JSDC

*Journal of Studies in Dynamics and Change (JSDC);*
*Vol-13, Issue-2, ISSN: 2348-7038*
*International Peer Reviewed Quarterly Journal*
*www.jsdconline.com*



# Shaping Electric Vehicle Perceptions: The Historical Normalization of Internal Combustion Automobility

Sweeyam Chakraborty[1]

Sudakshina Gupta[2]

**ABSTRACT**

*Electric vehicles are widely presented today as a new solution to the environmental costs of internal combustion engine (ICE) – a clean alternative challenging a technology that has dominated private mobility for more than a century. Over this period, the characteristics of the ICE have become so deeply embedded in public understanding that they now define, for most people, what a car simply is. Yet this perception obscures an earlier history. At the turn of the twentieth century, steam, electric, and internal combustion vehicles competed directly for the emerging private mobility market, and electric vehicles were not a marginal technology. By 1900, they accounted for nearly one-third of American automobiles and, in several respects, offered advantages over their rivals. This paper takes that overlooked technological contest as its starting point and argues that the subsequent dominance of ICE vehicles cannot be adequately explained as a straightforward market outcome in which the most efficient or practical technology prevailed. Instead, it contends that ICE dominance was substantially the product of path dependence. Contingent historical events, patent litigation, corporate financial collapse, and industrial-political manoeuvring locked in a technological trajectory that was not preordained by cost or performance alone. Once established, this trajectory was reinforced over successive decades into a deep cultural and psychological normalization, through which ICE characteristics became embedded markers of identity, status, and masculinity. Consequently, when electric vehicles re-emerged in the late twentieth century as a climate-policy priority, they appeared as a historical anomaly rather than the revival of an earlier competing technology, generating resistance from both industry and consumers. The paper concludes that economic incentives can move price-sensitive consumers but are structurally insufficient alone: sustained EV adoption requires policy that addresses the non-economic, identity-based residue of this history.*

**Keywords**: Path dependence, Technology lock-in, Automobility, Electric vehicles, Historical narratives, Innovation resistance

**JEL Classification Codes:** L62, N70, O31, O33, Q55

**Author Details:**

1. Sweeyam Chakraborty (Corresponding Author), Research Fellow, Department of Economics, University of Calcutta, Email: eco19.sch@gmail.com (ORCID ID: 0000-0002-2105-7431)
2. Sudakshina Gupta, Professor, Department of Economics, University of Calcutta, Email: sudakshina_urbaneco@caluniv.ac.in (ORCID ID: 0000-0001-5476-5904)



**Suggested Citation:**
Chakraborty, S. & Gupta, S. (2026). Shaping Electric Vehicle Perceptions: The Historical Normalization of Internal Combustion Automobility, *Journal of Studies in Dynamics and Change (JSDC), 13*(2), 41-67.
DOI: www. https://doi.org/10.5281/zenodo.22796632
Published on: 01 April 2026

## I. INTRODUCTION

Automobility refers to the complex social, cultural, and infrastructural system centred around the automobile, a concept widely attributed to the historian John C. Burnham and later expanded into a broader research paradigm by John Urry. Private automobility focuses specifically on the system of private car ownership and use embedded in infrastructure, institutions, culture, and everyday practice. Academic literature treats it as more than driving, because it is reproduced by planning, policy, social norms, and material systems that make car use feel normal or necessary (Burnham, 1961; Urry, 2004). Viewed this way, cars cannot be understood as isolated machines or neutral products that people simply buy.

This paper draws primarily on American and European historiography on automobility, because that literature provides the most developed vocabulary for analysing technological transition, path dependence, and the normalization of private motorized travel. This emphasis is also a product of the field's own formation – canonical studies were built around Western industrial societies, where automobility became especially visible, richly archived, and repeatedly treated as the default empirical basis for broader historical claims (Clarsen, 2017). Recent historiographical critiques warn against taking Western trajectories as universal models of historical development (Heng, 2026; Chakrabarty, 2008; Helliwell & Hindess, 2011). For that reason, this paper treats the Western literature not as a global template but as a bounded case for examining the contest among steam, electric, and internal combustion vehicles. The question here is not whether Western experience represents all mobility histories, but how private automobility was stabilized within the setting from which the dominant transition narrative was originally constructed.

The history of electric vehicles is not simply absent from popular and academic memory of the automobile's early decades. Where it appears at all, it is frequently folded into a narrative that treats gasoline's later dominance as the natural, inevitable centre of the story, with electric and steam propulsion reduced to footnotes or curiosities along the way. Kirsch (2000) identifies the underlying mechanism as a tautology: the internal combustion engine is said to have won because it was the superior technology, with its eventual victory itself offered as the proof of that superiority. This circular reasoning does more than distort the historical record. It forecloses the question this paper takes as its starting point, by treating what was in fact a contingent and actively contested outcome as though it required no further explanation.

Drawing on path dependence and increasing returns theory, this paper argues that ICE dominance was substantially a contingent, lockable-in outcome rather than a purely efficient one – the product of patent warfare, corporate collapse, mass-production economics, deliberate marketing strategy, and government policy that together tipped an open contest toward one technology and then made that tip difficult to reverse. This historical lock-in was subsequently reinforced by a century of cultural and psychological normalization, in which ICE characteristics – engine noise, manual control, tactile feedback – became embedded markers of masculinity, status, and identity rather than remaining neutral engineering choices.

This matters directly for the present. When electric vehicles re-emerged after the 1970s as a climate policy priority, they did not re-enter a neutral market. They re-entered one in which a century of lock-in had made the ICE vehicle the unmarked, "normal" automobile and the EV the anomaly. This paper argues that the resistance EVs have faced since – from industry incumbents seeking to protect the value of factories, dealership networks, and supply chains already built around ICE production, and from consumers whose automotive identity and expectations were shaped by exactly the normalization this paper traces – is best understood as a direct historical consequence of that lock-in, not a separate, unrelated phenomenon.

Accordingly, the paper proceeds in three movements. Sections II through IV establish the historical lock-in: the genuinely open three-way contest between steam, electric, and ICE vehicles, the theoretical mechanism of path dependence that explains how that contest closed (along with direct counterarguments to that account), and the specific industrial and political actions that closed it. Section V traces how this technical lock-in became cultural normalization. Sections VI through VIII turn to the present, examining the climate-driven EV resurgence and the industry and consumer resistance it has encountered, including evidence that this resistance is being actively renegotiated in current marketing rather than simply fading. Section IX concludes with implications for policy and a forward-looking assessment of what this history means for the electric vehicle's future.

## II. THE THREE-WAY CONTEST, c.1890–1910

Private automobility did not begin as automobility in any recognizable modern sense. It began as a luxury replacement for an already-existing private luxury. Owning a private carriage in the nineteenth century was itself a marker of wealth and status; the costs of keeping horses, carriages, and stable space made private ownership disproportionately associated with urban upper-class households, while most urban residents relied on hired hackneys, omnibuses, and horse-cars for everyday mobility (Tarr & McShane, 2007).

Industrialization in the nineteenth century drove transportation demand up sharply, and horses began competing with humans for cultivable land, raising the cost of horse maintenance (Cowan & Hultén, 1996; Amatucci, 2015). Several propulsion technologies – steam, electric, and internal combustion – emerged in parallel from innovations in other industries and sciences of the late eighteenth and nineteenth centuries. Around 1900, no single technology had established clear dominance (Kirsch, 2000; Taalbi & Nielsen, 2021). For roughly the first two decades of the automobile's existence, gasoline, steam, and electric vehicles alike were expensive, unreliable, and treated largely as novelties for wealthy hobbyists rather than practical transportation; car ownership was concentrated among the same urban class that had previously owned private carriages, and served much the same function – displaying status through mobility rather than substituting for everyday transport needs.

