Is Demand for EVs Slowing?
Transition Pathways in the US Electric Vehicle Market

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Abstract

Recent news reports have highlighted a slowdown in electric vehicle (EV) adoption in the United States, fueled by concerns about rising inventory levels and a decline in consumer interest. However, these reports often lack a historical perspective and do not account for the underlying factors driving EV adoption. In this paper, we provide a comprehensive overview of the US EV market, drawing on 23 years of data on hybrid and electric vehicle sales. We find that, while the rate of EV sales growth has slowed in recent months, the market share of EVs is still climbing, consistent with structural factors driving market formation. Moreover, we highlight that HEVs still sell as well as BEVs in the US, even though HEVs have received negligible policy support for over a decade. We highlight three distinct transition pathways that are all possible moving forward, depending on the market conditions that unfold. These findings have important implications for automakers, policymakers, and consumers, and help to clarify the current state of the US EV market and the factors that will influence its future trajectory.

Introduction

Articles about the US electric vehicle (EV) market in 2023 were dominated by the claim that EV adoption is slowing. Recent anxious headlines tell of how the “EV transition cools” (Whalen 2023) and note that EV inventories have been observed to be “piling up” at dealerships (Toussaint 2023), with nearly twice the amount of EV inventory on lots as is considered ideal. Leading automakers including Tesla, Ford and GM have walked back plans to open new EV manufacturing facilities in North America (Roy and Klayman 2023), and Mercedes has delayed plans to stop ICE sales in favor of EVs (Waldersee 2023).

Has the market for EVs hit a wall? Was past EV growth solely serving EV enthusiasts whose demand has now been filled, with mainstream buyers mostly uninterested in EVs? Or is this perceived slowdown just a temporary blip in demand on the way to EVs capturing 28% of US new vehicle sales by 2026 as predicted by industry analysts such as BNEF (2023a)? Understanding where the EV market is headed and why will shape how automakers invest in new EV product development and manufacturing capacity. It may also shape how consumers make expensive vehicle purchase decisions, and how policymakers react relative to energy and environmental policy goals. The above descriptions of current events in the EV market tell us relatively little about EV market fundamentals. For example, against what benchmark (right or wrong) is this perceived slowdown being measured? And what are the lasting implications of this slowdown, if any?

In this paper, we evaluate the current state of the US EV market (which we as all hybrid and electric vehicles) in the context of the 23-year history of hybrid and electric vehicle sales in the US. We show first that the market share of EVs is in fact still climbing, consistent with structural factors driving market formation, but that the rate of EV sales growth has slowed in recent times, with market conditions moving against BEVs at the margin. It is underappreciated that hybrid electric vehicles (HEVs) still outsell plug-in hybrid electric vehicles (PHEVs) and battery-electric vehicles (BEVs) in the US, even though HEVs have received negligible policy support for over a decade. Using a simple model, we assert 3 distinct transition pathways are still possible moving forward depending on the market conditions that unfold.

Adoption of Hybrid and Electric Vehicles Has Grown Strongly

The US EV market has been 23 years in the making, beginning with the introduction of the Toyota Prius and Honda Insight HEVs in 2000, advancing with the launch of the Chevrolet Volt PHEV and Nissan Leaf BEV at the end of 2010, and accelerated further with then Tesla Model 3 BEV in 2017 (Figure 1). Two distinct patterns of behavior are observable here: i) The decades-long market share growth of the EV category, which has grown at a compound annual growth rate (CAGR) of 32% per year, and which now accounts for 18% of new light vehicle sales in the US (Figure 1); and ii) The month-to-month fluctuations that occur where a modest slowdown in sales in the final months of 2023 and January 2024 can be seen.

