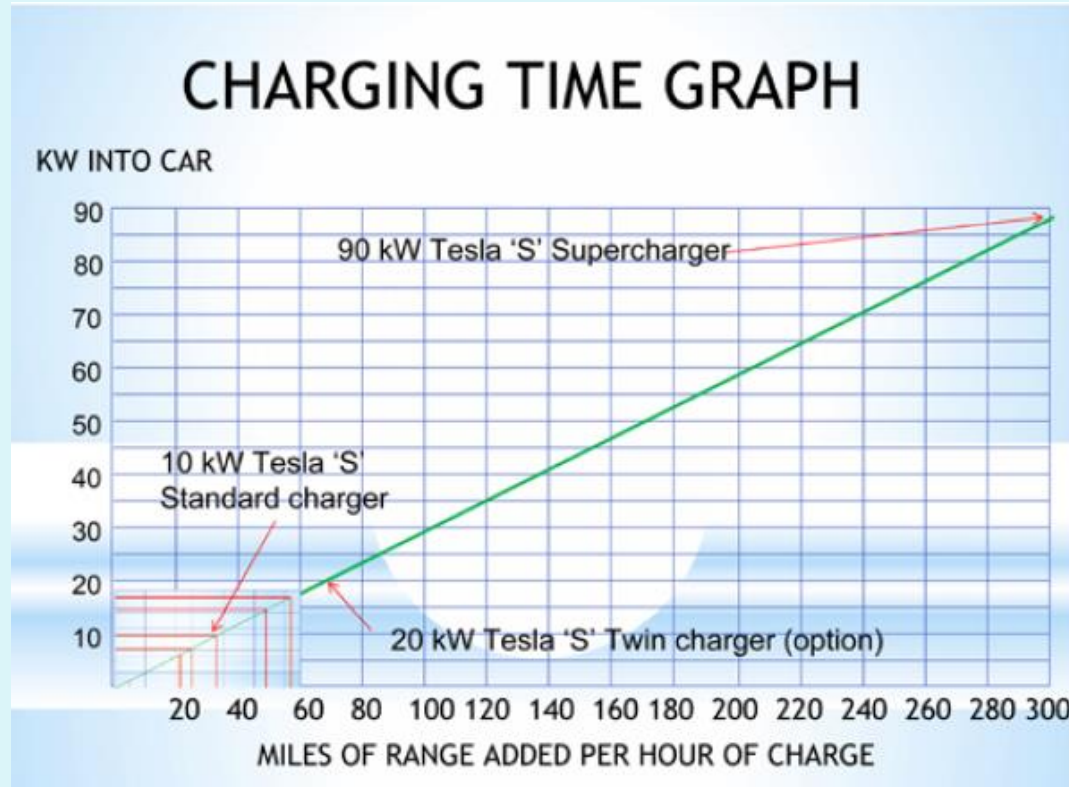
EV CHARGERS

- Defines “fill-up” time (more power, faster fill like a garden hose)
- *Fully* on-board, build into vehicle
- SAE defined spec: J-1772 2001, 2010, 2012 (connector refined)

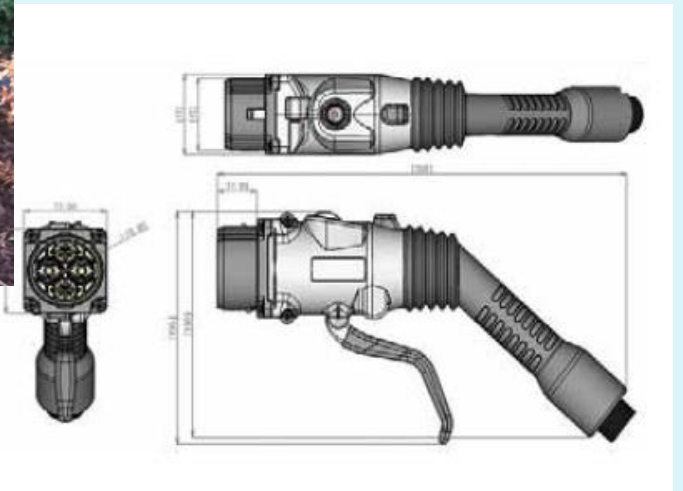
	Level 1 AC Charger	Level 2 AC Charger	DC Wall Box	Level 3 DC Fast Chargers		
Power	120~240V, 13~16A	120~240V, 32~40A	20kW~25kW	50kW~125kW	150kW~350kW	500kW~1MW
Location	Home	Home and workplace	Residential /commercial	Public area	Charging station, Highway corridor	Fleet charging, utility vehicle
Charger converter	Vehicle On Board Charger (OBC)	Vehicle On Board Charger (OBC)	1Φ/3Φ, 11kW module	3Φ, 10~15kW	3Φ, 20, 30, 40, 50kW, 60kW	50kW,60kW 120kW module
Description	Portable plug for standard socket	Permanently wired into home/pole	Bi-directional charger	Integrated high power DC charge station	Two-piece charger with remote power conversion	Container solution
						








EVSE (EV Supply Equipment)

Level 1	- 120V	1 phase	20A	1.92 kW
Level 2	- 208/240V	2 phase	40A	6.6/7.7 kW
Level 3	- undefined			
DC FC	- 480V	3 phase	60A	50 kW
Supercharger	- 12.5 kV	3 phase	120A	90, 120, 135 kW



Charging Connector



	N. America	Japan	EU and the rest of markets	China	All Markets except EU
AC	 J1772 (Type 1)	 J1772 (Type 1)	 Mennekes (Type 2)	 GB/T	 Tesla
DC	 CCS1	 CHAdeMO	 CCS2	 GB/T	

LARGE HOME LOADS

Consider duty factor (on/off time per 24 hours)