Electric vehicles held genuine early advantages like quiet operation, ease of use, and no manual cranking, which made them popular for urban and especially women's use, and for taxi fleets in cities such as London and New York (Kirsch, 2000; Mom, 2014). By 1900, EVs represented close to a third of American automobiles. Steam vehicles were competitive for heavier or longer-distance use but suffered from long start-up times. ICE vehicles were, at this stage, the least convenient of the three – noisy, dirty, and requiring dangerous hand-cranking (Flink, 1988).

The turning point at which private automobility stopped being an elite privilege and became a mass phenomenon can be dated with some precision. Eli et al. (2025), using US state and county-level data, show that the income elasticity of car ownership dropped sharply between 1909 and 1919, as ownership shifted from being concentrated among the wealthy in urban areas to becoming a mass-market good purchased far more widely, including in poorer rural states – illustrated by their California county data, where ownership was concentrated around San Francisco and Los Angeles in 1907 but had spread heavily into the rural Central Valley by 1921. The mechanism behind this shift was not Ford alone but the broader reorganization of production and diffusion associated with the Model T era. Ford's moving assembly line, introduced in 1913, sharply reduced production costs and retail prices, while wider processes of industrialization and urbanization helped turn the automobile into a viable mass technology (Kanger & Schot, 2019).

Loeb (2004) provides a detailed chronology of just how open this contest remained in practice, along with a framework for explaining why it closed the way it did. The automobile's American public debut, the 1895 Chicago Times-Herald race, was run in such severe snow that only two vehicles finished at all, both internal combustion, while both electric entrants – including the Morris & Salom Electrobat – suffered rapid battery drain in the cold and dropped out early. The judges nonetheless awarded the Electrobat the gold medal on the basis of its superior design, safety, and cleanliness, as evaluated in preliminary laboratory tests held before the blizzard struck ("The Times-Herald Motocycle Contest Awards," 1896, p. 139) – a result that sits uneasily with any narrative of early, obvious ICE superiority. Pope Manufacturing Company, the country's largest vehicle producer before 1900, built its business on electrics. The Stanley brothers' steam-powered Locomobile, introduced in 1899, then took outright sales leadership in both 1900 and 1901. Its success rested on a genuine engineering fix rather than price alone, since the Stanleys had achieved what Loeb terms the "miniaturization" of the steam engine, producing a small, light unit in place of the heavier, boiler-driven traction-engine designs steam cars had previously relied on. That fix in turn allowed the Locomobile to be sold at $600, undercutting the field, but the underlying steam architecture remained otherwise unchanged, still requiring up to 30 minutes to raise pressure from cold and frequent stops for water rather than fuel alone. As late as 1900, American factories built 1,681 steam cars and 1,575 electrics against only 936 internal combustion vehicles; ICE was running a distant third.

What changed was not a further technical breakthrough but a shift in what the automobile was understood to be for. Electric vehicles offered a cluster of virtues – cleanliness, quiet, safety, ease of control – well suited to "promenading," using a car to display status around town much as a fine carriage had. But a second, more captivating use emerged in 1899, when Alexander Winton drove a gasoline car from Cleveland to New York in under 48 hours with a newspaper reporter aboard; the resulting press coverage turned "touring" – open-ended travel limited only by fuel and road conditions – into the automobile's defining appeal. Touring demanded an entirely different combination of virtues: power, range, and a reliable refuelling infrastructure. Electric vehicles could offer none of these, while the Locomobile's unresolved dependency on water left it only partially equipped to meet such demands. Internal combustion alone could deliver all of them together. The shift became visible in 1901, when Oldsmobile had an employee, Roy Chapin, drive a curved-dash Oldsmobile from Detroit to New York in time for that year's National Auto Show; the car was the sensation of the show, and Oldsmobile secured an order for 1,000 units on the spot. The curved-dash Olds went on to capture roughly 36 percent of all US auto sales by 1903, and by 1904 internal combustion accounted for roughly six of every seven cars sold nationally.

This account rests on a broader framework. Loeb (2004) organises the period's competing vehicles around sixteen distinct "automotive virtues" – qualities such as cleanliness, quietness, safety, range, and low insurance cost. No single technology of the period possessed all of them simultaneously, which is precisely why the outcome was a matter of which virtues buyers came to prioritise rather than a straightforward technical verdict. Electric vehicles were clean, quiet, safe, and simple to drive and maintain, but limited by heavy lead-acid batteries to short ranges and low top speeds, and their reliability came at a cost he frames in sociological terms: their "black box" design left mechanically minded buyers with nothing to tinker with, draining much of the vehicle's recreational appeal for exactly the enthusiast demographic that came to dominate car culture. Thomas Edison had already made his own attempt to solve the battery problem, independent of and a full decade before the 1914 Ford-Edison project discussed in Section IV. His nickel-iron battery, launched with great fanfare in 1904, had to be withdrawn almost immediately after it began losing power and leaking in use. This earlier, very public failure meant that when Ford and Edison later joined forces, they were not entering untested ground – the battery problem had already failed publicly once, and that history likely shaped how sceptically the press and public greeted their second attempt. Steam vehicles offered excellent speed and power but required up to 30 minutes to raise boiler pressure from cold, were rendered useless below freezing, and carried a visible safety risk, dramatized when a boiler gauge burst on investors at the 1901 National Auto Show, and when two steamers burned during a 1904 national touring event.

This same virtues-framework clarifies the touring-capacity argument already introduced above. Electric vehicles suited urban "promenading," a status display well matched to their range, while the buying public increasingly prioritized "racing" and "touring" instead – long-distance recreational driving for which internal combustion's range and refuelling flexibility were uniquely suited. Once purchasing behavior shifted decisively toward gasoline vehicles on this basis, Loeb argues, it signalled a secure market to entrepreneurs, triggering the rapid build-out of wholesale petroleum distribution and filling-station infrastructure already discussed in Sections III and IV, infrastructure which then eliminated range anxiety as a purchasing concern entirely, for gasoline vehicles alone, closing the loop between an initial virtue-based preference and the infrastructural lock-in that followed from it.

The point to establish here is negative. Nothing about the moment around 1900 predicts ICE victory. All three technologies had genuine constituencies and genuine limitations. What happened next is the subject of this paper.

## III. PATH DEPENDENCE AND INCREASING RETURNS AS THE LOCK-IN MECHANISM

The competition described in Section II did not resolve through a straightforward efficiency contest. Urry (2004) frames that outcome explicitly through the vocabulary of path dependence. In the 1890s, gasoline, steam, and electric propulsion all appeared viable, and by several measures steam and electric batteries were arguably more efficient. The gasoline-based path nonetheless became established for "small-scale, more or less accidental reasons." Urry cites the fact that a gasoline vehicle was one of only two cars to complete a widely publicized Chicago competition in 1896, a result owing more to which vehicles happened to be entered and survive the course than to any decisive proof of gasoline's superiority. It is exactly this kind of minor, contingent event that the rest of this section traces forward: the small publicity edge gasoline gained from that race is the type of early advantage that, once compounded through the infrastructural and economic feedback loops discussed below, hardened into the century-long dominance this paper is trying to explain.

