EV Policy and Regulation

As Seen by a Regulator, Academic, and Policy Wonk

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My Messages

1. Policy is necessary for transition to EVs
2. EVs will soon be cheaper than gasoline ICEVs (and most diesel trucks)
3. US is falling further behind Europe and China
4. Many challenges along the way
5. Most effective policy is “sales mandates” (not “incentives”)
6. California policy model for cars and trucks

Future of EVs?

Technological vs Social Determinism

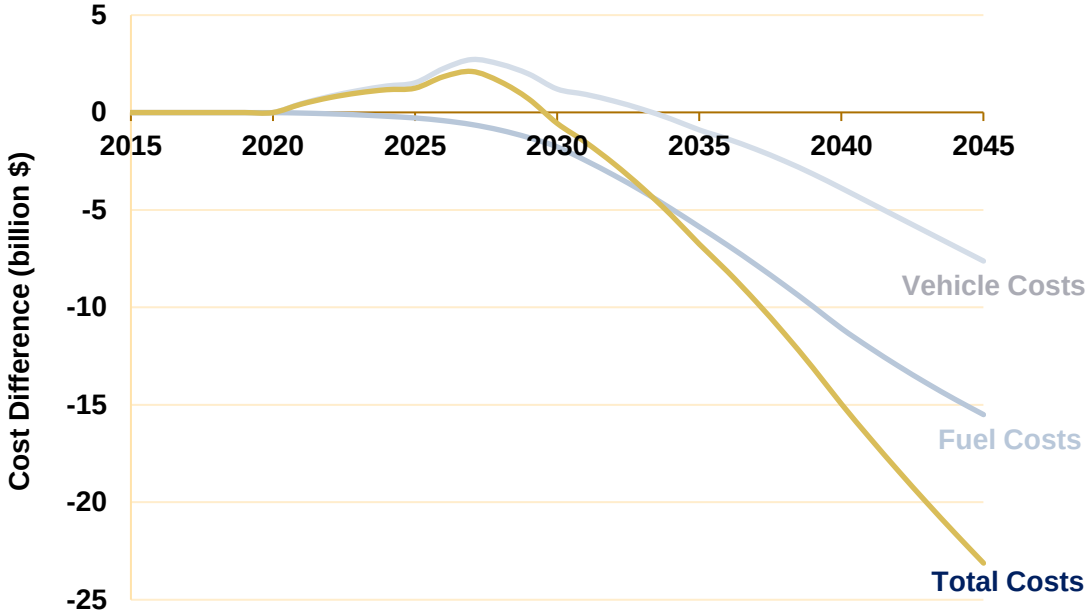
- Technological determinism: society's technology determines development of its social structure and cultural values.
- Social determinism: society is autonomous force shaping technology, cultural values, social structure and/or history.
- **EVs are mostly “socially determined”.**
  - Transition to ZEVs involves transformation of vast array of institutions, technologies, businesses, and behaviors.
  - It will be disruptive for many businesses, governments, and people.
  - For the automotive industry, it is the biggest change since the Model T
- I believe EVs are not inevitable for at least the next 30 years—without policy intervention

EVs are Policy Imperative for Climate Mitigation

- EVs are THE most important strategy to decarbonize transportation—by far!
- Automakers are responding where policy is strongest

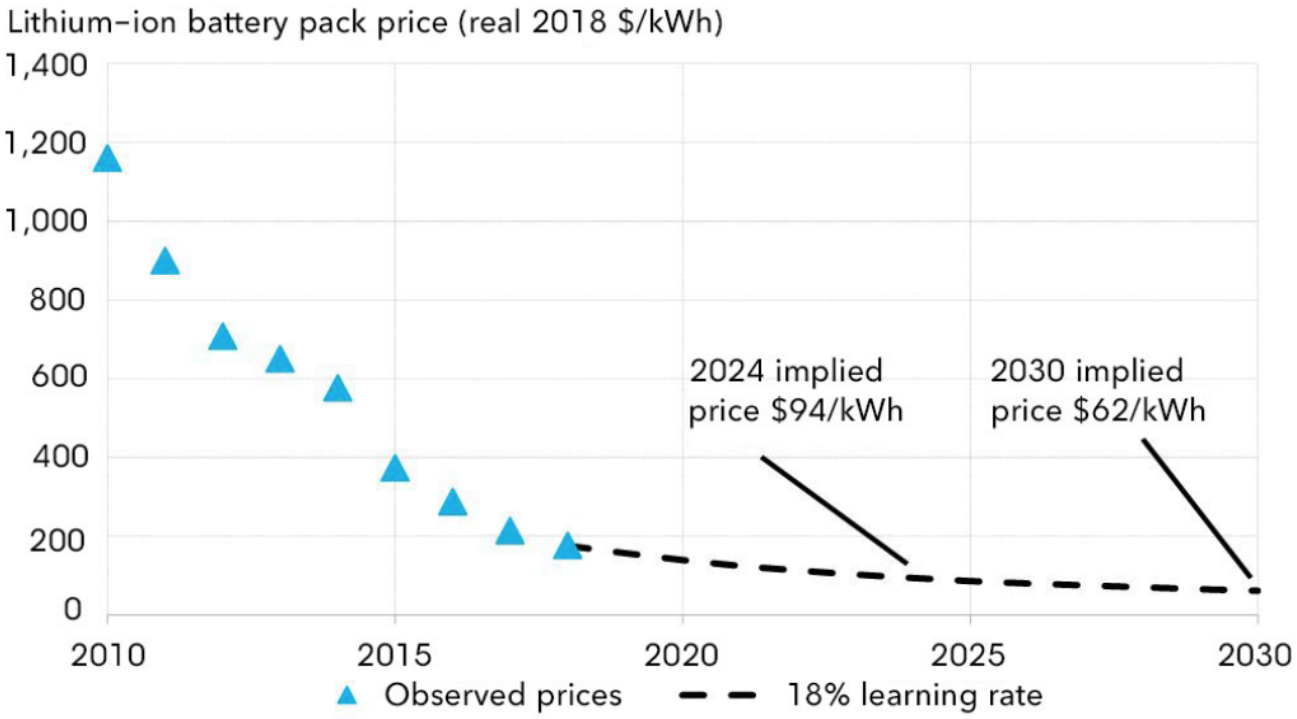
But EVs Will Also Save Money (Consumers and Economy) and Reduce Health Costs

Strong transportation decarbonization policies will result in net cost savings starting in ~10 years



UC ITS (Brown, Sperling et al, 2021)

EV Success Mostly Due to 90% drop in Battery Costs… But Will Trend Continue (7% increase in 2022)?