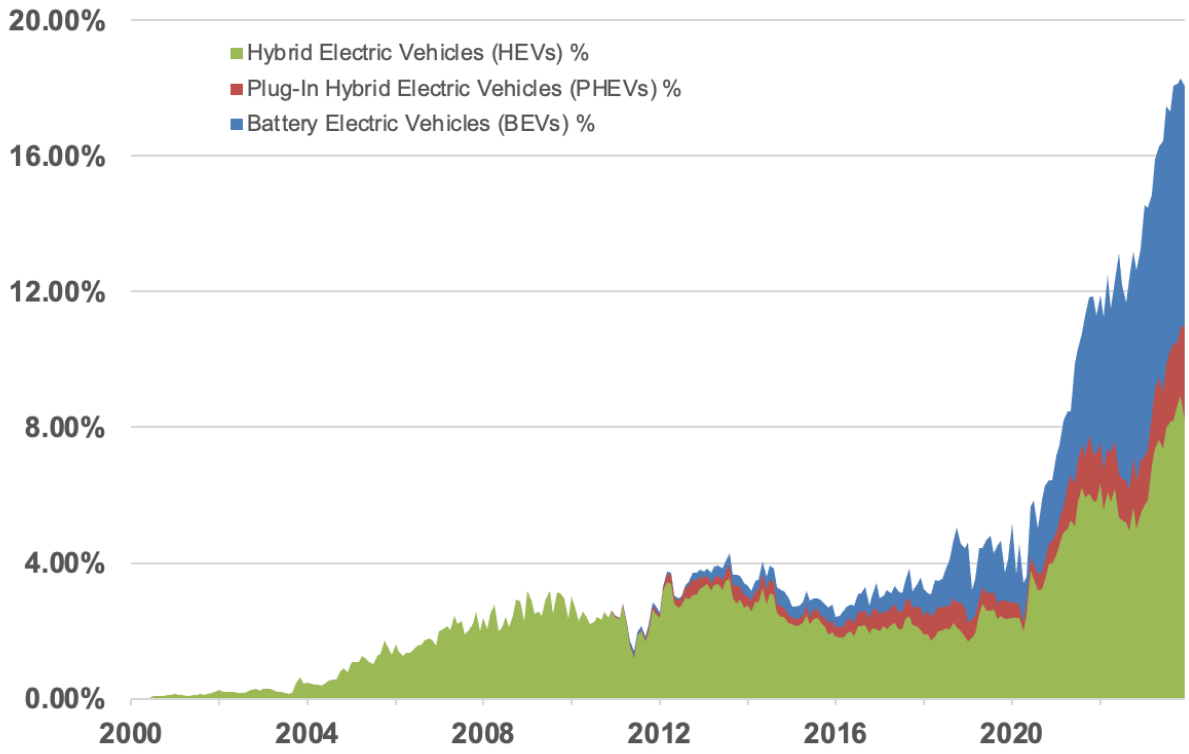


Figure 1: Stacked Market Shares of Hybrid and Electric Powertrains in the United States - Jan 2000-Jan 2024 (ANL 2024)

Considering first the overall market trend, the exponential growth observed to date is consistent with a system dominated by reinforcing feedback loops as shown in Figure 2 (see Sterman (2000) for detailed description of causal loop diagram syntax. Mechanisms that are likely to have driven increasing adoption of EVs include:

- Increasing consumer acceptance of EVs with social exposure through channels including word-of-mouth from EV owners, and observation of EVs in use;

- The build-out of EV charging infrastructure, with more EVs on the road increasing charger utilization and unit economics, leading to yet more chargers being built, and more EV driving again.

- The accumulation of EV manufacturing capabilities has improved the performance of EVs and reduced the cost of EV manufacturing dramatically (most notably a more than 5-fold reduction in unit battery costs from $780/kWh in 2013 to only $139/kWh in 2023 (BNEF 2023b).

- The impact of variety on buying decisions, with the increasing number of EV makes and models available in showrooms satisfying more consumers and resulting in more EV sales.