This is a primary argument – an early, small, and largely accidental advantage does not stay small. Once the "steel-and-petroleum" car gained even a marginal edge, it began generating what Urry terms "increasing returns" for everyone positioned around it – manufacturers, fuel suppliers, road builders, and ancillary service industries – which in turn produced systemic lock-in. Social and economic life became progressively tied to the petroleum-based vehicle, reinforced by co-evolving institutions (oil companies, suburban housing patterns, out-of-town retail built around car access) that made reversal increasingly costly the longer the system persisted. Urry stresses irreversibility as the key diagnostic. Because billions of individual agents and institutions adapted to the petroleum-car system over decades, undoing that adaptation became far harder than the original choice between technologies ever was.

This account gains empirical support from Taalbi and Nielsen's (2021) econometric analysis of early vehicle adoption, which finds that technology choice was strongly shaped by the cumulative proportion of prior producers already committed to a given propulsion type – a direct, quantified path-dependence mechanism. Their model further shows that gasoline's dominance was contingent on the slow, uneven expansion of electricity infrastructure at the time; a counterfactual in which electricity grids had been built out fifteen to twenty years earlier suggests the lock-in could plausibly have favored electric vehicles instead. This demonstrates that ICE dominance was not the necessary outcome of superior technology, but one realized path among several that infrastructure timing alone could have redirected.

Santini (2011) identifies the specific mechanism by which this path-dependent advantage was compounded. Gasoline vehicles were a "simple add-on" to an already-extensive kerosene distribution infrastructure (roughly 100 refineries and thousands of bulk stations by the early 1900s), and could be fuelled ad hoc from cans and barrels without waiting for dedicated infrastructure. Electric vehicles, by contrast, depended on an electricity grid that reached fewer than 10 percent of U.S. households by 1907 and remained non-standardized amid the AC/DC "war of the currents." Once this infrastructural gap opened, it was reinforced rather than closed: gasoline taxes funded road paving in the 1920s, better roads enabled higher-powered engines, whose average power rose from roughly 20 to 95 horsepower between 1926 and 1935, and this performance gain was something EVs, with their inherently limited top speed, could not follow. McCarthy (2007) documents the same reinforcing loop from the demand side. Ford's mass-production cost reductions and the 1920s expansion of consumer automobile financing removed purchasing barriers at a scale and speed no electric manufacturer could match, while Ford's backward-integrated investment in raw-material supply chains (the River Rouge complex) further locked capital into the gasoline vehicle's specific production process, making a later technological reversal progressively more costly to undertake.

Several further sources add concrete texture to this account. Heitmann (2009) provides specific comparative figures – early twentieth-century EVs were roughly three times more expensive to operate than ICE vehicles, carried batteries weighing a ton or more, and offered only 50 to 80 miles of range with poor hill-climbing ability, while steam vehicles required 10 to 30 minutes to build pressure from a cold start, weaknesses that led major steam manufacturers such as White and Locomobile to convert to internal combustion by 1910. He also notes a maintenance-network advantage specific to ICE vehicles. Early auto mechanics were frequently village blacksmiths already accustomed to repairing wagons, whose existing skills transferred more readily to ICE vehicles than to the more specialized ancillary equipment steam engines required.

This touring ideal did not originate with the automobile itself, and situating its earlier history clarifies rather than contradicts the specific 1899 and 1901 episodes discussed in Section II. Bladh (2019) talks about the concept of touring capacity as it originated during the 1890s bicycle boom, when people embraced long-distance leisure travel beyond fixed railway routes. As cycling declined, this culture of touring shifted to the automobile. Early reliability trials and cross-country journeys demonstrated that cars could travel long distances, helping build public confidence. As the Model T transformed touring from an elite activity into a mass recreational pursuit, by the mid-1920s, the automobile had become the dominant mode for leisure travel, replacing railways and establishing the "car-hotel-holiday" model of tourism. On this reading, Winton's and Chapin's celebrated drives (discussed in Section II) showed a public already primed by a decade of bicycle touring culture that those same touring aspirations could be dragged far beyond what earlier imagination had allowed.

Hadjilambrinos (2021) adds a striking statistic in support of Bladh's touring-capacity argument: in 1919, the average car was driven only 12.5 miles per day, yet buyers continued to select vehicles on the basis of touring capacity they rarely used, choosing ICE vehicles because they could serve as both city car and touring car, where electric vehicles were viewed strictly as city cars. This suggests the touring advantage functioned partly as an aspirational rather than a practical purchasing criterion, one that still prevails in modern society. Mom (2004) identifies a further asymmetry in how the two technologies were adopted: electric vehicle promoters organized into centralized "booster clubs" attempting to educate the public on what they termed "scientific transportation," while gasoline car culture spread through decentralized, individualist use that required no comparable coordinated advocacy, a difference in adoption structure that may itself have favored the technology requiring less organized promotion to spread.

The bicycle-to-motorcycle transition offers a further, more granular illustration of the same contingency. Alford and Ferriss (2016) challenge what they term the "evolinear" model, the assumption that the motorcycle simply represents a bicycle with a motor added as a later step. The Rover safety bicycle and Daimler's Einspur, the first recognized motorcycle, in fact appeared within the same year, 1885, developed along separate rather than sequential paths; the Einspur was built not to improve the bicycle but as a test-bed for an engine Daimler intended for four-wheeled vehicles. This same contingency shaped which two-wheeled designs survived at all: the tricycle, though stable and mechanically sound, became coded as a vehicle for the feminine, the elderly, and the infirm, while young male riders preferred the greater speed and risk associated with the high-wheeled "Ordinary"; early monocycle designs failed partly through an association with witches' brooms that the authors describe as an outright cultural superstition; and side-by-side "dicycle" designs, briefly popular for their stability, ultimately gave way to the inline, single-track configuration that became standard. The authors also trace how bicycle design borrowed directly from equestrian precedent, retaining the saddle, an upright riding posture, and steering through balance and bodily pressure rather than any purely engineering-driven layout, since the horse remained the culturally legitimate model for individual mobility that a new machine needed to resemble in order to be accepted. Although the authors do not use the specific term path dependence, they describe technologies becoming "obdurate" once a "closure" settles around one dominant type form, framing the episode explicitly through the language of contingency – it "could have been otherwise." This gives a second, independent case, alongside the automobile itself, in which an early and largely arbitrary alignment of cultural expectation foreclosed alternatives that were not obviously inferior on technical grounds.

Together, these sources support a central claim distinguishing path dependence from a simple market-efficiency story. Lock-in operated through compounding infrastructural and economic feedback loops set in motion by early, largely contingent events, not through the gradual revelation of ICE's inherent technical superiority.

This reading is not uncontested. Foreman-Peck (1996) argues directly against the lock-in account, holding that ICE dominance instead reflected ordinary, measurable economic advantage rather than a small accidental head start. Comparing US and British data, Foreman-Peck shows that steam vehicles were in 1900 both the most numerous and the cheapest of the three technologies in the United States, averaging $682 against $1,822 for electric vehicles, yet by 1904, of 21,692 American-built cars, all but roughly 300 were internal combustion, a reversal Foreman-Peck attributes to steam's heavy fuel consumption becoming a decisive weakness once cars were driven further and more reliably, not to any early gasoline advantage compounding over time. British trial data reinforce the same point: in the 1902 UK Automobile Club Reliability Trial, steam vehicles averaged roughly 18 miles per gallon against about 35.5 for internal combustion entrants in the same price class, a gap replicated in a comparable American trial that year (8.4 mpg for steam versus 16.1 for ICE). Because this same shift toward internal combustion occurred independently across countries with different institutions and starting conditions, Foreman-Peck concludes that ICE dominance reflects an accumulation of ordinary technical and economic advantages worked out over roughly two decades, not a single early contingent event subsequently locked in.