- 
- **Range / Oven / Microwave**
 - **Clothes Dryer**
 - **Lights**
 - **Refrigerator / Freezer**
 - **TV**
 - **Air Conditioner / Space Heater**
 - **Pool / Hot Tub**
 - **EVSE (100% for up to 5 hours)**
- e.g., a steady 10 kW draw for 4 hours is a 40 kWh**

PRIVATE IN-HOME CHARGING CHOICES

- **Standard 120 volt power outlets used by >50% of PEV drivers**
- **Post-1980 houses have garage 120 V outlets, older units may need upgrades**
- **Electric Dryer in garage? Easy 240 V addition by qualified electrician**
- **Carport? EVSE outside or behind gate**
- **Hi-power (10-20 kW) desired? Plan the expense, but *not needed, in most cases***

WORKPLACE CHARGING

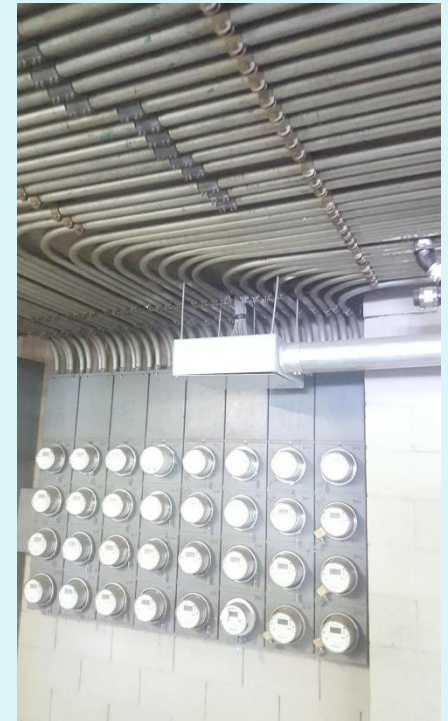
- **Mindsets: entitlement, contentious, busy...**
Level 1 (120 Volts) ← Why? Long dwell times!
- **Level 2 (208 / 240 Volts)**
- **Networked Chargers are NOT necessary!**
(Why? Because facilities usually monitor their load already!)
- **DC Fast Charging (using SAE CCS)**

Photo credit: Detroit Free Press



MULTI-UNIT DWELLINGS

- Multi-vehicle shared carports with lighting only
- Assigned parking locations
- Guest parking
- Multiple car ownership challenges.
- Centralized electric power billing for site
- Expensive individual metering retrofits



Rental Homes: EV ownership

- MFH/Townhouse CC&R regulations may address large parking area but w/ min. power access
- Creative policy for on-site community shared charging. e.g, Palo Alto allows curbside charging (by ordinance) Their public charger statistics reveal heavy usage all day, all year
- NYC resident purchased and brought home new EV w/o considering where to charge. Limited use within city, possible survival?