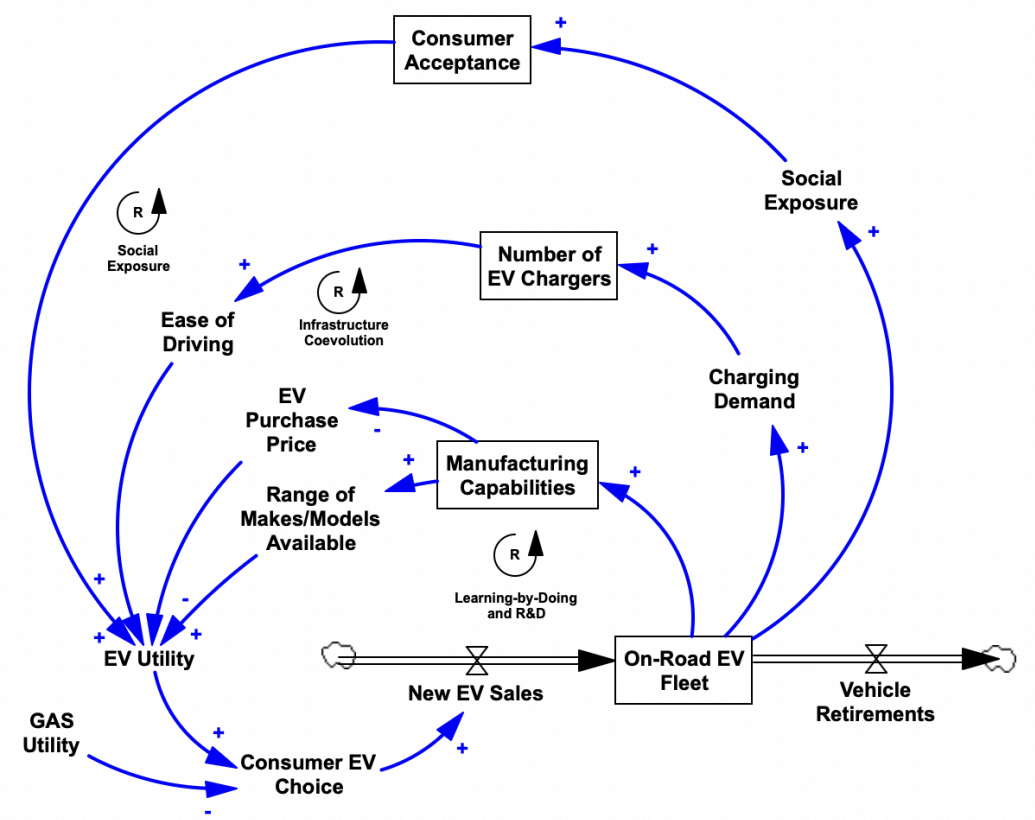


Figure 2: Reinforcing Feedback Loops Driving EV Adoption

The question of whether this exponential growth can continue depends in part on the extent to which further improvements are possible in these factors that influence EV Utility for consumers. For example, the Biden Administration's $7.5B investment in backbone National Electric Vehicle Infrastructure is intended to increase access to fast EV charging over the next 5 years. How quickly will these chargers come online, and how meaningful will the increase in EV utility be, particularly as EV adoption continues to grow at a similar or possibly even faster rate?

Recent Market Conditions Have Made Battery Electric Vehicles Relatively Less Attractive

Second, looking more closely at month-to-month variation in the market shares of individual hybrid and electric vehicle powertrains (Figure 3), the basis for current concerns about consumer adoption of BEVs emerges. While the market shares of both HEVs and BEVs have grown considerably over the past 5 years, with the PHEV market share growing more slowly, a noticeable slowdown (but not a decrease) in the market share of BEVs has occurred over the past 1 year. Such slowdowns in sales are not without precedent; sales of PHEVs dipped in 2019 and 2020, for example, before returning to levels consistent with the pre-dip trend.