This paper's position is that Foreman-Peck's evidence is compatible with, rather than fully overturning, the lock-in account. Steam's fuel-consumption disadvantage becoming decisive only after several years of accumulating road use and infrastructure investment is itself consistent with a path-dependent process, in which early technology choices shaped the infrastructure – better roads, longer average trips – against which later technical comparisons were then made. Even so, the disagreement is real and is acknowledged here as a genuine limitation on how strongly the paper's central claim should be read. The case for path dependence in this specific historical episode is strong but not undisputed.

Kirsch (2000) offers a related response to this kind of argument, restoring a central role for path dependence while avoiding a simple appeal to chance. His starting point is what he terms the field's "orthodox tautology," the assumption that the ICE won because it was the superior technology, an assumption Kirsch treats as circular. He identifies a genuine window of opportunity before around 1902, during which steam, electric, and gasoline vehicles remained realistic alternatives. What closed this window, in his account, was less a matter of gasoline's technical superiority than a series of organizational failures on the electric side, discussed further in Section IV below.

Ivory and Genus (2010) offer a further challenge to purely technical or economic accounts of lock-in, arguing that explanations centered on Arthur's (1989) and David's

(1985, 1997) systemic models, including Foreman-Peck's (1996) resource-endowment counterargument, share a common limitation: they cannot fully account for why a technology becomes culturally untenable to consumers, as distinct from why it becomes commercially unviable. Drawing on Bourdieu's (1979/1984) account of taste and social distinction, alongside Csikszentmihalyi's (1993) treatment of objects as "repositories of meaning about the self," Ivory and Genus argue that early automobile choice operated as a form of symbolic consumption, in which a vehicle communicated group membership and social standing as much as it performed a transport function. On this account, the electric vehicle's UK "lockout" between 1885 and 1914 cannot be explained by battery limitations or infrastructure alone. It requires understanding how the vehicle came to signify the wrong things to the buyers who mattered, a case developed in full in the second sub-section of Section V below.

## IV. INDUSTRIAL AND POLITICAL DRIVERS OF LOCK-IN

The mechanics of lock-in were not abstract; they operated through concrete corporate and political actions. The Selden patent – a broad patent on gasoline automobiles secured by George B. Selden in 1895 and licensed through the Association of Licensed Automobile Manufacturers (ALAM), which the Electric Vehicle Company (EVC) helped establish to collect royalties from independent gasoline carmakers – attempted to control the ICE vehicle market through litigation rather than innovation. Henry Ford refused to pay these royalties, leading to an eight-year legal dispute; his eventual victory in 1911 was followed by the ALAM's dissolution in 1912. The litigation, whatever its original intent, had the effect of publicizing internal combustion vehicles as a populist cause against established manufacturing interests, and coincided with Ford's rise as a producer of affordable cars (Black, 2006).

The EVC, then the largest vehicle manufacturer and operator in the country, had proposed a workable alternative to individual ICE ownership built around urban taxi fleets, but collapsed between 1897 and 1901 under stock manipulation, patent litigation, and a failure to standardise its own components. A second opportunity was missed when the electricity supply industry, absorbed in building central generating stations, moved too slowly to treat vehicle charging as a natural use of off-peak capacity; by the time utilities took the vehicle market seriously, internal combustion already held a decade-long lead. For a period, transportation in fact supported a differentiated system rather than a single dominant mode: horses handled short local trips, electric trucks served medium-haul urban deliveries, and gasoline vehicles covered longer distances, each within its own appropriate niche (Kirsch, 2000). This arrangement unravelled less through market competition than through external disruption, particularly wartime government procurement of gasoline trucks for the First World War, which flooded the postwar market with cheap surplus vehicles and undercut the electric truck's urban delivery niche specifically. The ICE vehicle did not simply defeat the electric vehicle but partly absorbed it. The modern gasoline car depends on an internal electrical system, beginning with the 1912 electric starter, making it in effect a hybrid of the two technologies it is conventionally said to have displaced (Kirsch, 2000).

Amatucci (2015) adds a related structural point: as US states began taxing vehicles by weight, on the assumption that heavier vehicles caused more road wear, the electric vehicle's heavy battery pack became a direct financial penalty that gasoline vehicles largely escaped, illustrating that no technology held a fixed advantage across every dimension, and outcomes depended on which features a given regulatory environment happened to reward. He also describes a "betrayed" coevolution between the electric vehicle and the battery industry: once battery development shifted toward the small, low-capacity batteries needed for the ICE vehicle's electric starter, rather than for propulsion, the sustained investment in large-capacity storage that electric vehicles needed to remain competitive was foreclosed.

Cowan and Hultén (1996) add a further layer to the lock-in account: a technology's fate depends not only on its own learning curve but on a "development block," a set of interrelated complementary investments spread across multiple firms and industries. For the gasoline car, this block included specialized repair mechanics, petroleum refineries, and an established dealership network, each reinforcing the others' value and raising the cost of any shift away from gasoline well beyond what the vehicle's own production costs would suggest. A difference in commercial strategy compounded these technical and infrastructural factors: gasoline manufacturers such as Oldsmobile and Ford pursued deliberate mass-market strategies, adopting Taylorist production methods to lower costs and expand output, while steam and electric manufacturers took the opposite approach, targeting a narrower, wealthier customer base at high prices. The Stanley brothers, for instance, declined to advertise their steam cars at all, effectively rationing sales by the suitability of the buyer rather than competing for volume.

Heitmann (2009) offers a concrete regional illustration of this development-block logic. Cleveland was, in the 1890s and early 1900s, home to numerous pioneering automobile firms – Winton, Stearns, Gaeth, Washburn, Marr, and Owen Rogers & Hanford among them – and possessed a vibrant carriage trade of the kind that fed directly into early automobile manufacturing. Detroit, by contrast, initially had no comparable head start. What tipped the balance was capital: Detroit's financial institutions proved far more willing to take on the risk of funding an unproven industry, while Cleveland's banking community remained comparatively conservative. Combined with the presence of figures such as Ransom Olds, Henry Ford, Henry Leland, and Billy Durant, this willingness to underwrite risk allowed Detroit to draw manufacturing activity away from Cleveland and other early centres, consolidating into the "Motor City" that then anchored the wider development block described above. This suggests the development block's geography was not solely determined by the underlying technology or even by early manufacturing presence, but partly by which regional banking sector was prepared to absorb early risk.

The road infrastructure that later reinforced this lock-in did not originate with the automobile at all. Alford and Ferriss (2016) trace the Good Roads movement to bicyclists, not motorists: in Britain, two national cycling clubs merged to form the Roads Improvement Association in 1886, while in America the League of American Wheelmen combined with the National Grange of the Patrons of Husbandry to found the National League for Good Roads in 1892, driven by the poor state of local roads under bicycle tires. Industrialist Albert Pope financed and organized this advocacy directly for commercial reasons. Smoother roads meant higher sales of his Columbia bicycles. He went as far as funding road-engineering courses at MIT and persuading the Commonwealth of Massachusetts to establish its own highway commission, while the 1891 McKinley Tariff's 45-percent duty on imported bicycles simultaneously protected his domestic manufacturing base. The organizational machinery this produced was then inherited rather than built anew: cyclist influence within the movement declined sharply after 1905, and the League of American Wheelmen was inactive by 1907, by which point the legal road rights, engineering expertise, and lobbying template Pope had assembled were available to be taken up by automotive and petroleum interests instead. This is a further, earlier instance of the kind of contingent, non-decisive advantage this paper's account of lock-in depends on – the infrastructural advantage ICE vehicles ultimately exploited was inherited pre-built from an entirely separate industry's self-interested lobbying, not secured through any contest between propulsion technologies.

