Analysis of the Hyundai Electric Vehicle Recall and Insights into Challenges Faced by the Electric Vehicle Industry

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# Introduction

In 2024, Hyundai Motor Company recalled over 147,000 electric vehicles (EVs) in the United States due to a critical failure in the Integrated Charging Control Unit (ICCU) (Osho-Williams, 2024). The ICCU plays a critical role in supplying power to low-voltage accessories and the 12-volt auxiliary battery, functioning like an alternator in a gas-powered vehicle. The problem was that the ICCU had the potential to experience electrical load conditions that could cause the internal transistor to fail, which would disable charging capabilities of the battery and could lead to a loss of power while driving (Stotz, 2024). While this recall was one of the largest EV-related safety concerns in recent years, it was not an isolated incident. For instance, Mercedes-Benz recalled approximately 32,000 vehicles in 2024 to address a fuse problem that could cause the vehicles to lose power (Tucker, 2025). Rapid scaling of EV technology has introduced new engineering challenges among many automotive manufacturers. Most analyses of EV failures focus on the technical aspects of the vehicle. However, such analyses neglect the larger socio-technical forces that shape these failures.

Electric vehicles have become a central figure in the fight against climate change. In recent years, governments have passed major legislation to incentivize their adoption, while public support of sustainable transportation has surged (Zhao et al. 2025). These developments have pushed automakers to expand their EV offerings rapidly. This transition, while environmentally urgent, has not always been supported by the time and resources needed to sufficiently test and validate new technologies.

This paper examines the Hyundai recall as a case study to explore the interactions between engineering, public sentiment, and government policy in the context of EV development. Following a review of relevant literature and a description of the methods that I employed, the analysis section will consist of three parts. First, an investigation of the interactions between a growing environmental movement and the development of Hyundai EVs. Second, the influence of government policy on the distribution of EVs. And third, an investigation as to how a compressed engineering timeline allows for engineering failures to occur.

In what follows, I argue that Hyundai's recall of electric vehicles due to ICCU failures reveals how engineering challenges can result when companies allow external pressures,

specifically government incentives promoting EV adoption and rising public demand driven by environmental movements, to dictate development timelines. Rather than being primarily technical, these challenges emerge from a sociotechnical network that prioritizes speed over rigor, ultimately highlighting the need for engineering processes to be governed first and foremost by technical readiness.

## Literature review

Prior research has established that the EV industry has experienced cyclical patterns of growth and decline, shaped by a combination of technological innovation, market forces, and policy decisions. One influential study, by Santini (2011), traces over a century of EV development and identifies distinct "waves" of progress and regression in EV adoption. The paper argues that the advancement of EV deployment has historically faced setbacks due to challenges such as limited infrastructure and competitive disadvantages relative to internal combustion engine vehicles. Recent studies confirm that these challenges remain highly relevant. For instance, a more recent study examining the challenges faced by the EV industry found that current obstacles to widespread EV adoption include battery degradation, long charging times, and gaps in charging infrastructure (Alanazi, 2023). Despite the significant innovation of EV technology over its history, challenges remain that limit its growth.

Previous research has also found that government policy plays a large role in accelerating the adoption of electric vehicles. Policies such as the Inflation Reduction Act of 2022 have incentivized both consumers and manufacturers to transition away from internal combustion engine vehicles. In particular, the Inflation Reduction Act of 2022 provided significant tax credit for consumers that drive "clean vehicles" and companies that sell them, and heavily funded several different emission reduction programs (Electrification Coalition, 2025). According to research conducted by Knittel & Tanaka (2024), the U.S. federal government, especially during the Biden administration, has stepped in to help solve the systematic challenges that hinder EV adoption. Federal and state policy responses include a broad mix of strategies such as funding to support expansion of charging infrastructure, rebates and tax credits, discounted electricity rates for EV charging, exemptions from High Occupancy Vehicle lane restrictions, and reduced vehicle registration fees. Especially over the past four years, the federal government has

significantly influenced consumer demand for sustainable transportation, thereby becoming a major actor in the EV industry as a whole.