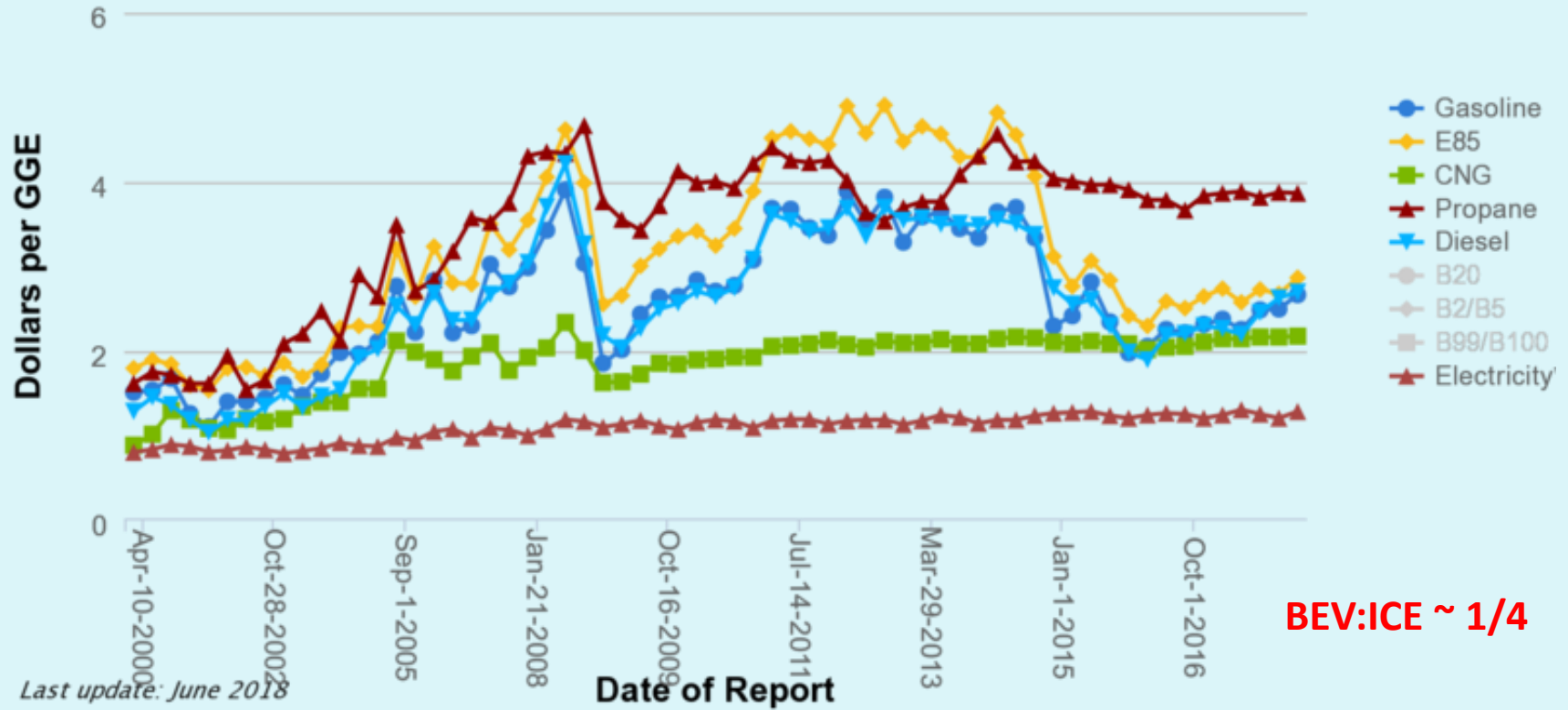
DC FAST CHARGING

- Long distance traveling by using only electricity *is possible.*
- Tesla's SuperCharger network – is still expanding, opening to non-Tesla vehicles in Europe today.
- After “Diesel-gate” VW funded Electrify America which is establishing DC-FC on interstate corridors



Mobility Fuel & Its Cost

Average Retail Fuel Prices in the U.S.



https://energyeducation.ca/encyclopedia/Comparing_gasoline,_diesel,_natural_gas,_and_electricity_prices

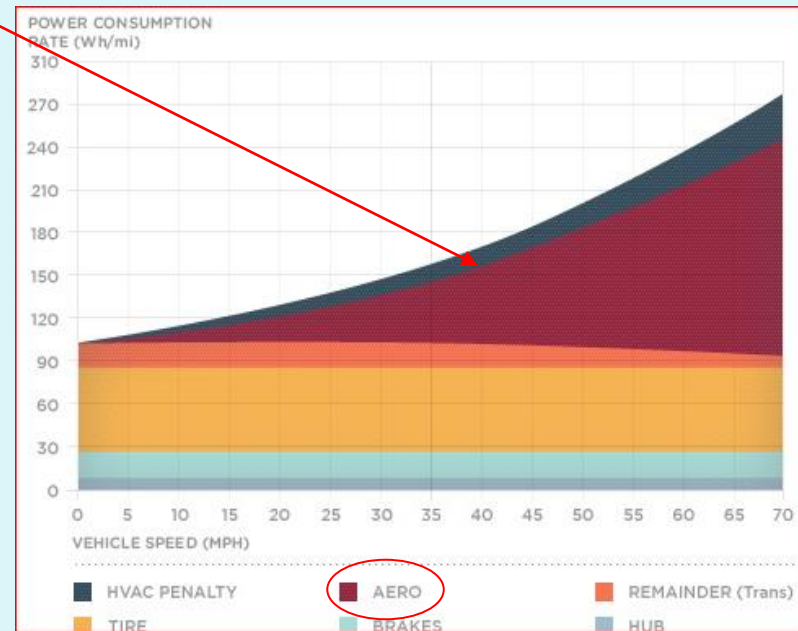
Comparing Efficiency

FUEL EFFICIENCY BY TYPE

TECHNOLOGY	SOURCE FUEL	WELL-TO-STATION EFFICIENCY	VEHICLE MILEAGE	VEHICLE EFFICIENCY	WELL-TO-WHEEL EFFICIENCY
TESLA ELECTRIC	NATURAL GAS	52.5%	110 Wh/km	2.18 km/MJ	1.14 km/MJ
HYBRID (gas/electric)	CRUDE OIL	81.7%	55 mpg	0.68 km/MJ	0.556 km/MJ
COMMUTER CAR (gas)	CRUDE OIL	81.7%	51 mpg	0.63 km/MJ	0.478 km/MJ
SPORTS CAR (gas)	CRUDE OIL	81.7%	20 mpg	0.24 km/MJ	0.202 km/MJ

About Driving Range

- Same factors that affect EVs affect gas car's driving range (ICE cars fuel gauge, typically 3 gradations plus yellow 'low fuel' light! EV displays provides 10 or more gradations on 'State of Charge' display)
 - No battery today can make it to Portland on a single charge either!
 - How many mpg's do you get when driving at 70 mph versus 35?
 - Aerodynamic drag applies as **square-law** to moving vehicle



- How long can you sit in your car?