Source: BloombergNEF (IEA, 2022)

Q: So why do we need government intervention for EVs?

A: Consumers don't make decisions based on total cost of ownership (TCO)

- Individual buyers are "conservative": concern over resale value, future price of energy, loss aversion, range anxiety
- Trucks are a little different: fleet owners are more likely to use TCO as decision variable

➢ *Incentives will be needed for a long time*

… but some incentives are more effective than others, and they don't need to be paid by taxpayers (feebates, LCFS, non-monetary….)

Forces and Factors Inhibiting EVs

- Consumer purchase decisions mostly based on vehicle price (not total cost of ownership)
- “Externalities”: climate change and local air pollution
- Consumers conditioned to ICEVs (range anxiety, refueling)
- Not profitable to build and operate EV charging stations
- …. and many other market failures and market conditions
  - Loss aversion by consumers
  - Principal agent problem (rental cars, new vs used car market, company cars)
  - Network externalities (expanding user benefits from charging and H2 stations)
  - Technology lock-in
  - Market power (cartels, oligopolies, etc)
  - R&D under-investment (due to: R&D spillover, Learning-by-doing spillover, etc)

How to Accelerate EV Sales?

- Huge incentives… Norway
- Very aggressive CO2/CAFE performance stds … Europe
- Aggressive ZEV sales requirement … California starting in 2027?!

❖ *But also need to do many other things such as installing charging/H2 stations*

Unique Context
"Informed" Leaders and Experts In Consensus

- LDVs will be mostly battery EVs (BEVs)
  - Definite some plug-in hybrid EVs
  - Probably some hydrogen H2 FCVs
- Most HDVs will be BEVs … but some traveling long distances will use:
  - Low-carbon biofuels (not in California and states following California)
  - Hydrogen FCVs

➢ *But how, when, and where? And what is the role of policy?*

Recent Announcements of OEMs….

BUSINESS | AUTOS & TRANSPORTATION | AUTOS INDUSTRY

GM to Phase Out Gas- and Diesel-Powered Vehicles by 2035

Auto giant's plan to eliminate tailpipe emissions is part of a goal to be carbon neutral by 2040

Volvo Plans to Sell Only Electric Cars by 2030

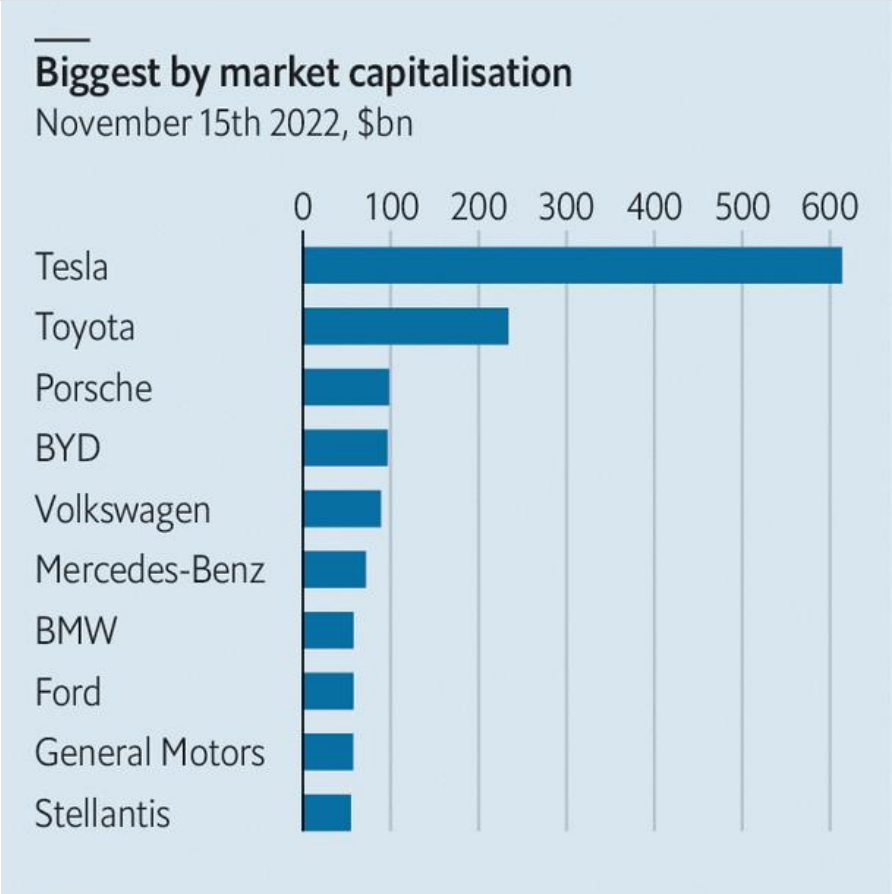
VW expects half of U.S. sales to be electric vehicles by 2030