Scholars have also widely recognized that environmental movements have contributed to rising public demand for sustainable transportation. With the aim of reducing carbon emissions, EVs serve as a viable and sustainable mode of transportation to help mitigate climate change (Cave & DeYoung, 2014). Public sentiment, amplified by social media and environmental organizations, have shifted towards favoring sustainable practices. In particular, social media plays a central role in spreading environmental awareness values. Hamid et al. (2018) have argued in their research paper that social media use in higher education has become a powerful driver of sustainability awareness. Through social media platforms, news about environmental issues rapidly spreads among its users, fostering pro-environmental attitudes and behaviors among younger generations. In addition to this, Jie Wu and colleagues (2024) have argued in their research paper that individuals who engage in green behaviors and perceive significant benefits in eco-friendly products are more likely to purchase "green vehicles." This suggests that environmental advocacy not only raises awareness, but also cultivates behaviors and perceptions that directly influence consumer choices. The growth of an eco-friendly sentiment and a willingness to adopt sustainable practices in society contribute significantly to the rise in public demand for an alternative to internal combustion engine vehicles.

My analysis of the Hyundai electric vehicle recalls will draw on the science, technology, and society (STS) concept of actor-network theory (ANT), which allows me to examine how technical outcomes are shaped by the dynamic relationships between human and non-human actors. Developed by scholars such as Bruno Latour and Michel Callon, ANT suggests that networks of diverse actors interact in a way that shapes social and technological developments (Cressman, 2009). In this case, I will analyze how engineers, government policies, corporate strategies, public opinion, and EV technologies themselves interact within fluid and interdependent actor-networks. Additionally, I will apply the concept of punctualization, which is the idea that an entire complex actor-network can be treated as a single unit and linked with other actor-networks to create an even larger network (Cressman, 2009). This concept will allow me to develop an analysis of the Hyundai EV recalls that can offer broader insights into the interconnected actor-networks that define the electric vehicle industry as a whole. While existing research agrees that the EV industry has faced many challenges shaped by both social and

technological factors, scholars have not yet adequately considered that the technical issues may stem from overly compressed engineering timelines, driven by external pressures such as government policy and rising public demand.

## Methods

My research for this paper adopts a qualitative case study approach to examine the technical challenges faced by the EV industry, with a focus on the 2024 Hyundai ICCU recall. The case study method is well-suited to this investigation because it enables an in-depth analysis of a specific example that can offer insights into the rest of the industry. Through this approach, the research paper seeks to address how external pressures, such as government policy and environmental advocacy, can influence the internal engineering timeline decisions and lead to technical issues.

Hyundai was selected as the focal case due to the grand scope of its technical failure and the recency of which it occurred. With over 147,000 vehicles being recalled, this is one of the largest EV recalls that has ever occurred. The study is bounded from 2022 to 2024, which captures Hyundai's recent development strategy and the timeline of the ICCU issue.

I primarily found my sources through UVA's online library catalog, Virgo, as well as through internet searches of relevant studies and statistics. The references used consist of a variety of primary and secondary sources, including academic research papers, official government publications, news reports, official Hyundai corporate releases, and technical reports. My research aimed to develop a strong background of the evolution of the EV industry, and provide specific information about government policy related to EV development, the environmental sustainability movement, and the Hyundai recall itself.

Within the analysis section, the actor-network theory will be applied by identifying key actors involved in the ICCU recall, mapping their relationships, and analyzing how they contributed to the issues faced by Hyundai. Utilizing actor-network theory and a case study approach will allow for me to break down this complex topic and reveal deep insights into why the EV industry consistently faces challenges and setbacks.

#### Analysis

Environmental Advocacy as a Driving Force In Hyunda's EV Development

A prominent actor in the case of the Hyundai EV recall incident was the growing environmental awareness in society that increased public demand for sustainable transportation. The interaction between Hyundai and this shift in public opinion suggests that the engineering timeline in Hyundai's development of their new EV models was compressed in order to fulfill this demand in the automotive industry. According to a study conducted by the Environmental Protection Agency in 2022, the transportation sector is the largest source of direct greenhouse gas emissions (EPA, 2022). Additionally, the emissions from the transportation sector primarily come from the burning of fossil fuels for cars and trucks. Being that electric vehicles do not emit any greenhouse gases in their usage, they offer a great solution to the excessive emissions coming from the transportation industry (Cave & DeYoung, 2014). In the United States, new electric car registrations totalled 1.4 million in 2023, and increased by more than 40% compared to 2022 (IEA, 2024). Based on this information, the United States has had an increasingly favorable view of the adoption of electric vehicles into the transportation industry. As established in the literature review, social media and environmental organizations have played a major role in increasing public awareness of the necessity to address the huge threat to humanity that is climate change. Due to EVs being a viable solution to the biggest cause of climate change and social media spreading awareness for the need to address climate change, electric vehicle advocacy and social media have become closely intertwined in recent years (Hamid et al, 2017). The interaction between these two actors largely contributes to the rise in demand for EVs in the automotive industry.