Henry Ford's moving assembly line, introduced in 1913, sharply reduced ICE vehicle production costs and prices. Combined with the introduction of the electric starter in 1912, which removed hand-cranking, one of ICE's principal disadvantages, the economic and practical gap between ICE and EV closed rapidly (Flink, 1988). This was reinforced by petroleum infrastructure development: by the 1920s the U.S. had over 200,000 gasoline filling stations, an infrastructure that electric vehicles had no equivalent for. Growing gasoline demand pushed the oil industry beyond simple distillation toward thermal cracking, a refining process pioneered by Standard Oil of Indiana that more than doubled the gasoline yield obtainable from a barrel of crude (Yergin, 1991). The First World War reinforced petroleum's strategic importance beyond the consumer vehicle market: the internal combustion engine displaced horse-drawn and coal-powered transport on the battlefield, prompting major naval powers, including Britain, to convert their fleets from coal to oil for greater speed and manoeuvrability, consolidating oil's centrality to national infrastructure well beyond private automobility.

Government and industry consolidation of ICE dominance continued well past the initial lock-in period. Black (2006) describes how General Motors, together with Standard Oil and Firestone, financed National City Lines, which acquired electric trolley systems in numerous American cities and replaced them with gasoline-powered buses. In the postwar period, the expansion of the National System of Interstate and Defence Highways, overseen by former GM president Charles Wilson, prioritized automotive infrastructure while mass transit investment lagged. Taken together with the early lock-in mechanisms already discussed, this suggests that ICE dominance was not simply established once, in the 1900s and 1910s, but was actively reinforced across several subsequent decades through continued industrial and infrastructural investment.

## V. CULTURAL NORMALIZATION – CONSTRUCTING THE "NORMAL" AUTOMOBILE

Lock-in at the level of infrastructure and economics does not by itself explain a century of consumer preference. This section addresses the cultural mechanism: how ICE characteristics were converted into felt, personal, and gendered markers of identity.

### *Habitus, Distinction, and the System of Automobility*

Urry (2004) argues that ICEV normalization became embedded within a broader "system of automobility," a self-organizing arrangement that, once established, generates the conditions for its own continuation. Institutions such as oil companies, suburban housing, and out-of-town retail developed in a mutually reinforcing relationship with the car, so that the built environment itself came to presuppose ownership. Urry describes the resulting condition as "coerced flexibility" and the fully normalized car as an "iron cage of modernity." Bourdieu's (1979/1984) theory of habitus offers a complementary account: social agents adjust their tastes and expectations to the objective conditions available to them, making "a virtue of necessity." Applied to this case, consumer preference for ICE vehicles was not simply pre-existing; it was partly formed by the narrowing of available alternatives. Gartman (2004) draws these together directly, applying Bourdieu's framework to early automobile history: gasoline vehicles were coded masculine (noisy, mechanically demanding), while electric vehicles were coded feminine (quiet, easy to operate). He attributes the marginalization of the electric vehicle to women's own demand for greater range, combined with gasoline manufacturers' commercial interest in the outcome; once ICE dominance was set, existing gender and class distinctions were "reinscribed" within the gasoline market itself, for instance through styling.

Taalbi (2025) offers a significantly more precise account of the timeline that complicates the Gartman reading just given. The association between electric cars and women did not exist at the outset; early electric vehicle advertisements in fact targeted men, specifically business and family buyers, framing the electric car as a reliable alternative to gasoline "adventure machines." Feminization occurred primarily in the 1910s, and crucially, after electric vehicles had already begun losing market share, functioning as a strategic survival response by producers rather than an original cause of the vehicle's decline. Feminization did provide a genuine niche – Taalbi's quantitative analysis finds that producers who marketed a majority of their models to women were actually more likely to survive – but it simultaneously locked electric vehicles into a conservative "separate spheres" ideology that became a lasting barrier once broader car culture came to prioritise touring and adventure, ground gasoline vehicles increasingly occupied.

### ***The Making of Combustion Masculinity***

Gender coding in private transport did not begin with the automobile. Beauvais and Robbins (2019) show it was already established in horse-drawn carriage culture, resting on a "separate spheres" ideology that assigned women to domestic life and men to public life, and extended this onto vehicle design itself: men had access to a wide range of carriage types, including sportier models permitting displays of individual skill, while women were largely confined to a small number of low, easy-to-enter carriages and were expected to appear as part of a coordinated ensemble with carriage, horses, and servants rather than as independent operators. Even horse selection was gendered, with docile mares or geldings considered suitable for women and spirited stallions reserved for men. By the time the motorized automobile appeared, the idea that vehicles and driving competence could be sorted into masculine and feminine categories was already culturally established, giving the automobile a ready-made framework to inherit rather than invent.

The same logic carried directly into the automobile era, though it now operated through spatial and infrastructural design rather than reins and whip length. Wachs (1987) shows that transportation systems, and eventually the automobile itself, were shaped to reconcile the demands of industrial concentration with a persistent desire for open, natural surroundings, effectively building the separation of home from workplace into the transport system. This separation deepened with the rise of the closed car in the 1920s, which moved rapidly from 10.3 percent to 89.4 percent of production within the decade, making the automobile usable in all weather turned it from an open-air recreational luxury into what was marketed as a family necessity. As sales of a household's first car began to plateau, manufacturers promoted the two-car household as the next stage of growth, reframing the second car not as an indulgence but as an investment in "family harmony." This same normalization carried an explicitly restrictive edge for women: Wachs documents contemporary anxieties that framed the automobile as a threat to female virtue, with cars sometimes described as spaces where a young woman's chastity was at risk, prompting parental and social restrictions on her mobility that echoed the earlier carriage-era insistence that women not drive unaccompanied. The postwar landscape of freeways and suburban design extended this pattern at an infrastructural scale: suburbs functioned as residential "dormitories" physically separated from workplaces, embedding the home-work division directly into the built environment, and this arrangement persisted even as women's participation in paid labor rose.

The same class- and gender-coded meanings reappear, in a more explicitly documented form, in Ivory and Genus's (2010) study of the early British motor car. Contemporary publications such as Cycling and Moting and The County Gentleman repeatedly framed the gasoline car as an "adventure machine," suited to a brash, self-reliant masculinity built around touring and cross-country racing, behavior the authors link to an imperial ideal of the young British gentleman proving himself in the wider reaches of the Empire. The electric car, by contrast, was coded as "gentle," clean, and suited to less adventurous urban use, an association reinforced in the period press: an interviewee in Hearth and Home explained her preference for electric cars because she "could not stand" gasoline-driven alternatives, while The Women's Signal promoted electric cabs as a cleaner, easier substitute for horse-drawn hansoms. Because touring and racing defined what counted as a genuine motor car within elite British car culture, an electric vehicle's inability to perform this specific brand of masculinity made it, in the authors' words, a "culturally and socially untenable object" for the buyers whose taste set the market's direction. This dynamic fed directly into the vehicle's marginalization: because women were excluded from the elite male circles that dictated automotive "good taste," the electric car's growing association with women's urban mobility stripped it of the signification needed to make it desirable to the primary purchasing group, reinforcing through cultural meaning the same lockout that infrastructural and economic accounts describe only partially.