Ford Motor Vows To Sell Only Electric Cars In Europe By 2030

Honda Will Go Electric- and Fuel Cell-Only by 2040

- *But for investors….*

But… Tesla =
Toyota + VW + GM + Ford + Mercedes + BMW + Honda + Stellantis



Source: The Economist, 11/15/22

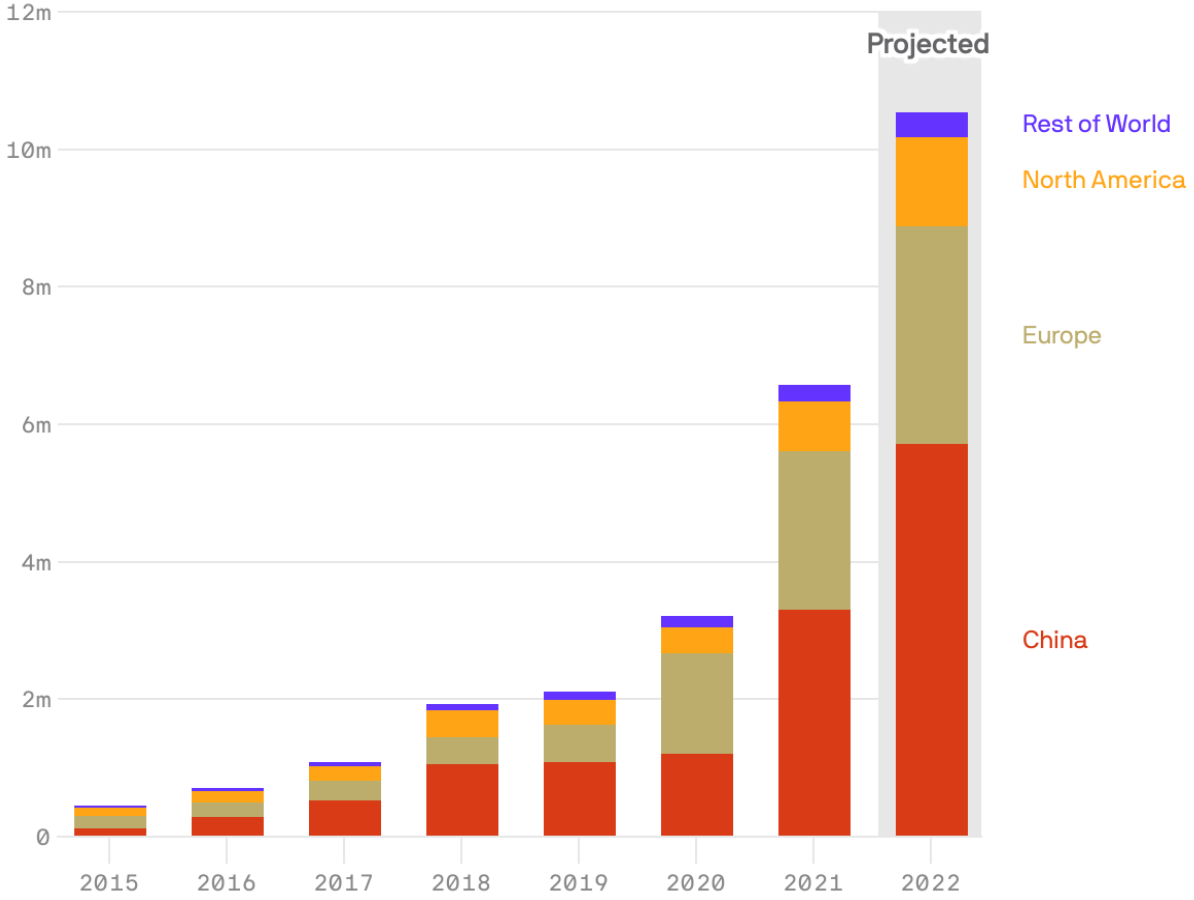
Tesla is Dominating Not Only Because Appealing Product, But Also Because Many Innovations

- Vertical integration, including minerals (following Henry Ford)
- Integrated design of vehicles and factories
- Software leader (in house, allowing re-programming of chips)
- Pioneered over-the-air software updates
- Built its own charger network
- Partial vehicle automation (aka “Full Self Driving”)
- No dealer network (direct sales)

