EV Myths, Misconceptions, Surprises, and Perspectives A Research- and Personal Experience-Based View

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Agenda

30-35 minutes of talking

- Lots of different ways to look at EV-related problems
- I'll move quickly
- Cover more topics (in less depth) and dive into detail in Q&A

25-30 minutes of questions

- Take note of things you want to hear more about!
- Happy to go into more depth either during the questions or after the webinar
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Why This Topic?

- Contrast with typical mass media article about EVs
 - Deeper dive more detail
 - Different way of looking at the EV experience

Summary of 10 years of conversations

- What made people go "huh!" and think
 - i.e. "EV" vs. "electric car"
- Not just a carbon copy of talking points



Contents

Typical article about EVs

- Range anxiety
- Charging cost
- Vehicle cost
- Charging time / hassle Environmental benefit

- My high-level summary of EVs
 - Cheaper

Gotta get used to it •

- Cleaner •
- More convenient
- More fun •
- Useful Technical Factoids



Cheaper

- $c/kWh \rightarrow s/gal$
 - Multiply ¢/kWh by 10 to get equivalent \$/gal¹
 - Actually 8.5, but 10 is easier and still gets super-compelling numbers
 - 12.5 ¢/kWh is \$1.25/gallon
 - \$1.25/gallon makes the news whenever some gas station accidentally mis-prices their gas

Hedge / lock in rates

- No gas station lets you buy in advance
- Up to 5 years with a REP
- 30+ years with solar panels
 - ~6 ¢/kWh energy charge
 - 30 year contract
 - True net metering still available (if you buy panels through GME)
 - Free L2 chargers available (size for future EV)
- \$20/mo to drive my 2012 Leaf
 - When was the last time \$20 in gas got you a month of driving?
- ¹ Source: EPA eGallon Methodology



Cheaper

- Sticker Price
 - Average new car price is ~\$45,000!
- Total Cost of Ownership
 - Fuel (solar!)
 - Maintenance
 - PHEVs vs. BEVs

I∩SIDEEVs

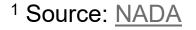
Base price (MSRP + DST and a	fter <u>Ta</u>	ax Credit)			
All-electric range (EPA)					
· · · · · ·	\$0	\$50 000	\$100 000	\$150 000	\$200 000
2022 Nissan LEAF S (40 kWh)	149	\$208 5			
2022 MINI Cooper SE	114	\$23 250			
2022 Nissan LEAF e+ S (62 kWh) 2021 Hyundai IONIQ Electric	226	\$25 775 \$26 750			
2021 Hyundal IONIQ Electric 2022 Mazda MX-30	170 100	\$26 / 50			
2022 Hyundai Kona Electric	258				
2022 Nissan LEAF e+ SV (62 kWh)	215	\$27 685 \$3 875			
2022 Chevrolet Bolt EV	259	\$31 995			
2022 Kia Niro EV (e-Niro) 2021 Volkswagen ID.4 Pro	239	\$23 665 \$3 690			
2021 Voikswagen 10.4 Pro 2022 Chevrolet Bolt EUV	260 247	\$ 3 690 \$33 995			
2022 Chevrolet Bolt EOV 2021 Ford Mustang Mach-E Select SR RWD	247	\$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" 2021 BMW i3s	265	\$39 700			
2021 Bivivi Iss 2021 Tesla Model 3 Standard Range Plus	153 262	\$41 145 \$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			
021 Ford Mustang Mach-E Premium ER RWD 2022 Volvo XC40 Recharge	300 223	\$46 200			
021 Ford Mustang Mach-E Premium ER AWD	270	\$48 89			
2021 Tesla Model 3 Long Range AWD	353	\$51 19			
2022 Volvo C40 Recharge	210	\$52.34			
2021 Ford Mustang Mach-E GT ER AWD	270	\$53 5			
2021 Tesla Model Y Long Range AWD 19"	326	\$55 1			
2021 Tesla Model 3 Perf. LR AWD 20" 2021 Ford Mustang Mach-E GT Perf. ER AWD	315 260	\$58 \$58			
2021 Ford Mustang Mach-E GT Ferr. EK AWD 2021 Audi e-tron	200		495		
2022 Rivian R1T (Large pack, 21")	314		000		
2021 Tesla Model Y Perf. LR AWD 21"	303		2 190		
2022 Rivian R1S (Large pack, 21")	316	\$6	2 500		
2021 Audi e-tron Sportback	218		2 695		
2022 Jaguar I-PACE EV400 2022 Rivian R1T (Max pack, 21'')	234		3 550		
2022 Rivian R11 (Max pack, 21°) 2021 Porsche Taycan (79 kWh)	400		\$70 000 \$73 750		
2022 Audi e-tron S 20"	208		\$78 395		
2021 Porsche Taycan (93 kWh)	225		\$79 530		
2022 Audi e-tron S Sportback 20"	212		\$80 995		
2021 Porsche Taycan 4 Cross Turismo	215		\$84 750		
2021 Tesla Model S Long Range (AWD) 19" 2022 Audi e-tron GT quattro	405	_	\$91 190 \$93 445		
2022 Audi e-tron G I quattro 2021 Porsche Taycan 4S (79 kWh)	238 199		\$93 445	0	
2021 Tesla Model X Long Range (AWD) 20"	360		\$101		
2021 Porsche Taycan 4S (93 kWh)	227		\$103		
2021 Porsche Taycan 4S Cross Turismo	215		\$104	150	
2021 Tesla Model X Plaid 20"	340	_		\$121 190	
2021 Tesla Model S Plaid 19"	396			\$131 190	
2022 Lucid Air Grand Touring (21") 2022 Lucid Air Grand Touring (19")	469 516			\$133 000 \$133 000	
2022 Audi RS e-tron GT quattro	232			\$133 445	
2021 Tesla Model S Plaid 21"	348			\$135 69	
2021 Porsche Taycan Turbo (93 kWh)	212			\$144	
2021 Porsche Taycan Turbo Cross Turismo	204			\$14	7 350
2 Lucid Air Dream Edition Performance (21")	451				\$163 000
2 Lucid Air Dream Edition Performance (19")	471	_			\$163 000
2022 Lucid Air Dream Edition Range (21") 2022 Lucid Air Dream Edition Range (19")	481				\$163 000
2022 Lucid Air Dream Edition Kange (19") 2021 Porsche Taycan Turbo S (93 kWh)	520 201				\$163 000 \$178 850
2021 Porsche Taycan Turbo S Cross Turismo	201				\$178 850