Redshaw (2008), Tranter and Marusek (2023), and Clarke (2007) trace how this gendered coding deepened over the twentieth century into what Redshaw terms "combustion masculinity," a psychology of mastery and control expressed through speed, power, and risk-taking, reinforced by manufacturers through "muscle" cars and aggressive styling. Tranter and Marusek extend this into an account of aggressive, sometimes violent, gender performance: cars used to intimidate, and even, in extreme cases, as weapons against pedestrians, cyclists, and protestors. Clarke traces the same anxiety through popular fiction, showing that "manly" car marketing repeatedly resurfaced whenever vehicles coded feminine (minivans, and later EVs) threatened to unsettle male identity, prompting compensatory products such as SUVs.

The gendering of two-wheeled transport offers a further, class-inflected parallel to this pattern. Alford and Ferriss (2016) show that the bicycle's celebrated role in women's emancipation was, in its first decade, available only to the wealthy: Pope's Columbia high-wheeler cost $125 at a time when this represented roughly half a year's wages for an average worker, and elite women organized into exclusive bodies such as New York's Michaux Cycle Club, treating the machine as a luxury leisure object rather than a practical tool. This exclusivity persisted until the collapse of the American bicycle manufacturing cartel around 1898 to 1902, after which cheaper stamped-steel production finally brought bicycles within reach of working-class buyers. The postwar motorcycle followed close to the reverse trajectory: its association with working-class rebellion, crystallized by the 1947 Hollister race weekend and fixed in popular memory by the 1954 film The Wild One, shifted only with Honda's 1963 "You Meet the Nicest People on a Honda" campaign, which deliberately replaced the outlaw image with clean-cut students and young couples, pushing annual sales from roughly 40,000 units in 1962 to 500,000 by 1970 and repositioning the motorcycle as middle-class and utilitarian. Alford and Ferriss describe this as a "curious inversion": bicycle-era gendering moved from upper-class luxury toward working-class accessibility, while motorcycle-era gendering moved in the opposite direction. Read against the automobile's own history, this suggests the class coding attached to a vehicle type was never fixed to the technology itself, but was continually renegotiated through marketing, directly relevant to how ICE and EV vehicles are shown, in Section VIII, to be similarly recoded in present-day marketing.

#### *Visceral and Sensory Normalization*

Several accounts locate normalization in bodily sensation itself, not just symbolism. Redshaw (2008) and Sheller (2004) describe how manual gear control, engine sound, and vibration gave drivers a felt sense of mastery, what Sheller calls a "metaphysical merger" between driver and machine. Mom (2004) traces this to the very unreliability of early gasoline engines, which male enthusiasts treated as a virtue rather than a flaw, and describes ICE driving as a kind of nervous-system therapy against modern life's strain. McCarthy (2007) frames the same sensations – engine roar, visible combustion, shared hardships like hand-cranking – as sources of thrill, reassurance, and group belonging that electric vehicles, precisely because they lacked these frictions, could not replicate. Gössling (2017) extends this into a biological register, comparing engine sound to animal dominance displays, and links the expectation that a "real" car be loud and substantial directly to reinforced masculine and social stability norms.

#### *Popular Culture, Design Standardization, and the Public Face of Normalization*

Beyond bodily sensation, normalization was actively performed and marketed. Heitmann (2009) documents the automobile's rapid absorption into American popular culture: car-themed songs proliferated from 1899 onward (53 published in 1908 alone), racing produced celebrity drivers such as Barney Oldfield, and early slapstick cinema repeatedly depicted crashes as the result of driver incompetence rather than vehicle design, trivializing real safety concerns and easing public unease even as some contemporaries warned about exhaust toxicity and oil depletion. Hadjilambrinos (2021) adds a more specific engineering dimension to the story of lock-in: the technology that actually "won" was not internal combustion in general but a particular design standard, the 1901 Mercedes touring car, whose four-cylinder engine and improved handling nearly all American manufacturers had converged on by 1906. He also sharpens the infrastructural account already established in Section III: between 1895 and 1905 there was no standardized voltage, frequency, or charging plug among local electricity providers, and utilities showed little interest in supporting EV charging, compounding gasoline's existing distribution advantage. His work further confirms the gendered "separate spheres" pattern found in Mom (2004) and McCarthy (2007): manufacturers and journalists actively constructed gasoline as masculine and adventurous, electric as feminine and city-bound.

Giucci (2004/2012) extends this account into industrial strategy and language. Ford's 1913 assembly line converted the automobile from a handcrafted luxury into a massaccessible good, but General Motors, under Alfred Sloan, added a second, complementary mechanism: consumer credit, trade-in markets, and, crucially, planned obsolescence through the annual model change, which built a structural incentive for repeat purchase directly into the ICE vehicle's business model. Giucci also documents how automotive vocabulary filtered into everyday language and how early twentieth-century avant-garde movements, notably Italian Futurism, explicitly celebrated the engine's roar and violence as an aesthetic ideal, an extreme version of the sensory-mastery claims already established above.

Taken together, these accounts show normalization operating on at least four reinforcing levels: psychological identity (habitus, distinction, masculinity), bodily sensation (sound, vibration, tactile control), public culture (music, film, celebrity, marketing), and industrial design (a converged engineering standard, plus a business model built on repeat purchase). By the time EVs re-emerged as a serious market alternative, ICE characteristics had become the unmarked default across all four registers simultaneously, and the EV's absence of these traits registered as a deficiency rather than a neutral difference.

## VI. CLIMATE CHANGE AND THE POST-1970S EV RESURGENCE

Geels (2002) explains technological transitions through three levels: niches, where radical innovations are sheltered from normal market pressure; regimes, the rules, practices, and infrastructures that stabilise existing technologies; and landscape, the broader political, cultural, and material context. Regimes persist as long as these elements remain aligned; change occurs when landscape pressure disrupts that alignment and opens a window for niche innovations to break through. This offers a useful vocabulary for the transition described in this paper: the locked-in ICEV system traced in Sections III through V, with its infrastructure, industry, and cultural normalization, corresponds to what Geels calls a regime. Geels (2011) adds a further complication directly relevant here: car-based mobility is reinforced not only by regime-level lock-in but also by ongoing landscape trends such as globalization, individualization, rising wealth, and international travel. EV adoption therefore faces landscape pressures pulling in opposite directions, climate concern working to destabilise the regime, while these other trends continue to reinforce car dependence more broadly.

Concrete political pressure on the American car industry built gradually over more than a decade before translating into binding regulation. Climate change entered scientific meetings as a recurring topic through the 1970s, but the issue gained public and political traction only later: a 1986 letter from Senator Al Gore and colleagues expressed public alarm, and the 1988 Senate hearings, built around NASA scientist James Hansen's widely reported testimony, marked the point at which the press treated global warming as an established phenomenon rather than a speculative concern (Penna & Geels, 2015). This shift, reinforced by a string of unusually hot summers and droughts, produced several legislative proposals aimed directly at vehicle emissions, including calls for fuel economy standards as high as 45 to 55 miles per gallon, though none of these early bills were enacted.

The regulatory action that did take hold, California's 1990 Zero Emission Vehicle mandate issued by the California Air Resources Board, did not in fact originate from climate policy at all. It was formulated to address local air pollution and only later became bound up with broader climate goals. Because battery electric vehicles were the only viable zero-emission technology available at the time, the mandate functioned as a direct EV sales requirement, with targets rising from 2 percent of sales in 1998 to 10 percent by 2003, backed by a $5,000 penalty per non-compliant vehicle sold. A policy shaped by a separate, pre-existing air-quality agenda was subsequently pressed into service as a climate-era EV forcing mechanism, layering one contingent regulatory history on top of another (Vergis & Mehta, 2012). Beyond the United States, this top-down correction of market lock-in has continued globally through later subsidy structures.