➢ *Large profit margins*

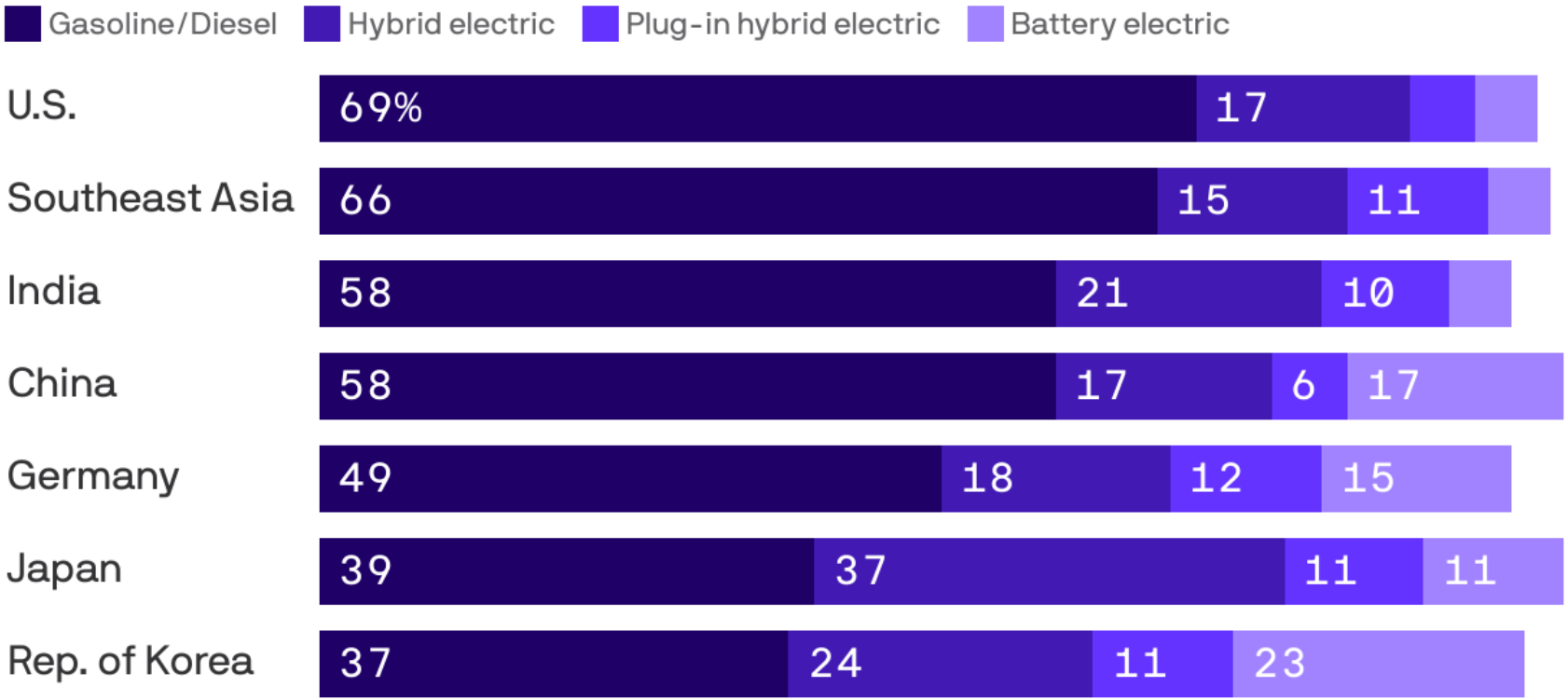
Passenger electric vehicle sales

Battery electric and plug-in hybrid electric vehicles



US is falling far behind EU and China in EV sales

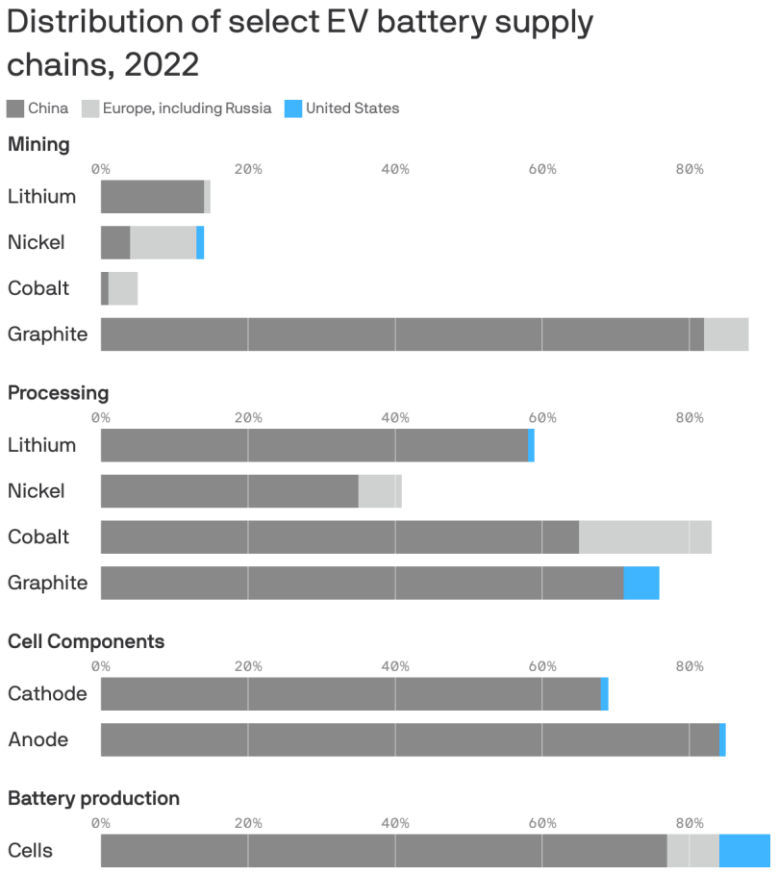
Consumer preference for next vehicle type …US lagging



2022 Deloitte Global Automotive Consumer Study; Chart: Thomas Oide/Axios

Cause for Concern

Rising Prices and Supply Shortfalls for Minerals/Metals…
Will NIMBYism and Sustainability Concerns Overcome Market Forces—in US and Elsewhere?



IEA, 2022

Many Process and Product Innovations to Reduce Costs, Improve Performance and Safety, and Reduce Dependence on Critical Materials

- Battery chemistries
- Battery design
- Vehicle/battery designs
- Manufacturing processes

Innovations in Battery Chemistry Reduce Costs and Dependence on Critical Metals

- COBALT → Scarce, concentrated (nearly 50% in Congo) where mining Is linked to human rights abuses