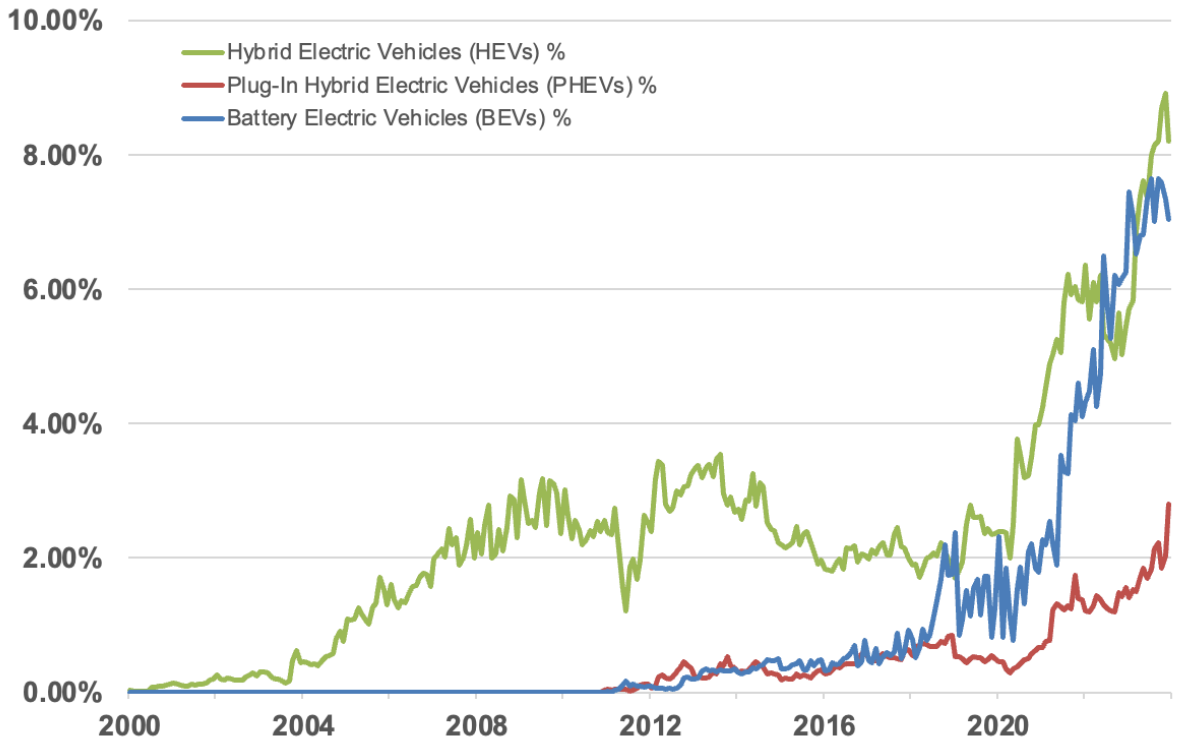


Figure 3: Market Share of New Light Vehicle Sales in the United States by Powertrain - Jan 2000-Jan 2024 (ANL 2024)

What might explain the recent slowdown in BEV adoption observed? We point to changes in four key factors that have cause a reduction in BEV attractiveness, and an increase in HEV attractiveness:

- **Falling Gas Prices**: The price of gasoline is a key factor influencing consumer choice between conventional gasoline vehicles and electric vehicles, as well as choices between HEVs, PHEVs, and BEVs (Bushnell et al. 2022). Higher gas prices make more fuel-efficient vehicles more economically attractive, and vice-versa. National-average gas prices peaked in June 2022 at over $5.00/gallon, but fell to $3.30/gallon by the end of 2023, lowering the cost of operating a gasoline vehicle, increasing the payback period for EV investment, and making HEVs relatively more attractive within the EV market.

- **Reduction of Government Incentives**: PHEVs and BEVs have received substantial policy support in the US over the past 10+ years, led by the $7,500 Federal income tax credit and additional incentives in many states. When the Inflation Reduction Act passed in 2022 was praised for extending the Federal income tax credit that was previously capped to 200,000 units per manufacturer. However, increasingly stringent rules have been introduced that limited EV make/model eligibility for this incentive. In April 2023, minimum content requirements mandated mineral and battery content be sourced from providers in North America and other US free trade countries. In January 2024, batteries with any components from China, Russia, North Korea, and Iran were deemed ineligible. As of early 2024, only 13 of the 40+ PHEVs and BEVs for sale in the US are eligible under these most stringent requirements.

- **Decreasing Reliability of Charging Infrastructure**: While the quantity of public charging stations available to EV drivers in the US continues to grow, the reliability of these charging stations has been a rising concern in the last 2 years, with approximately 1 in 4 attempts to charge being unsuccessful (Rempel et al. 2022; Keith and Womack 2023). While it is unclear how much this lived experience affects first-time EV buyers, continued media attention to this problem (e.g. Voelcker 2023) can only affect consumer EV perceptions negatively.

- **Rising Interest Rates**: With nearly 80% of new vehicle sales in the US paid for with loan financing, and another 18% of new vehicles leased (Zabritski 2023), the rapid increase in interest rates from near-zero in January 2022 to over 5% by the end of 2023 (FRED 2023) has impacted the purchasing power of essentially all buyers in the new vehicle market. Given that EVs cost considerably more upfront to buy than comparable gasoline vehicles, this has made buying an EV relatively less attractive.