Quantitative evidence supports Geels' landscape-pressure mechanism directly. Vasi and Sauder (2024), using a state-level panel study of alternative fuel station density in the United States between 1994 and 2015, find that the local density of environmental organizations had no significant effect on EV charging-station growth in general, but became a significant positive predictor specifically during the "high contention" period beginning in 2008, the same period, not coincidentally, in which climate change had become an established rather than speculative concern in public discourse. They also provide a useful negative comparison: ethanol infrastructure grew fastest where corn-farming interests were locally concentrated, showing that industry diversification, not environmental advocacy, drove that technology's diffusion, while compressed natural gas infrastructure grew fastest simply where freight trucking was concentrated, attracting support from neither environmental organizations nor its own parent oil-and-gas industry, and consequently stagnated. This last point echoes Kirsch's (2000) earlier observation about electric utilities moving too slowly to support vehicle charging: the electric power generation industry showed no significant effect on EV charging growth even during the high-contention period, suggesting the utility sector's disengagement from EV infrastructure persisted across nearly a century, from the industry's earliest missed opportunity through to its most recent regulatory window.

Cowan and Hultén (1996) identify six general avenues by which a locked-in technology can in principle be displaced: a crisis in the existing technology, regulation (of exactly the kind the ZEV mandate represents), a technological breakthrough, a shift in consumer taste, the cultivation of niche markets, or new scientific results. The regulatory route was the one actually taken in California, but their own pricing data from the period illustrate just how large a gap that regulation was attempting to close. A Kewet, a small two-seat electric city car with a range of roughly 50 to 100 km, cost around 129,000 Swedish kronor; a comparable electric conversion of a mainstream model showed the gap even more starkly, with an electric Volkswagen Golf retailing at roughly 288,000 kronor against 110,000 kronor for its gasoline equivalent, and an electric Renault Clio costing around 177,000 French francs against 79,500 francs for the standard gasoline version. Even allowing for the small production scale of electric vehicles at the time, this represents a price premium well over double the conventional vehicle's cost. This is the concrete economic backdrop against which the ZEV mandate's sales targets, and the sustained industry resistance to them discussed in Section VII, need to be read: manufacturers were not simply resisting a change in principle, but resisting a mandate to sell a technology that, at the time, cost roughly two to three times as much to produce as the vehicle it was meant to replace.

## VII. INDUSTRY RESISTANCE

Industry resistance to efficiency and low-emission regulation predates the ZEV mandate by over a decade, and operated through legislative loophole-engineering as much as through direct opposition. When Congress designed the first fuel economy

(CAFE) standards in 1975, Detroit secured an exemption for light trucks from both the stricter passenger-car standards and the "gas-guzzler" tax, framed at the time as protecting a working tool for farms and small businesses; this exemption later became the legal foundation for the SUV boom of the 1990s (Sperling & Gordon, 2009). Detroit's lobbying group again defeated proposed fuel-economy legislation in 1991, arguing publicly that tighter standards would force a dangerous downsizing of the American vehicle fleet. This pattern continued into the following decade: between 2005 and 2006, manufacturers secured weight-based standards for light trucks that reduced the competitive advantage lighter Japanese trucks would otherwise have held, and lawmakers extended fuel-economy bonus credits to flexible-fuel ethanol vehicles, which Detroit produced almost exclusively and used to offset large SUV sales even though fewer than 0.1 percent of US fuel stations actually sold ethanol.

Japanese manufacturers followed a markedly different path over the same period, offering a direct counter-case to this resistance pattern. Sperling and Gordon attribute this divergence to structural rather than moral differences: Japan possessed no domestic oil reserves, forcing manufacturers toward fuel efficiency and compact design from the outset, while a dense home market left no consumer demand for the heavy, high-margin vehicles Detroit relied on. When the US Clean Air Act passed in 1970, Honda's leadership treated compliance as an obligation and a market opportunity rather than a burden, developing the clean-burning CVCC engine years ahead of Detroit's own efforts. This orientation extended into the hybrid era: Toyota began developing what became the Prius in 1993, launching it in Japan in December 1997 after roughly a billion dollars in development costs, where monthly sales quickly outpaced projections. Its 2000 US debut was commercially modest, hampered by poor reviews of its styling and sluggish performance, but a redesigned second generation in late 2003 changed this trajectory sharply, with US sales roughly doubling in both 2004 and 2005; by June 2007, Toyota's cumulative hybrid sales worldwide surpassed one million units. Read alongside the CAFE lobbying history above, this divergence suggests that industry resistance to efficiency regulation was not an inevitable response to regulatory pressure, but one strategic choice among others, and one that carried a real commercial cost relative to the alternative Honda and Toyota pursued.

Automobile manufacturers, whose capital, supply chains, and expertise were built around ICE production, also resisted the ZEV mandate directly and sustainedly rather than through a single act of opposition. When other states began considering adoption of California's rule in 1994, General Motors, Ford, and Chrysler mounted a joint lobbying campaign, and by the mandate's 1996 biennial review they had aligned their public position closely enough that no single manufacturer would appear to move ahead of the others in complaining about battery costs, technical limits, and weak consumer demand (Penna & Geels, 2015). This pressure led CARB to drop the 1998–2002 sales requirements entirely in 1996, followed by further amendments in 1998 and 2001 that introduced credit-trading flexibility and reduced the pure battery-electric requirement to just 2 percent by 2003, with hybrid and natural-gas vehicles permitted to satisfy the remainder. Legal challenges reinforced this pattern: General Motors led a 2002 lawsuit arguing the mandate was pre-empted by federal fuel-economy standards, winning a court ruling that barred CARB from enforcing the program, and manufacturers later lobbied successfully to delay California's federal emissions waiver following the 2007 Massachusetts v. EPA ruling, before submitting a further petition to the EPA in 2012 arguing that sufficient consumer demand for electric vehicles could not be reliably predicted.

Resistance to the ZEV mandate was not a fixed posture but one that shifted systematically as manufacturers' own technological investments changed. Wesseling et al. (2014) trace this shift through four successive CARB rulemaking periods between 2000 and 2013, using a framework that distinguishes defensive strategies aimed at protecting the status quo from proactive strategies aimed at shaping regulation to favor a firm's own technology choices. In the 2001 rulemaking, manufacturers relied almost entirely on defensive tactics: concealing electric-vehicle waiting lists to make consumer demand appear artificially weak, proposing voluntary alternatives to the mandate, and commissioning studies arguing the mandate would paradoxically increase emissions by slowing overall fleet turnover. By the 2003 rulemaking, this hardened into coordinated litigation, with manufacturers partnering with dealership networks to file lawsuits that delayed enforcement and pressured CARB into more flexible amendments. At the same time individual firms began competing over technical details, including credit limits for neighbourhood electric vehicles, and started promoting hydrogen fuel cell vehicles as a longer-term alternative to battery-electric compliance. This picture changes markedly after 2008: manufacturers moved toward proactive rather than defensive strategies, but not toward acceptance of the mandate's underlying goal; rather, firms began lobbying to shape the mandate's specific terms in ways that favored whichever low-emission technology they had already invested in, including easier compliance treatment for immature technologies like hydrogen fuel cell and plug-in hybrid vehicles. This produced genuine fractures within the industry's previously unified front: large-volume manufacturers successfully opposed a compliance extension granted to smaller intermediate-volume manufacturers, and by 2012 BMW lobbied successfully to create a favorable "BEVx" credit category tailored to its own i3 model, a move that competitors including Ford actively opposed. Wesseling et al. note a consistent pattern underlying this shift: individual manufacturers increasingly used industry associations to continue defensive opposition, particularly against the federal pre-emption waiver, while individually adopting cooperative, technology-specific positions designed to secure competitive advantage. Opposition to the ZEV mandate, in other words, did not simply persist or fade over time, but evolved from blanket resistance into a more selective, competitive contest over which specific technology the regulation would ultimately favor.