  - RESPONSE: Battery companies switching from NMC (Nickel Manganese Cobalt) to Lithium Iron Phosphate/LFP), reducing dependence and cost
- NICKEL→ Scarce, concentrated (50+% in Australia, Indonesia, South Africa, Russia, Canada)
  - RESPONSE: New formulations using less nickel
- LITHIUM → Abundant, but supply lags demand (prices increased 400-600% since January 2022
  - CHALLENGE: Widespread resistance to new mines (role for policy?!)

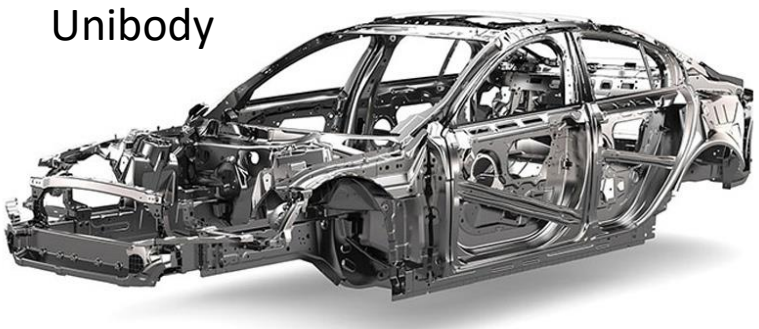
Innovations in Battery/Vehicle Design Reduce Costs and Weight

- Battery makers are eliminating modules (cell-to-pack)
- OEMs are packing cells directly into the chassis (cell-to-chassis)
  - Like using airplane wings to hold fuel

➢ *Both save weight and reduce manufacturing costs*

➢ ***But reduce ease of repair and recycling/repurposing***

Unibody



Skateboard

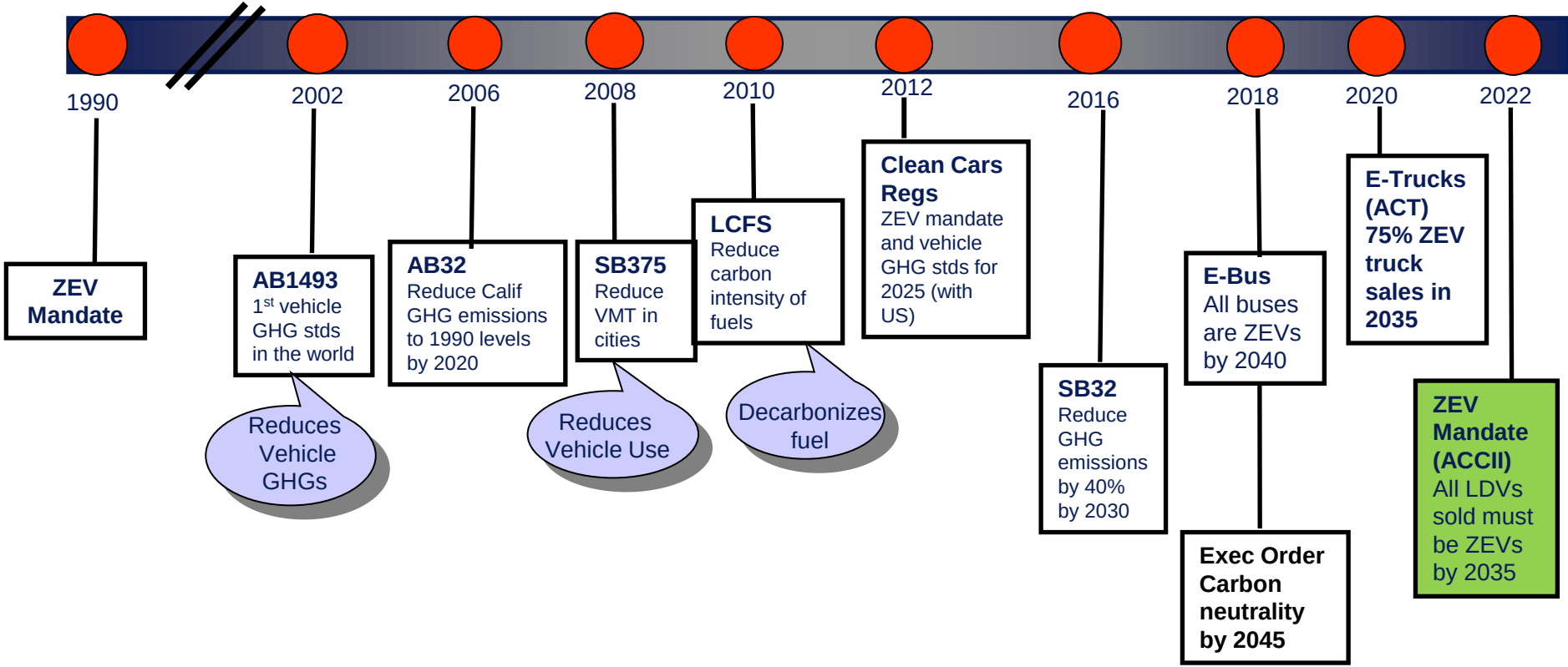
Supply-Side Regs Are Most Effective Policy to Accelerate ZEVs