Changes in these factors can occur in a weeks-to-months time frame, affecting the attractiveness of EVs at the margin for worse (or better). Note that the factor affecting demand can vary much more quickly than the factors that affect automotive supply, as the feedback loops shown in Figure 2 unfold over several years. With automotive development times in the 2-4 year range, automakers have to make difficult-to-reverse CAPEX decisions worth billions based on noisy demand signals. While consumer preferences can change quickly, automakers have limited ability to change production in the short-term, explaining both periods of surplus inventory (or stockouts) as observed and also recent decisions to defer future capacity expansion investments as described above, which is the leverage that automakers do have.

We further note that while changes in these factors may be exogenous to EV demand in the short-term (e.g. the price of gasoline fluctuating in response to global economic activity and OPEC oil production decisions), the first 3 of these 4 factors are all endogenous to EV demand in the long-term, creating balancing feedback loops that resist EV adoption (Figure 4). As EV adoption grows in the United States and globally, demand for gasoline will fall, putting downward pressure on gas prices and making EVs relatively *less* attractive. Similarly, rising EV adoption reduces the need for government purchase incentives for EVs, and increasing EV ownership and use will increase charging station utilization (all else being equal) that will result in more charging station breakages. The faster EV adoption grows, the more these balancing feedbacks will push back.

Taken together, this analysis highlights the limits of simple “S-shaped” forecasts of EV adoption whose origins trace back to theory on the diffusion of innovations (Rogers 1962) and the seminal Bass diffusion model (Bass 1969). It can be tempting to look for analogs such as market adoption of cellphones, where a single new technology clearly superior to the incumbent landline technology quickly dominated the market, growing from 20% market share in 2008 to 70% market share in 2022 (CDC 2022). But such comparisons are erroneous in our opinion, because the EV market has multiple new vehicle platforms (e.g HEV, PHEV, and BEV), each competing with each other and with an entrenched and still attractive incumbent (Gasoline/Diesel), in the presence of the market formation dynamics described above. Here, more complex patterns of technology diffusion are likely, including the plateauing and/or decline for individual platforms, as the *relative* attractiveness of each platform changes over time in this highly dynamic market.