In a capitalistic society, supply and demand are primary drivers for the decisions made by individuals and businesses. At its core, capitalism drives companies to pursue profit through market share and innovation. In the United States, the automobile industry is particularly competitive. This leads to companies rapidly responding to consumer trends in order to prevent competitors from getting there early and dominating the space. The surge in public support and demand for clean transportation presents a prime opportunity for automotive companies to produce EV technology that meets the demand (Zhao et al. 2025). In an attempt to achieve a significant market share of the sustainable transportation sector, Hyundai announced plans in 2022 to rapidly scale their EV production in order to grow their market share in this industry (Hyundai Media Center, 2022). Like many other automotive companies, Hyundai reacted to

market trends in order to fill the growing demand for electric vehicles in society. The problem, however, comes from how exactly the development timelines of the new EV models were determined. In 2022, Hyundai announced an ambitious electrification plan, targeting 7% of the global EV market by 2030 and significantly increasing its EV production (Hyundai Media Center, 2022). It was a strategic business move to display their commitment towards developing sustainable transportation. This commitment, however, puts significant pressure on the engineers developing the new EV models to complete their work in short periods of time. While other automakers, such as Toyota, had been producing EVs since before 2000 (U.S. Department of Energy, 2014), Hyundai did not begin discussions about developing an EV platform until 2016 (Hyundai Motor Company, 2022). This shows that Hyundai began working on EV development only a relatively short time before releasing their first model in 2022, the Ioniq 5. In this case, a network of interactions between the engineers, corporate commitments, and public demand accelerated the development of EV models within Hyundai at a rapid rate. In a more broad view, Hyundai is a single actor in a large EV industry network where competitive interaction spur a collective increase in supply of EVs to the automotive industry.

It would be reasonable to counter this by indicating that Hyundai's goal was to achieve this market share by 2030, therefore this wouldn't have had a large effect on a recall occurring in 2024. I would counter this however, by arguing that in order for Hyundai to reach their goal by 2030, they would need significant growth in EV sales each year following the announcement made in 2022. Since it takes time to sell the product, multiple EV models need to be made available to sell as early as possible. Therefore, Hyundai aimed to quickly produce and distribute their new EV models well before the 2030 deadline.

In addition to influencing the decisions made by automotive companies, the growing environmental awareness in society is also connected with federal and state governments. Since the government is meant to represent and advocate for the opinions of its constituents, a growth in support of sustainable transportation in society directly impacts the policy decisions made by government officials.

Government Policy as a Driving Force in Hyundai's EV Development

Another important actor in the Hyundai EV recall incident is government policy that provided incentives for development and usage of sustainable transportation. The interaction between government policies and Hyundai indicates that the development of new Hyundai EV models was a direct response to the incentives issued by the government. Following the rise in environmental advocacy and growing public demand for sustainable transportation, political institutions began responding with legislation that offered economic incentives for both producers and consumers of electric vehicles. In this way, government policy has not acted independently, but rather as a reflection of the growing sentiment of its electorate. Under the Democratic Biden administration in the United States, the Inflation Reduction Act of 2022 serves as a prominent example as to how the federal government incentives EV development through its significant financial incentives to both consumers and automobile companies (Electrification Coalition, 2025). This federal policy is particularly intriguing when considered alongside the timeline of Hyundai's EV development. Between 2022 and 2023, Hyundai and its affiliated companies, Kia and Genesis, released six new electric vehicle models. Notably, all 147,000 vehicles affected by the ICCU recall fall within model years 2022 to 2025 (Stotz, 2024). The fact that these models were announced and brought to market shortly after the passage of the Inflation Reduction Act in 2022 strongly suggests that the timing was not coincidental. Rather, it indicates a reactive shift in production strategy by Hyundai, likely influenced by the newly available government incentives. In this circumstance, the Inflation Reduction Act is a non-human actor that interacts with the Hyundai corporate strategies in a way that may have contributed to the ICCU failures of Hyundai EVs.

In addition to government policy encouraging companies to produce and distribute more EVs, the policies also incentivize consumers to purchase EVs. Policies that include rebates, tax credits, discounted electricity rates for EV charging, exemptions from High Occupancy Vehicle lane restrictions, and reduced vehicle registration fees for example, motivate more consumers to transition to EVs. Even people who don't believe in the importance of transitioning to sustainable transportation to fight climate change would be willing to switch to an EV for financial reasons. In this sense, the sociotechnical system is reinforcing itself over time by means of a positive feedback loop. As public environmental advocacy and awareness grows, governments respond with supportive policies. These policies then make EVs more accessible

and viable, which in turn inspires more advocacy and awareness to further put pressure on governments and EV manufacturers.