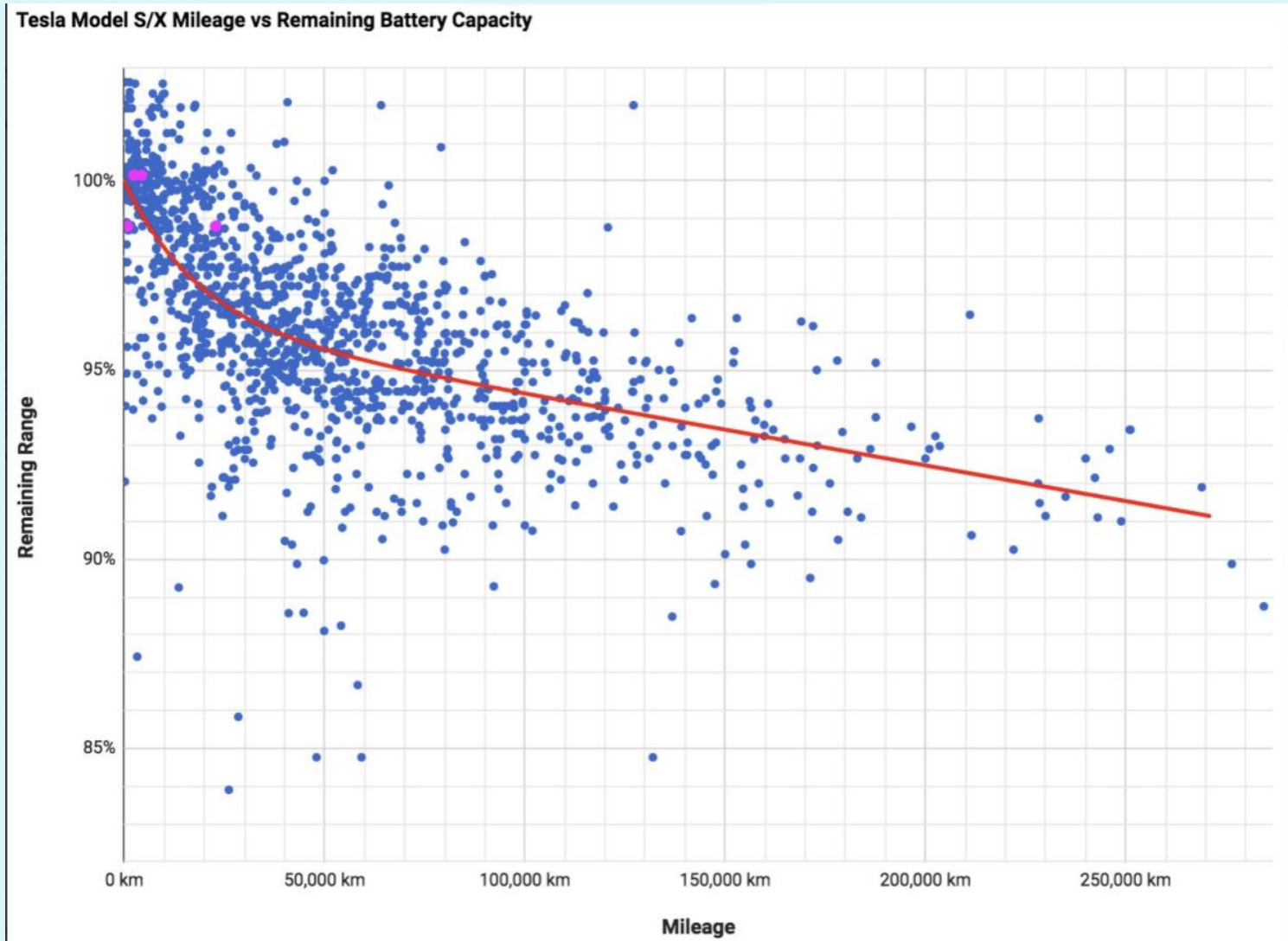
Key takeaway: Reduce energy to go set distance

- Enter aerodynamics and streamlined design
- Add in an effort to reduce vehicle weight
- *Slow down* when you find yourself somewhat short on range!

Supercharging Network in 2022



Tesla Battery Degradation – Driver Data



EVs In The Making: Success In The Market

- 2021 was remarkable despite supply-chain shortages which hurt all OEMs. 2022 looks set to be better still with higher production capacity coming on-line. Happy to see most major automakers make strides towards electrifying their lineup!
- Tesla's Shanghai plant was built in less than a year during 2019. Company borrowed \$1.6B from China government, repaid fully in 16 months. BTW: It's fully owned by Tesla, no partnership with others (nobody else has done that in China)! Now add Austin and Berlin.
- A gross automotive margin is 23% outstanding.
<https://www.statista.com/statistics/783477/gross-margin-by-segment-of-tesla/>
- Product isn't perfect but adaptive, their 'circular' approach is working
- Some other OEMs are learning from Tesla. VW, Ford. Others are still resisting the move towards electrification.
- Financial markets stunned with market capitalization, giant rewards for early investors.

New Electric Offerings From OEMs Worldwide ^{1/3}

Good EV database of all available models: <https://ev-database.org> & https://en.wikipedia.org/wiki/List_of_production_battery_electric_vehicles

VW MEB platform: [ID.3](#) / [ID.4](#) / [ID.5](#) – 170-280 mi, utilitarian, lowest entry

[VW e-UP](#) - sporty, two seats, 150+ mi. \$27K US

[VW e-Golf](#) - older, 24kWh, only J-1772, no DC FC - but max 83 mi.

[Mercedes EQS 580](#) - top-tier offering, available late 2022

[Porsche Taycan](#) – exotic drivers car, 4-wheel steering, top-tier perf, price \$195K

[Audi RS e-Tron GT](#) – best looking, high luxury 230 mi

[MG ZS](#) – British 273 mi, \$38K US, nearly ID.3, practical

[MG5](#) - old fashioned estate SUV, 61 kWh

[Carver](#) - (tandem) ‘leaning’ 3-wheeler, 30 mph max, fun! 24kWh 60 mi. \$10,260

[Citroen Ami](#) - 2 seater, ~30 mph max! ‘Nuf said.

[Fiat 500e](#) - 100 mi, convertible too, but discontinued 2020, 87 mi

[Lucid Air](#) – 1,100 hp! Top-tier offering, built in AZ, several versions, to \$170.5K

[Polestar 2](#) – brilliant Swedish, top info-tainment, 249-265mi, ½ motors, 78 kWh

[Volvo XC40](#) - Recharge – big PHEV maker’s full BEV, 75 kWh, 208 mi. \$51.7K

New Electric Offerings From OEMs Worldwide ^{2/3}

Tesla Model S / X – w/ std SuC ntwk top-rated, (reliable, multiple ports per site), no fed tax credit. The Plaid, w/ 3 motors... See <http://tesla.com>

Tesla Model 3 / Y - self-driving option, top UI, very spacious CUV, std SuC

[Toyota RAV4EV Prime PHEV](#), only 42 mi AER from 18.1 kWh

[BMW e-Mini](#) 2nd generation <100 mi AER, pricey but fun!

[BMW i3S](#) – now in 7th yr, 43 kWh for 153 range, prod. end 7/'22

[BMW i4](#) - well executed, >330 mi AER, from \$55k, 200 kW DC FC, OTA

[BMW iX](#) – fast, top rated, 100kWh for 373 mi, yet \$55.4K

[Honda e](#) – lightweight, 160 mi from 35 kWh, their first EV entry!