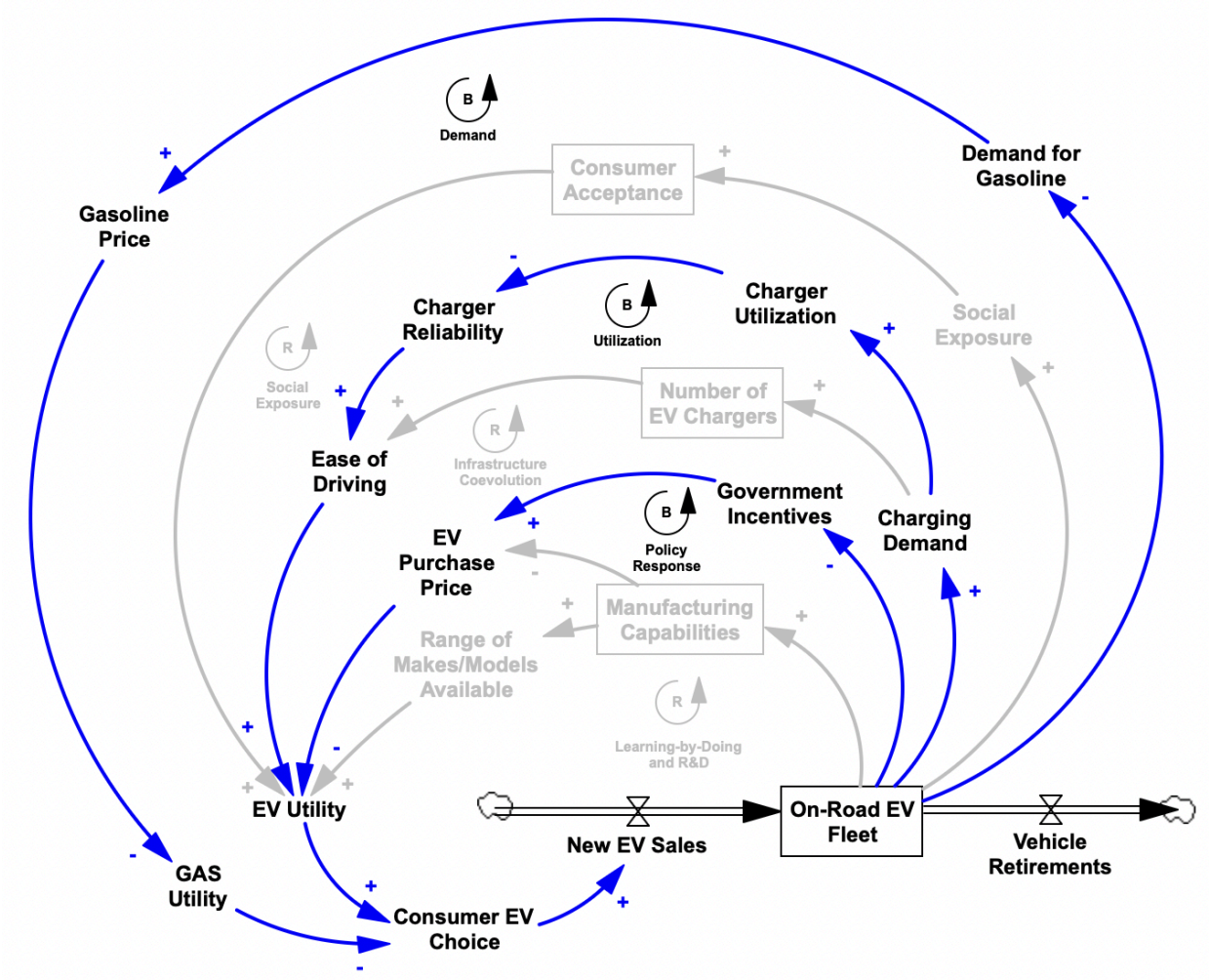


Figure 4: Balancing Feedback Loops Resisting EV Adoption

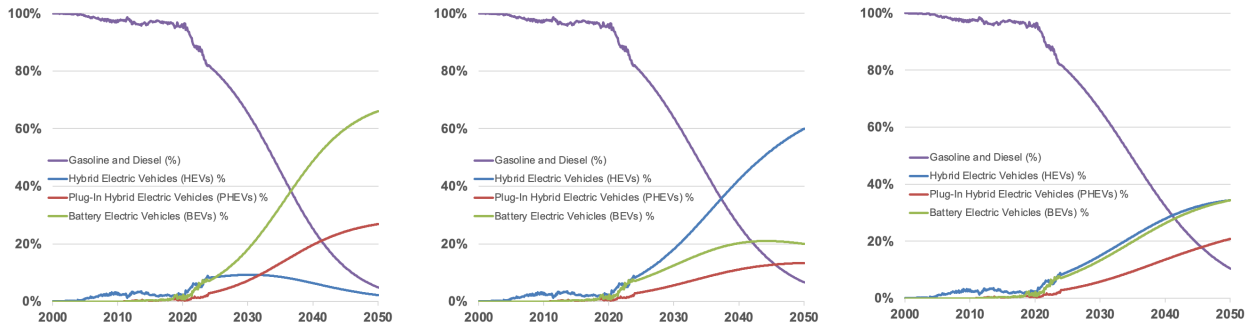
What Does This Tell Us About the Future of EV Sales?

There is little doubt that EVs will play a significant role in the US on-road fleet over the coming decades, evidenced by the sales and valuation of BEV-only automaker Tesla and policies such as the Zero Emissions Vehicle (ZEV) mandate adopted in California and the Northeast states. Yet the question of what fraction of the fleet will be EVs and how soon - critical to the strategies of several automakers and our ability to meet societal policy goals - remains tantalizingly difficult to answer. What will hundreds of millions of individual car buyers do over the coming years when forced to choose, spending their own money and taking their needs and preferences into account?