- EU CO_2 vehicle performance standards effectively require large sales of EVs
  - Schedule to update standard to be 0 g/km by 2035 (by end of 2022)
- US also has "CO_2/GHG standards (equivalent to CAFE), but much weaker.
  - New standards proposed by Biden Administration (but not yet adopted) would require automakers to sell ~18% EVs by 2026
- California ZEV mandate requires EV sales.

California Leadership is Pivotal for US

...Far More Aggressive than Feds, and Many States Follow CA

Plus, ecosystem of supportive policies

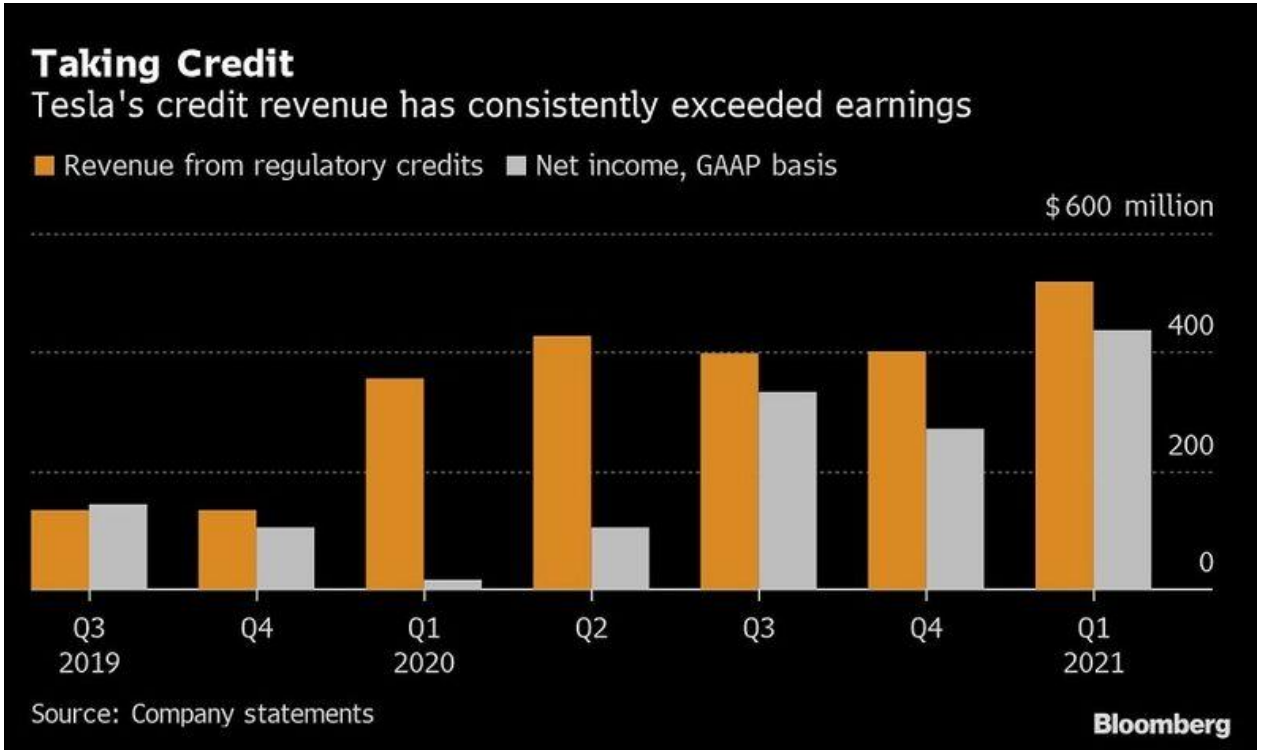


Controversial History of California ZEV Mandate

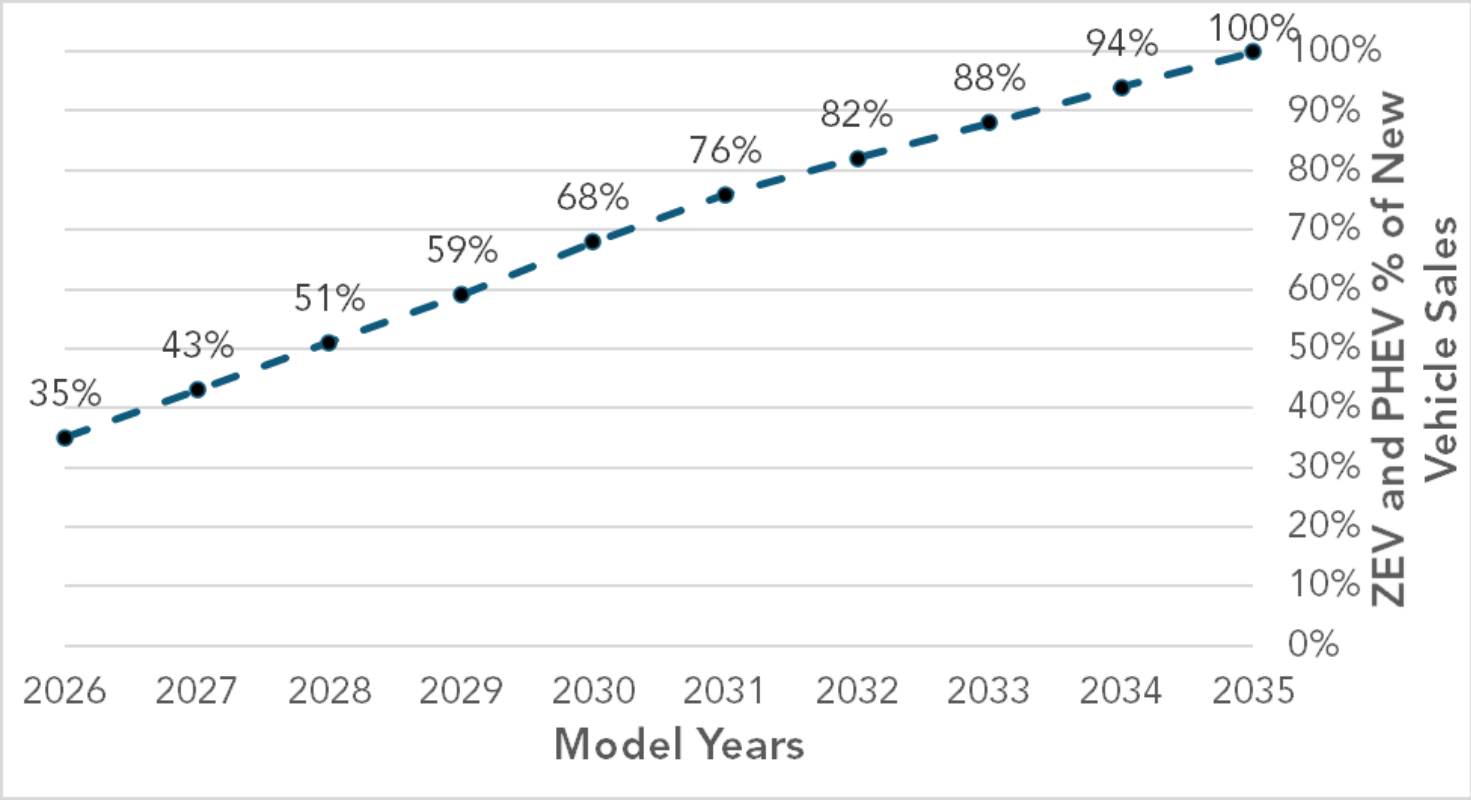
1990	**ZEV mandate adopted**: 2% ZEVs in 1998, 5% in 2001, 10% in 2003—measured as % of new car sales
1996	**Weakened**: Eliminated 2% 1998 requirement and replaced with much softer requirement of 3750 BEVs
1998	**Weakened**: % ZEV requirement further reduced by allowing very clean gasoline (and other alt fuel) vehicles as partial substitute ("PZEV")
2001	**Weakened**: % ZEV requirement further reduced by allowing small numbers of FCVs to satisfy requirement
2008	Minor strengthening: 12,500 BEVs or 5000 FCVs, plus 58,000 PHEVs by 2014
2012	**Major strengthening**: PEVs + FCVs = ~15% of LDV sales in 2025
2022	**Revolution**: 100% ZEV sales by 2035

ZEV mandate was too aggressive too soon, but now "best" policy?

Tesla Survived Bankruptcy Because of ZEV Credits Sold to Legacy Automakers … Policy Intervention!



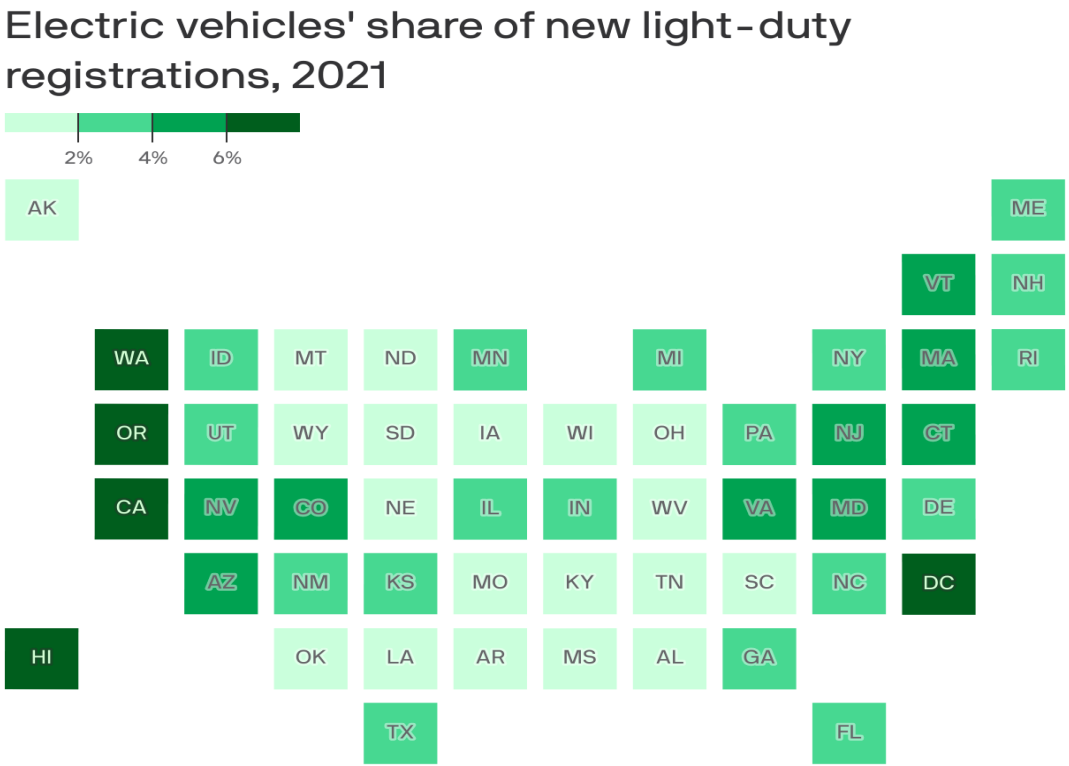
California Adopted Rule Requiring 1/3 of sales to be ZEVs in 2026, 2/3 in 2030, and 100% in 2035



The Nuances of Policy Design Are Very Important … and Ignored by Academics

Cause for Concern

Other States (§177) Must Adopt Every Detail of California's ZEV Mandate … Is that Good Policy?