[Hyundai Santa Fe PHEV](#) – 13.8 kWh, 1.6L 30 mi AER

[Hyundai Ioniq 5](#) - top impression, 'affordable' 4 trim levels w/ AWD

[Hyundai Kona](#) - 300 miles, sans heads-up display, great warranty!

[Mazda MX-30](#) – 35 kWh pack, \$39.5K 160 mi AER, slow...



Photo courtesy Wired

New Electric Offerings From OEMs Worldwide 3/3

[Chevy Bolt EV /EUV](#) – launched in 2016, a '22 gets 259 mi, 65 kWh LG battery, no fed tax credit or select a LEAF, Niro, Kona

[Jaguar i-Pace](#) – more refined, 90 kWh, 222 mi, twin motor, from \$70K, leather luxury

[Bentley EV](#) – high end promises...

[Peugeot e208](#) - 45 kWh, 200 mi. low end competition to LEAF, 500e, Zoe, ID.3

[GMC Hummer EV](#) - \$115.9 K, heavy duty, extract mode, 4 panel removable roof, [off-road capable](#)

[Ford Mach-e](#) - dual motor, sounds of ICE vehicles available. GT version new

[Renault Zoe](#) (2nd generation) 52 kWh capacity

[Rivian R1T / R1S](#) – cool reviews, R1T's pull-out kitchen option Starts at \$69,900. 300 mi, 10K lbs towing!

[Range Rover P440e](#) PHEV 48 mi range, 50 KW DCFC, \$105K, starting in 2024, (Targeted by R1S)

[Kia e-Niro](#) EV for \$52K US, 64 kWhr battery, high 200's range

[Jeep 4xE](#) 17.1 kWh PHEV w/ 2.5 gallon tank, 20 mi EV range for \$62K

[Kia EV6](#) – sensible, sporty 275 mi, based on Hyundai Ioniq 5.

Stellantis [Citroen e-C4](#) comfortable 50 kWhr battery 217 mi. range, \$28.8K US

[BYD e6](#) for fleets only, China's popular MPV, 71 kWhr for nearly 300 mi. >1 M sold worldwide.

[Nissan LEAF](#) – perfect entry level EV, 62 kWh 226 mi. used 2011-2015, degraded range

[Subaru EV](#) – “Solterra” compact SUV is a BEV developed w/ Toyota, 2 motors, off-road cap. 220 mi.

[Aptera](#) – 3 wheeler, two hub motors; “a never charge” EV, composite structure. Solar cells of monocrystalline powder with copper matrix in back light flexible.

<https://www.youtube.com/watch?v=qVxLI87Ap6s> Large crumple zone, target 40 cars/day. 1st effort failed

[Ford F-150 Lightning](#) with [Intelligent Back up Power](#) Tom Moloughney discusses specs,

131 kWh Extended Range, 98 kWh Standard Range pack (usable capacity), towing 10,000 lbs. Derate down to 20 A to charge. DC feeds house via an “Intelligent Backup Power” station. It's standard with Extended Range pack, done by SunRun. Works on standard range too but need buy Ford Charge Station Pro, and *pay to activate*.

[Proterra ZX5 Bus](#) - Pure electric city bus, 329 mi, seats 29, pantograph charging connection, carbon composite body



The Future: More EVs

- Due to mandated air quality standards
- EV acceptance ramp-up
 - Over 5M US PEVs today, 2% of new cars
 - Battery cost reductions continue
 - Big OEMs are (finally) entering the market
- Grid energy storage using EV fleets
- Gradual reduction in ICE usage

EVs are the future!

Sunshine will never cost \$4/gallon!



Thank you!