The reality is that historic data tells us very little about the future trajectory of technology diffusion processes, because it is essentially impossible to estimate the speed and extent of S-shaped diffusion curves *ex-ante* (Sandberg et al. 2021). The trajectory of an S-curve is determined by 'damping' or deceleration in sales growth (the second half of the S-curve), and yet little or no signal of this damping exists during the initial growth phase of a technology (the first half of the S-curve). Structural models such as the System Dynamics model highlighted in this article can help decision-makers better understand these complex diffusion dynamics. However, the goal of decision-makers should be to achieve robust high performance across plausible futures rather than predicting specific market outcomes.

We propose that multiple distinct pathways are possible for the US EV market in the coming years, each entirely consistent with the patterns of sales observed to date but dependent on how market conditions unfold, and with vastly different implications for the automotive ecosystem, from product volumes for automakers and battery manufacturers, to the effectiveness of public policies, and utilization of charging infrastructure. Here we describe three key scenarios deliberately selected to highlight the range of pathways possible.

In Scenario 1 (Figure 5(a)), BEVs dominate the market by 2050, complemented by a significant proportion of PHEVs, with HEVs playing a transitional role before declining in later decades. This scenario is consistent with an extrapolation of improvements in the performance of EVs (e.g. increased driving range, easy access to charging), and would require further acceleration of market conditions and policies that make driving with gasoline much less attractive, such as higher oil prices or a carbon tax. In Scenario 2 (Figure 5(b)), HEVs become the dominant technology by 2050, with BEVs and PHEVs maintaining significant but smaller market shares over time. This scenario is consistent with a future in which EVs struggle to achieve mass-market acceptance (e.g. due to range concerns and long recharging times), and where gas prices remain relatively low such that automakers can meet existing fuel economy regulations primarily with HEVs. In Scenario 3 (Figure 5(c)), HEVs, BEVs, and PHEVs grow in approximately the same proportions as they currently have within the EV market. This scenario is consistent with a fragmentation of the market in response to heterogeneous consumer preferences that are not satisfied by one dominant technology.



(a) BEV Dominance (b) Hybrids as Best of Both Worlds (c) Platform Coexistence

Figure 5: Possible EV Transition Pathways

To be clear, these 3 scenarios are explicitly not forecasts; inevitably, the future trajectory of the US automobile market will be influenced by forces we cannot foresee. And none of these

pathways will be this smooth in practice, being subject to real-world idiosyncrasies. Nevertheless, we believe it is valuable to build playbooks for each of these transition pathways in order to develop improved mental models about what could happen and why, with the goal of making EV factory capacity decisions, charging network location and capacity decisions, and policy decisions that are robust to uncertainty.

What conclusions can we draw from these scenarios if indeed the future of the EV market remains so uncertain?

1. **To date, the slowdown in BEV sales can be explained by adverse market conditions rather than changing consumer preferences.** The explanatory factors we identify for the market movements observed (gas prices, EV incentives, interest rates, and access to reliable charging) are not surprising - many analysts have already discussed some or all. This is nevertheless important, because any or all of these factors may move favorably again in the near-term (for example, if stronger economic conditions provide both lower interest rates and higher consumer spending resulting in higher gas prices) At this time a return to the pre-slowdown growth trend should be expected if consumer interest in BEVs is unchanged. The failure of BEV sales to rebound in this way would be more concerning for companies invested in BEVs, suggestive of a lasting change in consumer tastes away from BEVs.

2. **HEVs and PHEVs are likely to play a substantially greater role than the current consensus suggests**. While BEVs have attracted much attention and policy support, and BEV have the greatest per-vehicle emissions reduction potential, the data shows that HEVs and PHEVs continue to resonate with consumers, delivering much of the benefit of BEVs without the range and recharging limitations. Automakers should take seriously the ongoing opportunity with HEVs and PHEVs, considering product portfolios and vehicle architectures that can accommodate multiple powertrains to hedge risk. Policymakers should extend available EV incentives to HEVs and PHEVs in proportion with the extent of environmental benefits realized.

3. **Diffusion trajectories that deviate from simple S-curves should be expected**. With multiple competing vehicle platforms, and heterogenous consumer preferences, a winner-take-all outcome is unlikely in this market. Product development and manufacturing capacity planning decisions should explicitly consider how sales of these platforms will evolve jointly.

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