Major change for 2026

All Vehicles Are Equal

- **BEVs = PHEVs = FCVs**
- PHEVs: Minimum of 50 miles of electric range (35 miles in 2026-2028)
  - Capped at 20% of ZEV compliance

➢ Outcomes

- ➢ PHEVs play limited role
- ➢ Vehicles and batteries get huge (exacerbating supply problems with batteries and critical materials)
- ➢ No incentive for H_2FCVs

Major change for 2026

Durability Requirements … for 10 years/150,000 miles

- 2026-2030: 70% of certified range for 70% of fleet (excluding outliers)
- 2030+: 80% of range for all vehicles (on average)

  - Motivation: protect the consumer, and also make sure that when middle and low income people finally get the vehicles, that the batteries are reliable

Also a Truck ZEV Mandate

California Requires Most Trucks to be Zero Emissions by 2035 … With Likely Update to 100% of Sales by 2040 or sooner

- Adopted June 2020, effective 2024
- Applies to large truck manufacturers who sell trucks in California
- Credit trading allowed
- Partial credits allowed for PHEVs (based on all-electric miles)

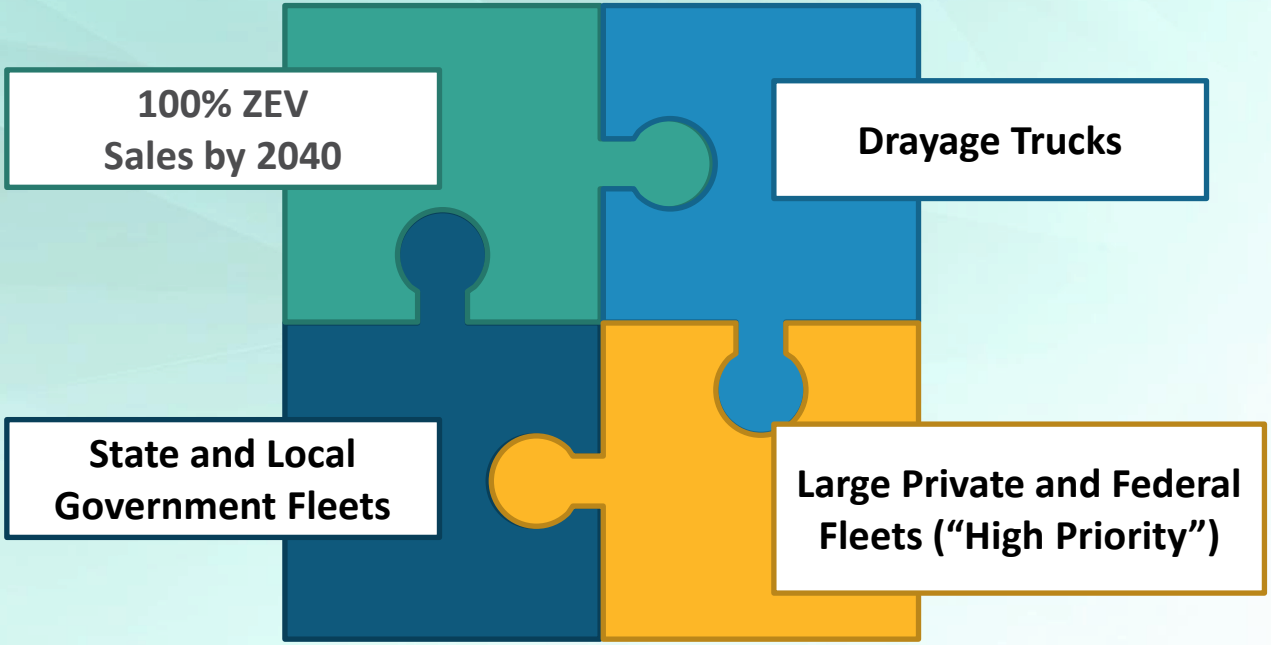
Model Year (MY)	Class 2b-3	Class 4-8	Class 7-8 Tractors
2024	5%	9%	5%
2025	7%	11%	7%
2026	10%	13%	10%
2027	15%	20%	15%
2028	20%	30%	20%
2029	25%	40%	25%
2030	30%	50%	30%
2031	35%	55%	35%
2032	40%	60%	40%
2033	45%	65%	40%
2034	50%	70%	40%
2035	**55%**	**75%**	**40%**

CARB

Another Policy Innovation from CA

Proposed "Advanced Clean Fleet" Rule (likely adopted in April 2023)

4 Regulation Components



CARB

Some Thoughts on Incentives

IRA (signed August 16, 2022)
Federal Consumer Incentives (through 2032)

New Vehicles: Up to $7500/veh

- Manufacturer caps eliminated (200k/OEM)
- Vehicle must be assembled in North America, 40% of critical minerals and 50% of battery from US or countries with free trade agreements (~20 countries) (with 40% ratio increasing to 80% in 2027)
- One credit per vehicle: not based on size of battery
- Income limited to $150k/$300k
- MSRP < $80k for LDTs, $55k for cars
- Point of sale (based on dealer disclosures)

Used Vehicle Credit: Up to $4000/veh

- 30% of value of used EV with $4,000 cap; vehicle price <$25k
- 2+ years old
- Conditions: purchased from a dealer; vehicle qualifies for credit only once in its lifetime; must be an individual; once per three years/individual; income cap of $75k/$150k
- At time of sale by dealer.
- No requirements for “made in USA”

➢ ***<u>No</u> EVs will get full rebates for many years; OEMs (and many countries) unhappy***

… And Many Other Incentives Across US

These are California Vehicle Purchase Incentives….

Rebate Type	Fuel Cell Electric Vehicle	Battery Electric Vehicle	Plug-in Hybrid Electric Vehicle[1]	Zero-Emission Motorcycle
Increased Rebate for Low-Income Applicants Households with income less than or equal to 400% of federal poverty level	$7,000	$4,500	$3,500	$750
Standard Rebate Available for: Individual tax filers whose income is greater than 400% of the federal poverty level but less than or equal to $135,000 Head-of-household tax filers whose income is greater than 400% of the federal poverty level but less than or equal to $175,000 Joint tax filers whose income is greater than 400% of federal poverty level but less than or equal to $200,000	$4,500	$2,000	$1,000	$750
Above Income Cap[2] Individual tax filers whose income is greater than $135,000 Head-of-household tax filers whose income is greater than $175,000 Joint tax filers whose income is greater than $200,000	$4,500	Not eligible	Not eligible	Not eligible

New Federal Incentives—by Themselves—Will Have Small Impact

- Few buyers will receive $7500 rebate for many years because of the aggressive "protectionist" conditions
- Income cap of $150k/$300k and MSRP cap of $80k for LDTs and $55k for cars is good (cost-effective and equitable) policy, but significantly limits effect on sales
- California's ACCII (ZEV mandate), likely to be adopted shortly by ~1/3 of the market (~10-15 states), will swamp effect of incentives (doubly so because OEMs will be diverting sales to states with the rule in place, and not to other non-ZEV states, in order to be in compliance)
- With current (pre-IRA) incentives, Tesla and GM vehicles did not receive the $7500 credit the last few years, and yet Tesla sold 2/3 of all EVs, and GM was second.