This pattern extends well beyond Hyundai as well. As government policies around the world have increasingly provided funding and tax credits that encourage the growth of electric vehicles, automakers across the industry have adopted similar strategies to Hyundai. In the United States, government incentives programs such as the California Zero-Emission Vehicle (ZEV) program and Maryland's (ZEV) incentives continue to motivate producers and consumers to enter the EV industry (Department of the Environment, 2025).

It has now been made clear that increasing public awareness of the importance of transitioning to sustainable transportation and related government policies that incentivize EV usage have prompted automotive companies to rapidly scale EV development. However, it is important to analyze why this quick acceleration of EV development can be damaging to the industry as a whole.

# Technical Challenges Stemming from Rapid EV Development

The interactions between environmental advocacy, government policy, and Hyundai EV development created engineering vulnerabilities that allowed for the massive EV recall to occur. As inferred from the analysis up to this point, Hyundai allowed the demands of environmentally conscious consumers, competitive markets, and policy incentives to dictate the development timelines of their EV models. The compression of their engineering timelines would allow them to meet the consumer demand and benefit from the government incentives, but it made them exposed to the potential for technical issues. The failure of the ICCU could have potentially been avoided had Hyundai spent a sufficient amount of time testing and verifying the new vehicle models. For example, Hyundai introduced the Ioniq 6 in mid-2022 and released it to market just a few months later, by the end of that year (Hyundai Media Center, 2023). This rapid turnaround left little time for a thorough testing and evaluation of potential long-term issues. In this circumstance, interactions between Hyundai engineers and corporate goals occur within the Hyundai EV actor-network in a way that limits the engineers to properly complete their jobs. The ICCU defect was not simply missed, the vetting process to check for this sort of issues was deprioritized amid broader organizational goals.

This pattern of interactions occurs across the EV industry. When product timelines are dictated by these external forces rather than by the time needed to test, validate, and refine, then reliability becomes a secondary concern (Dodd et al. 2024). As the EV industry continues to expand, companies must recognize that the long-term success depends not just on how quickly they can respond to the demand, but on whether the systems they deliver can withstand the demand. Understanding the network of actors that interact within Hyundai and in the broader EV industry will allow companies to make better decisions about their product development and avoid technical failures that create major setbacks.

## Conclusion

The challenges facing the EV industry cannot be understood through a purely technical lens. As the case of Hyundai's ICCU recall illustrates, engineering failures often emerge not from the lack of technical understanding, but from the influence of external forces. Public sentiment, government policy, and market competition were able to influence Hyundai's engineering timelines, allowing for the failure to occur. The drive to rapidly scale EV production, while motivated by legitimate and important environmental concerns, has created a sociotechnical environment in which sufficient engineering is compromised in favor of speed. Hyundai's experience, and the broader industry context in which it occurred, highlights a critical issue in the transition to sustainable transportation where the pressure to act quickly can unintentionally slow progress when systems fail and consumer trust is damaged.

As more automakers rush to electrify their products, failures similar to Hyundai have occurred, such as the Mercedes-Benz recall in 2024 (Tucker, 2025). These types of failures will continue to occur if a change is not made. It would be reasonable to counter this by arguing that these setbacks are an inherent part of the development process of a technology. Even though these challenges occur, the industry as a whole is still growing. Although this may be true, these setbacks are damaging to an industry that is crucial in the fight against climate change. The more recalls and failures that occur in electric vehicles, the worse the public perception becomes of this technology. The technical challenges that limit the success of Hyundai and other EV manufacturing companies is also slowing down the necessary transition towards sustainable transportation.

The practical implications of these insights are significant. The setbacks are not the fault of environmental advocacy and government policies, rather the automakers that allow these external forces to influence their development timelines are at fault. It is expected that automakers will respond to market pressures or policy incentives, but issues arise when that response significantly compresses the duration of engineering development timelines. This analysis points to the broader lesson that in the effort to address one of the most urgent challenges of our time, we cannot afford shortcuts. If electric vehicles are to play a central role in decarbonizing the transportation sector, they must be engineered on a timeline that reflects the complexity and responsibility of that task.

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