Cheaper

- Model Availability •
 - Trucks and SUVs

Year	New cars	Light-duty trucks	Total light-duty vehicles	Light-duty trucks as % of total
2009	5,456,300	4,945,400	10,401,700	47.5%
2010	5,635,400	5,919,100	11,554,500	51.2%
2011	6,089,300	6,644,900	12,734,200	52.2%
2012	7,242,800	7,199,000	14,441,800	49.8%
2013	7,582,500	7,942,300	15,524,800	51.2%
2014	7,688,900	8,748,100	16,437,000	53.2%
2015	7,525,023	9,861,024	17,386,047	56.7%
2016	6,873,158	10,591,862	17,465,020	60.6%
2017	6,079,584	11,055,149	17,134,733	64.5%
2018	5,304,347	11,910,816	17,215,163	69.2%
2019	4,790,846	12,317,310	17,108,156	72.0%
2020	3,408,778	11,055,157	14,463,935	76.4%





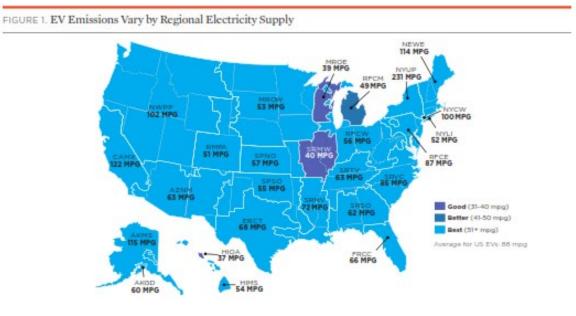
Cleaner

- Usually the lead point not always the selling point!
 - Tesla proved people want to buy "fun / high-performance"
- Gotta figure out what resonates with people
 - Can't ask Americans to change their lifestyle
 - EVs win on ALL fronts
- Usual focus is CO₂
 - Very divisive
- Need to focus on local air quality, too
 - SOx, NOx, VOC, PM, CO
 - Nobody likes smog
 - Much less divisive



Cleaner

- "Charging from a coal power plant is dirtier than gasoline!"
 - Time/place of emissions Power plant full of V8s? Running at most efficient output
- Grid power: 65-70% reduction in pollution (CO₂ and local)
- Renewable power from GME: 100% reduction in pollution (CO₂ and local)
- Diesels not subject to emissions testing in TX!



Sources: UCS, EIA, EPA National Emissions Inventory



Cleaner

- What's the biggest source of CO₂ emissions? House or gas car?
- Gas car: 800 lbs/mo
 - 12,000 mi/yr / 25 mpg / 19.8 lbs CO_2 per gallon
- House: 2,000 lbs/mo
 - 2,000 kWh/mo / 0.991 lbs CO₂ per kWh ("grid intensity")
- Important to address biggest sources of emissions first!
 - House is much easier to make renewable, too!
- EVs unsuitable for (1) aviation, and (1.5) long-haul trucking
 - Super-curious to see how Tesla Semi (and competitors) do
 - Carbon offsets can handle CO₂ emissions of aviation and trucking
 - Similar offsets for other pollutants? Do SOx offsets make any sense?