➢ *Given all this, I expect small marginal impact of federal consumer EV incentives*

IRA is not just for consumers

Incentives for Automotive, Battery, Mining, and Recycling Industries … More Impactful Than Consumer Incentives??

- Tax credit of $35/kWh for each U.S.-produced battery cell (~35% of cost)
- Tax credit of $10/kWh for U.S.-produced battery modules (~1/3 cost of assembling battery pack)
- 10% tax credit for critical materials and minerals produced in U.S.
- $2 billion in grants to retool existing auto plants to make clean vehicles
- Up to $20 billion in loans to build new factories.

➢ ***Reflects "new" approach where incentives go to industry, and less to consumers***

Cause for Concern

Last 30% of Consumers

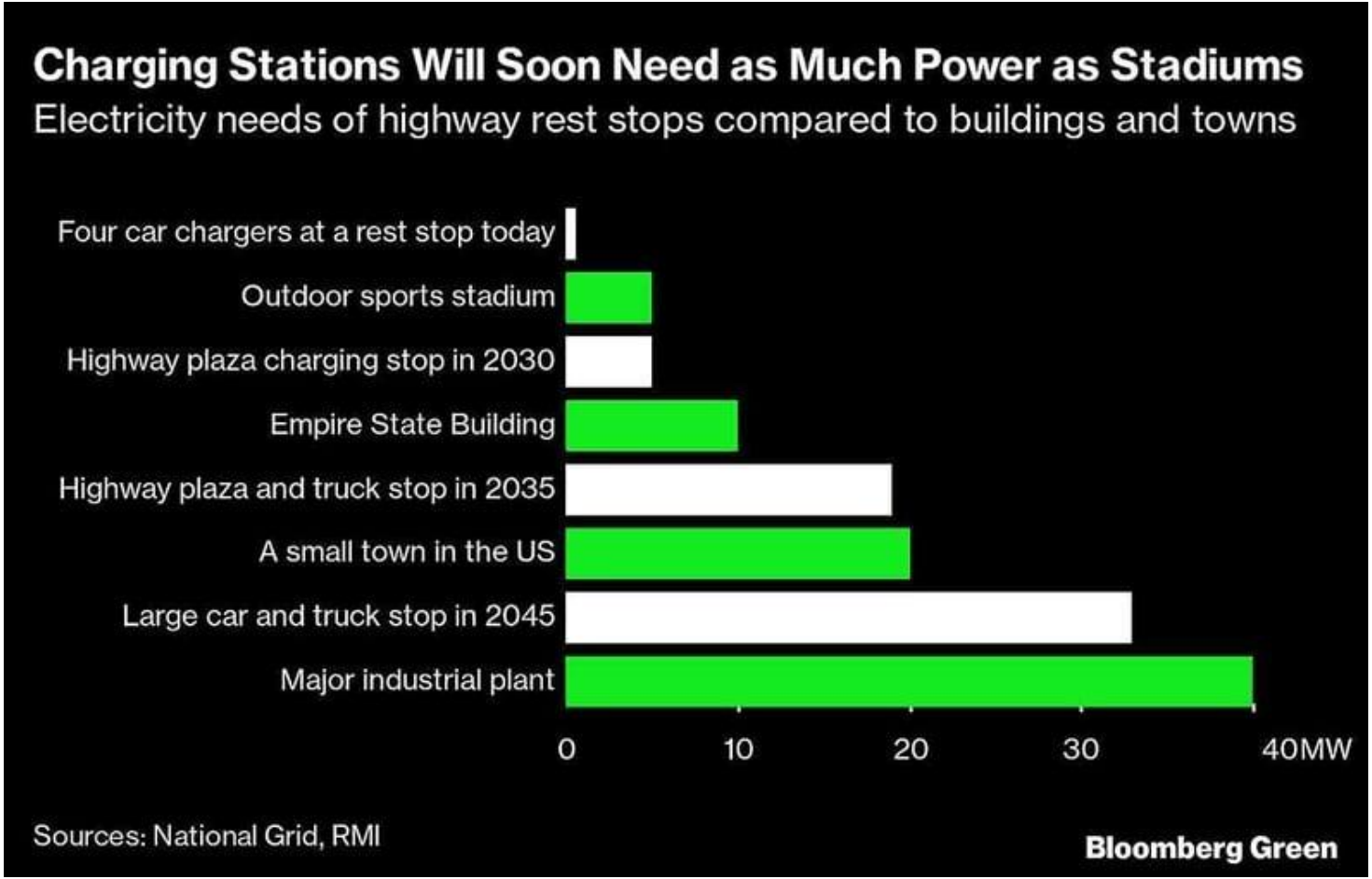
- Vaccine analogy
- Buyers in multi-family dwellings
- Ideological opposition (EVs are politicized?)

➢ *Will PHEVs and H2 FCVs gain more appeal??*

Cause for Concern

Will Enough Public Charging Infrastructure Be Built Fast Enough?

- Need is not urgent for next 5 or so years, but then becomes critical
- Subsidies from national and state governments, electric utilities
- Concern: permitting, reliability of chargers, accountability of operators of chargers


Charging Stations Will Soon Need as Much Power as Stadiums
Electricity needs of highway rest stops compared to buildings and towns
Four car chargers at a rest stop today
Outdoor sports stadium
Highway plaza charging stop in 2030
Empire State Building
Highway plaza and truck stop in 2035
A small town in the US
Large car and truck stop in 2045
Major industrial plant
0
10
20
30
40MW
Sources: National Grid, RMI
Bloomberg Green

Charging Infrastructure Policy

- Resolve jurisdictional disputes (municipal, PUC, state, federal) over installing charging
- Accelerate/approve/fund infrastructure and grid enhancements—esp for trucks
- Address unprofitability ….. Encourage partial subsidies by businesses
  - Operations or installing equipment…..
  - Employers (workplace)
  - Retail stores (enticement for customers)
  - Behind-the-meter make-ready by utilities
- Strategic investment/subsidies by local, state and federal governments (IIJA)
  - Link to reliability (97% up-time required?!)
  - Ease of use (confusing and competing apps, use of credit cards, unbanked)
  - Network coverage (every 50 miles, underserved communities)

Why Is US Lagging and What Do We Do About It?

“We can not solve our problems with the same thinking [and institutions and research] we used when we created them.”

- Albert Einstein

Thank You

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