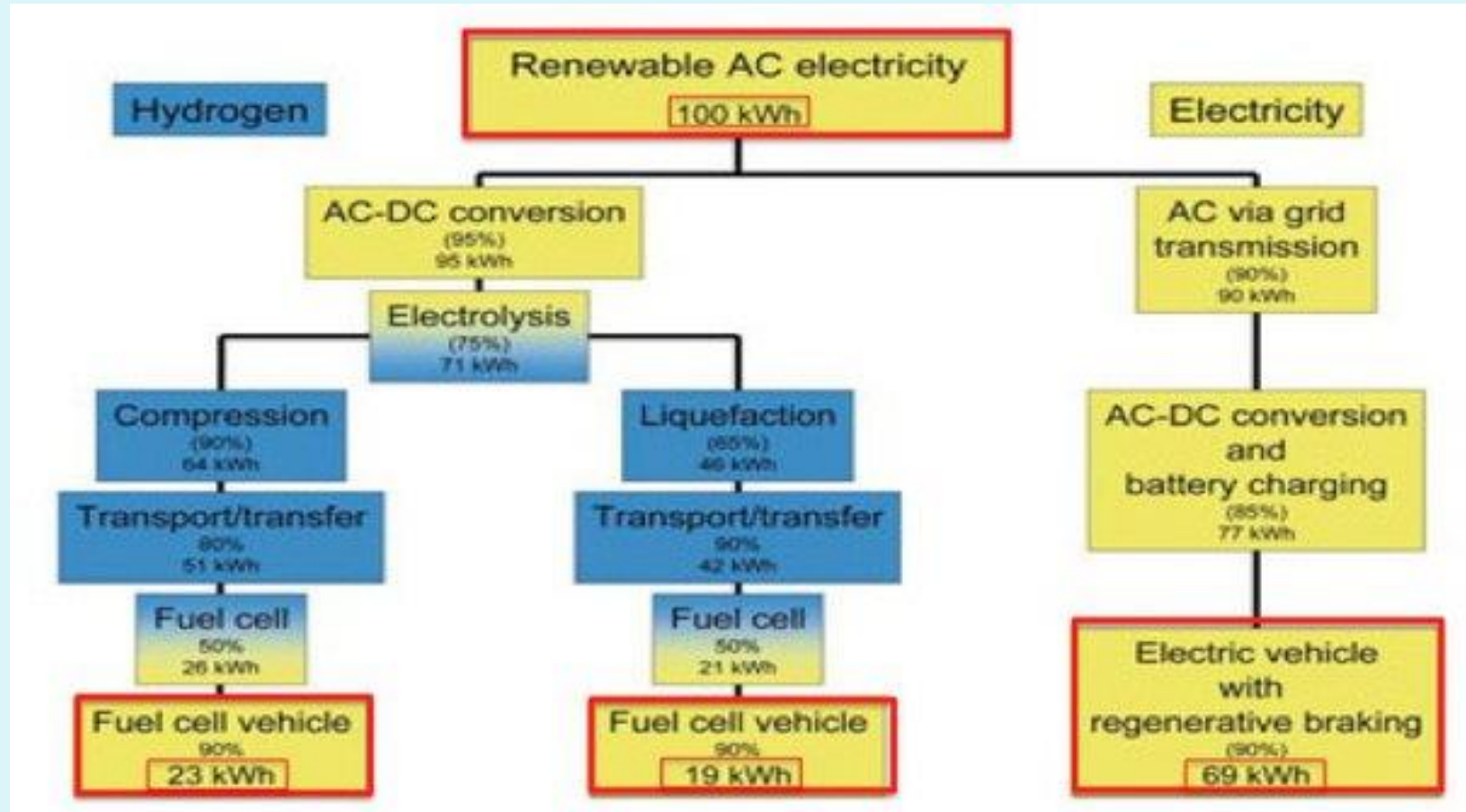


EV + PV = near self-sufficiency in energy!

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Supplemental Slides

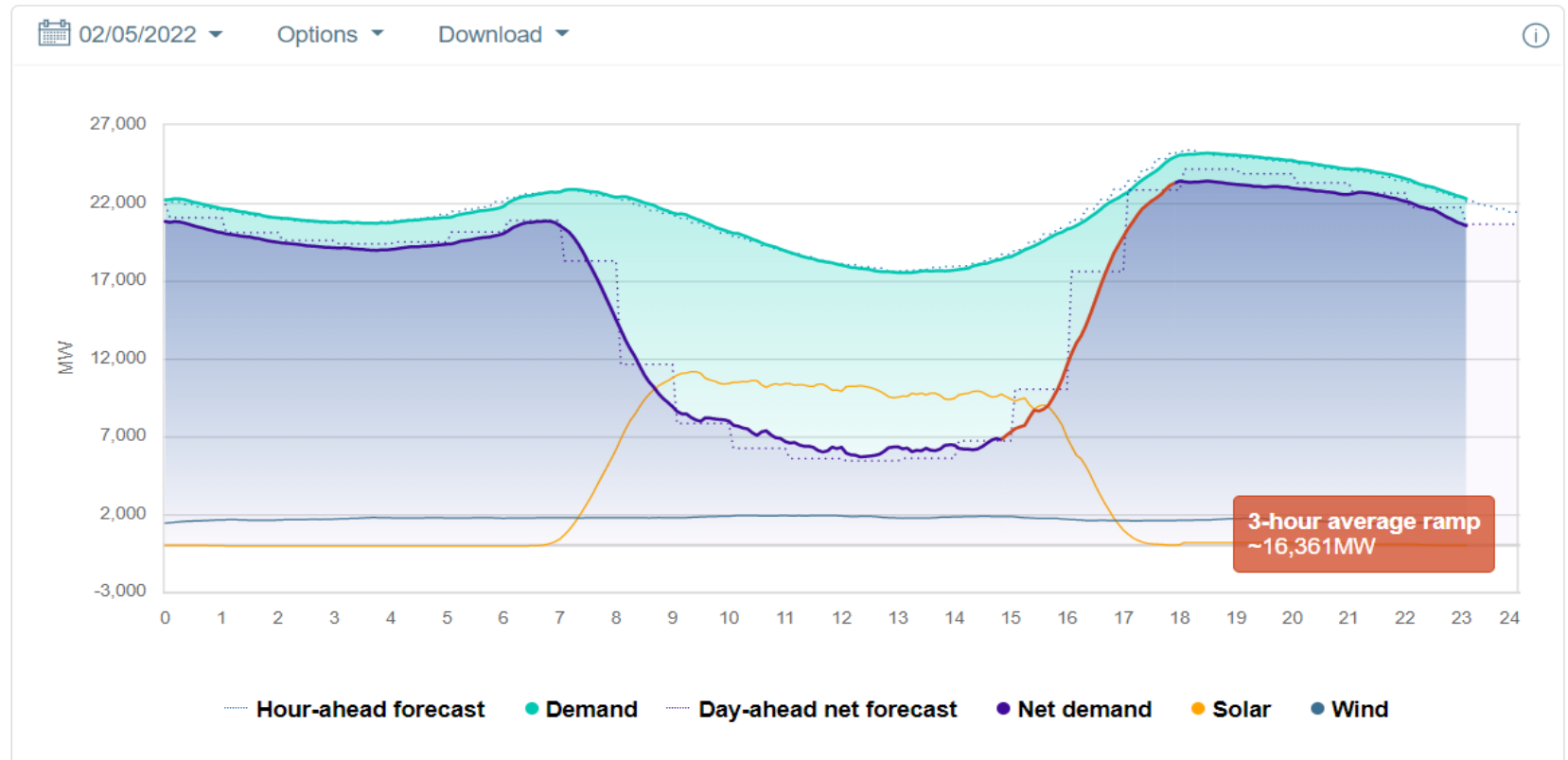
BEV vs FC EV



Cal ISO Data Off-Peak Capacity

Net demand trend

System demand minus wind and solar, in 5-minute increments, compared to total system and forecasted demand.