More Convenient

- Range Anxiety
 - "I'm going to get stranded either on the road or at home"
 - It exists with gas cars, too!
- Multi-car families
 - At least one EV/PHEV per family
- Typical treatment: "Recharge time from empty"
- More important metric: "Time spent recharging"
 - Usually lower for EVs!
 - Can charge at home, no special trips to fuel up or maintain it, car charges while you do other things
 - Average car utilization: <5%
 - 12,000 miles per year / 30 mph average speed = 400 hrs per year / 8,760 hours in year = 4.5%
- 3-6 months to get into the habit of driving an EV
 - Love to run a study where people get an EV for 3-6 mo. See how many return it early
 - Give them a taste and get them hooked



More Convenient

- Charging
 - Harder to set up than for a gas car (especially for apartments)
 - But easier to use once it's set up
- GME offers a free L2 charger if you buy solar panels from us and size your system to power a future EV (i.e. ~120% offset.)
 - True net metering available, too.
- Difficult for public to keep up with rapid advances in EV capabilities
 - EVs in infancy
 - Costs continue to fall, range/capabilities continue to increase rapidly
- Takeaway:
 - Electrify what's easy to electrify
 - Plenty of opportunity with multi-car-garage single-family homes
 - Worry about edge cases once low-hanging fruit is complete
 - Give people what they want / what they think they need.



More Fun

- EVs vs. Hybrids
 - Hybrids trade off fun driving experience for better mileage. EVs give best of both worlds
- Quieter
 - Live next to a freeway?
 - Listen next time one drives down a street.
 - Conversation between front and back seat
- Zippier
 - All torque available all the time
 - Zip out in front at a stoplight to change lanes



Combining the Above

- Why do I want an EV?
 - Hybrids trade off fun driving experience for better mileage. EVs give best of both worlds
- I want an EV so I can feel less guilty about my lifestyle.
- With an EV, I don't have to feel bad driving to the grocery store anymore to pick up a gallon of milk.
- I don't have to feel bad taking a trip because I know it's zero-emission, I'm not harming the environment, it's as efficient as I can make it, and I've minimized the burden I'm putting on other people (noise and pollution.)





To start

What is a kWh?

- Ineffective definition:
 - "the energy needed to run ten [now nearly-outlawed] 100W light bulbs for an hour"
- Effective / Impactful definition:
 - "8 hours of manual labor (shoveling dirt, etc.) expends 0.5 kWh"
 - "1 full day of manual labor could be replaced by \$0.05 worth of electricity"

Electricity is powerful

• To power an air conditioner, you'd need 40 people pedaling bikes (for 12 hrs/day!)



- Comparing gasoline to batteries
 - Gasoline: 6 lbs per gallon
 - Battery: 150 lbs per gallon equivalent (33.7 kWh)
 - Technically 450 lbs, but battery can be used 3x as efficiently as gasoline
 - Will we need more electricity to power these EVs?
 - How much electricity does it take to MAKE gasoline?
 - Explore, drill, transport, refine, transport, pump into tank?
 - 6 kWh. To get you ~25 miles
 - Use the 6 kWh to drive an EV directly? ~25 miles
 - We don't need more electricity to power EVs. We just need to redirect it away from producing gasoline!





- Everything about an EV is backwards compared to gas car experience
 - You need charging where you PARK most often, not where you DRIVE most often
 - 225-mile Leaf / 0 fast charges in 6 months
 - City efficiency is better than highway efficiency
 - Larger batteries can get by with slower chargers
 - Don't let L2 charging (or its install cost) be a hurdle
 - Larger batteries let "low mileage" days offset "high mileage" days
 - Not possible with small (~75 mile range) batteries

	-	Vehicle mpge (mi/kWh)					
ജപ		2.5	3	3.5	4	4.5	
Hours of charging (per day)	8	30	36	42	48	54	
char day)	10	38	45	53	60	68	
rs of (per	12	45	54	63	72	81	
) unc	14	53	63	74	84	95	
Ĭ	16	60	72	84	96	108	
-			(Model X)		(Model Y)		
			(Model S)		(Model 3)		

Available miles per day BEFORE falling below 100% SOC (L1)

Available miles per day BEFORE falling below 100% SOC (L2)

Vahiela manaa (mi/W/h)

	-	venicie mpge (mi/kwh)				
ലപ		2.5	3	3.5	4	4.5
Hours of charging (per day)	8	132	158	185	211	238
	10	165	198	231	264	297
rs of (per	12	198	238	277	317	356
) I)	14	231	277	323	370	416
Н	16	264	317	370	422	475
			(Model X)		(Model Y)	
			(Model S)		(Model 3)	



- EV Subsidies
 - EVs: <\$2 billion (2020)¹
 - Oil/gas: \$10 billion (average 2002-2008)²
 - Tax breaks and direct spending
 - Oil/gas: \$0.25-\$0.75/gal³
 - Military subsidy to defend free flow of oil
- "Level the playing field?" I'd be happy to.





The Future Is Here Today

- New/expanded technologies
 - GME EV app (integrating EV charging with REP)
 - TOU (cost / emissions)
 - Demand Response
 - V2G
 - F-150 Lightning 10 kW out
- Typical day at work for me:
 - Daniel: "The answer is EVs. The answer is always EVs. Sometimes also solar."
 - Coworker: "...what was the question?"
 - Daniel: "Doesn't matter."
- Plug for GME
 - Glad to work there
 - I get to influence electricity product development taking these insights into account
 - Keep an eye out for things we'll be releasing over the next few years

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