<http://www.caiso.com/Pages/TodaysOutlook.aspx>

Battery Improvements

1980-2000 Energy Density Comparison

These represent the same electric capacity!

**210 Alkaline cells
equals
1 Lithium (LiMn2O₄)**

2500 g vs 95 g

**Driving force behind quest:
increased use of portable
electronic devices (cell
phone, laptops, tablets,
music players, games).**

**Things have gotten even
more interesting in the
past two decades, with
density increases**



About Range Anxiety

“While it is common for pundits to speak of **range anxiety** ... , in this study we heard more about **range desire** as drivers ... sought to expand their BEV spaces.”

photo and quote from:

Turrentine, Garas, Lentz, and Woodjack;

[“The UC Davis MINI E Consumer Study”](#);
[May 2011](#).



Other FAQs and Topics

How do various cars compare in terms of efficiency? Aren't EVs just "emissions elsewhere" vehicles?

<https://www.youtube.com/watch?v=2rywz73vwKw> See this "Engineering Explained" video. Also it references Martin Eberhardt/Mark Tarpenning 2006 Tesla 'Efficiency' [paper](#).

Historic gasoline prices since 2001 versus electricity prices for same period

<https://www.eia.gov/energyexplained/gasoline/history-of-gasoline.php>

<https://www.eia.gov/electricity/data/browser/#/topic/77>

Compare price variability of gasoline to the relative constancy of electricity:

<https://www.nrel.gov/docs/fy17osti/67645.pdf> on page 12 of 289!

Before Tesla Roadster there was this: AC Propulsion, The tZero with Tom Gage and Alec Cocconi vintage 2010. An excellent overview of this whole electric thing!

<https://www.youtube.com/watch?v=gb9E222QsM0>

Additional FAQs

Cold weather EV behavior, etc.

YouTube videos and useful links

<https://www.youtube.com/watch?v=i3E0t0kGeug>

During Jan. 2022, after long hours in I-95 traffic jam in No. Virginia - stranded both EVs and ICE drivers. Everyone whined. Technology comparison and notes. Many good comments regarding circumstances and comparing two different heating approaches in use today.

John Voelcker for Car and Driver: <https://www.caranddriver.com/news/a38883045/electric-cars-snow-cold-fact-check/> And the Reuters fact check mentioned therein:

<https://www.reuters.com/article/factcheck-environment-ev/fact-check-electric-cars-not-more-likely-to-get-stuck-in-traffic-jams-idUSL1N2RW0QD>

Are EVs more comfortable on long trips, if so why?

Every stop to charge has already been laid out before leaving the last charger, so there's *never any anxiety* about what kind of fueling station you'll end up at. You also get a twenty-minute break every couple hours which drastically reduces road frustration.

Electricity Prices vs Gasoline Prices over 45 years

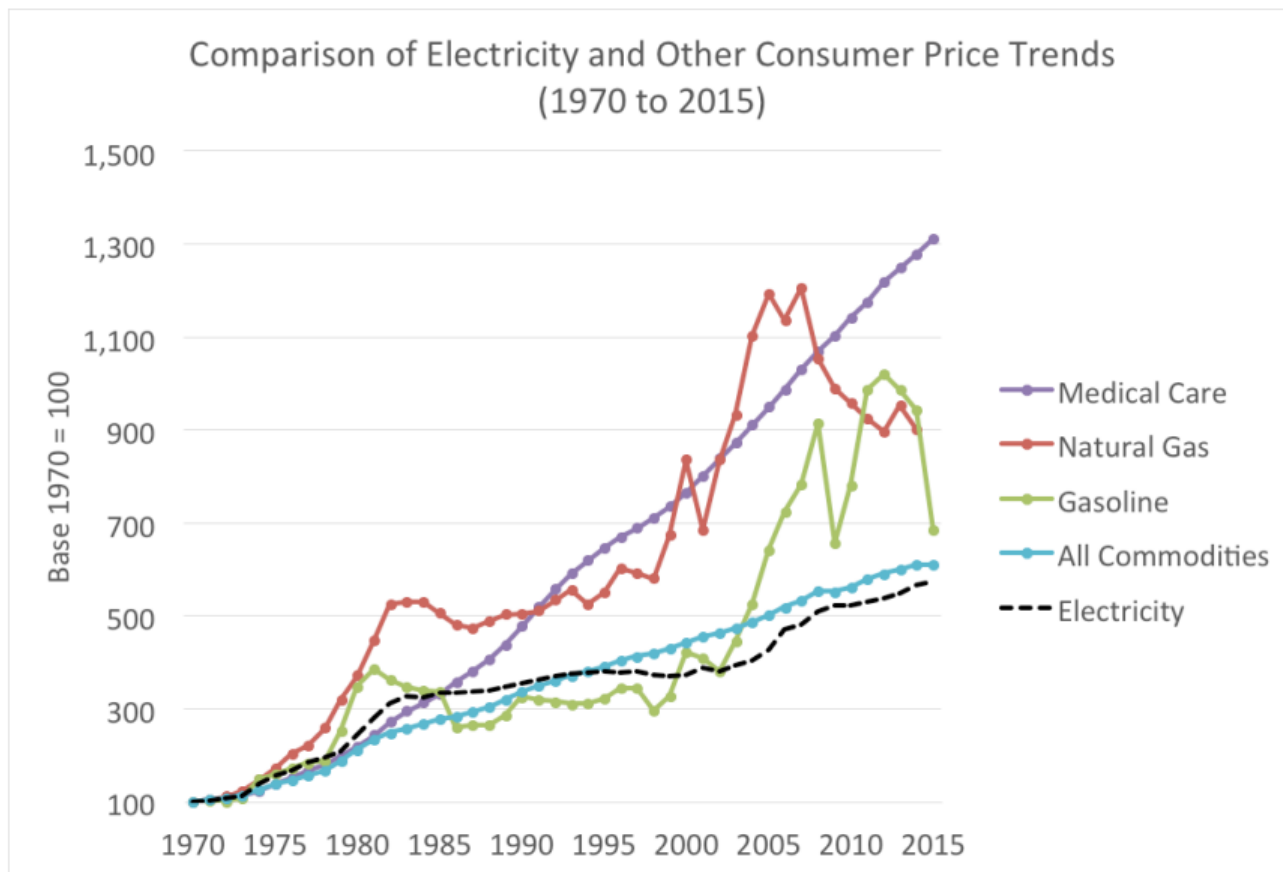
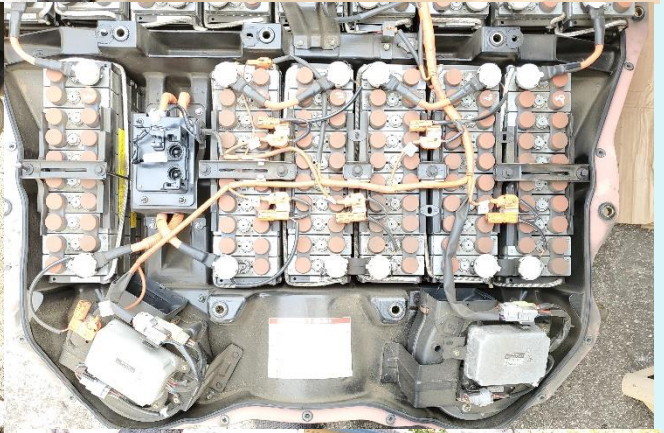


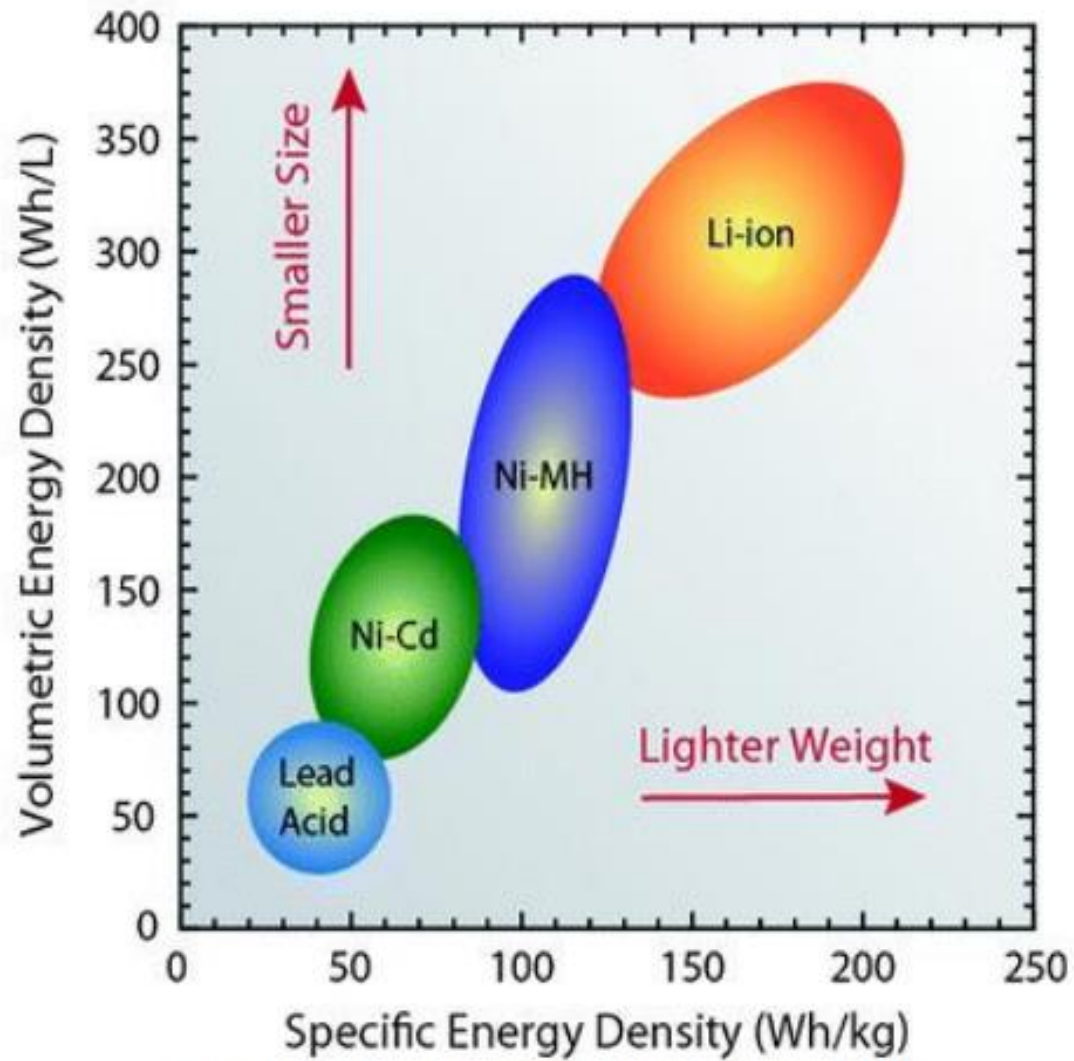
Figure ES-4. Comparison of electricity, natural gas, gasoline, medical care, and all commodities prices, 1970 – 2015 (1970\$)

Electricity prices have risen over time, but less in comparison to other commodities.

Source: EIA 2016 and BLS 2016⁶



Battery Pack Swap 2002
Toyota RAV4EV – Nov 2021
@ 126,510 miles



SOURCE: <http://www.epectec.com/batteries/cell-comparison.html>