The General Motors EV1 offers the clearest single case of this resistance operating at the level of a specific vehicle program. GM invested some $300 million in the early 1990s to develop the car, later scaled the program down substantially, and leased only around 760 first-generation units between 1996 and 1997, before discontinuing the program entirely in 2002–2003 and reclaiming and destroying all the leased vehicles (Penna & Geels, 2015). GM's official explanation cited low consumer demand, a substantial gap between the vehicle's roughly $78,000 production cost and its $33,995 lease price, and a strategic pivot toward fuel-cell research; Penna and Geels read the decision instead as consistent with GM's broader political opposition to the ZEV mandate, noting that the same period saw the closure of the Partnership for a New Generation of Vehicles, a comparable joint low-carbon research program that a 2002 industry press assessment described as having produced few tangible results and served largely political rather than technical purposes. Later compliance-era vehicles, including the Chevrolet Spark EV, Ford Focus Electric, and Honda Fit EV, followed a similar logic in the 2009–2012 period: built specifically to satisfy California's sales quotas rather than to be marketed or sold at volume.

Industry resistance also operated through direct control over the underlying battery technology itself, not only through lobbying and litigation. Eisler (2024) traces how Western oil majors, despite their core business resting on primary fossil fuel extraction, became early and consequential developers of the materials needed for advanced battery technology; Exxon researchers pioneered the lithium intercalation chemistry that would later underpin lithium-ion batteries, and Exxon's affiliate Tonen Chemical became a major global supplier of polymer battery separators. This involvement was defensive as much as commercial: following the 1973 oil embargo, Exxon treated battery research as a hedge against the possibility that automakers would shift decisively toward electric propulsion. This hedging strategy created a structural conflict that industry resistance could exploit – oil companies could tolerate hybrid vehicles, which continued to consume gasoline while creating a market for petroleum-derived separator materials, but a full battery electric vehicle threatened their core fuel business directly. This tension is illustrated concretely in the case of large-format nickel-metal hydride batteries, initially developed by Stanford Ovshinsky's Ovonic Battery Company with funding from the oil company ARCO. General Motors partnered with this venture in 1994 to develop batteries for its EV1, but in 2000 sold its stake to Texaco, which was shortly afterward acquired by Chevron. Chevron subsequently exercised a patent encumbrance over the underlying battery chemistry, restricting its licensing for electric vehicle use so severely that Ovshinsky's own attorney warned in 2004 that the company appeared intent on neutralizing the technology's commercial prospects altogether. Read alongside the discontinuation of the EV1 program itself, this case suggests that industry resistance to electric vehicles operated not only through public lobbying but through direct commercial control over the technology electric vehicles depended on, exercised by firms whose core business the technology ultimately threatened. Even where oil companies contributed materials that EVs required, Eisler argues this did not represent a genuine transition away from fossil fuel dependency, since modern lithium-ion batteries still rely on petroleum-derived components such as carbon-based anode materials and polymer separators, meaning even a fully electrified fleet would remain materially entangled with the petroleum industry.

## VIII. CONSUMER RESISTANCE

Section V established how ICE characteristics became embedded markers of identity over the twentieth century. This section addresses a distinct question: why that identity, once formed, is defended rather than easily abandoned when a viable alternative appears.

Social Identity Theory (Tajfel & Turner, 1979) offers a direct mechanism, and its application to automobile enthusiasm specifically has been developed in prior work (Chakraborty & Gupta, 2025), which this section extends by connecting it directly to the path-dependence and normalization argument developed above. Even a "minimal" categorization, driving one type of vehicle rather than another, is sufficient to trigger in-group favoritism, and ICEV drivers maintain a positive self-concept partly by perceiving their group as superior to EV drivers on dimensions that favor the in-group: mechanical "muscle," sensory feedback, the mastery of manual control established in Section V. When EVs threaten this distinctiveness, particularly by matching or exceeding ICE vehicles on price or performance, Tajfel and Turner predict a specific response: rather than conceding the comparison, the threatened in-group often prefers "maximum difference" over "maximum joint payoff," meaning ICEV loyalists may resist adoption even where an EV is objectively cheaper or better, because preserving relative group status is more psychologically rewarding than the material benefit of switching. Where direct comparison becomes unfavorable, the theory predicts "social creativity," redefining the terms of comparison toward attributes the in-group still wins on, such as "heritage," "soul," or "mechanical purity." If the shift is perceived as an illegitimate imposition, mandated by regulation rather than chosen, the theory predicts a hostile, defensive reaction rather than gradual acceptance. Gössling (2017) documents a concrete present-day instance of exactly this predicted reaction: the practice of "coal rolling," in which pickup trucks are deliberately retrofitted to emit visible clouds of soot, functions as an active, symbolic act of rebellion against environmental regulation and the growing visibility of EVs specifically.

Belk's (1988) theory of “possessions as the extended self” offers a complementary, more individually-focused account. Possessions are not merely functional; they become incorporated into a person's sense of identity, such that changes to them are experienced as changes to the self. Applied cautiously here, a vehicle's power, sound, and responsiveness may form part of an owner's self-concept, so that switching to an EV can be felt as identity loss rather than a product upgrade. Years of manual gear-shifting and maintenance represent an earned mastery, Belk's second mechanism of self-extension, and an EV's different skill demands may unsettle that sense of competence, at least temporarily. Where a shift away from a familiar vehicle feels involuntary, driven by regulation rather than choice, Belk's account suggests the loss may carry emotional weight beyond the material, and a long personal history with a given vehicle type may function as part of a broader personal narrative, so that adopting a markedly different technology can feel like a discontinuity in that narrative rather than a simple improvement.

Together, these two frameworks suggest EV resistance operates on both a group level and an individual level. Innovation Resistance Theory (Ram, 1987; Ram & Sheth, 1989) offers a third, more behaviorally-oriented lens, identifying functional barriers (usage, value, risk) and psychological barriers (tradition, image) as distinct resistance categories; empirical work applying this framework to EVs has found tradition- and image-based barriers to be as significant as functional ones (Xue et al., 2024).

Sovacool et al. (2019) provide contemporary, quantitative confirmation of this gendered pattern in a Nordic context, using a mixed-methods study of over 5,000 respondents alongside expert interviews and focus groups. They find that men own and use EVs roughly twice as often as women, and that men and women weight vehicle attributes differently in ways that map closely onto the historical coding traced in Section V: women place relatively more importance on safety, convenience, and environmental impact, while men emphasise acceleration, range, and design, with some male adopters in the qualitative interviews associating vehicle power directly with masculinity and status. At the same time, this coding is not static. Participants in their study described EVs as a "hybrid construction" capable of appealing across gender lines, and some explicitly pushed back against residual stereotypes, such as labelling small, easy-to-park EVs as "girly." This suggests that while the gendered resistance mechanisms traced throughout this paper remain measurable in the present day, they may be somewhat more contested and less settled for electric vehicles specifically than the century of ICE normalization would predict, a point of cautious optimism the paper's argument should not overstate, but also should not ignore.

The identity-based purchasing patterns theorised abstractly by consumer psychology have a direct, documented precedent worth situating chronologically here. Sperling and Gordon describe how automakers deliberately cultivated an identity-driven market for trucks and SUVs from the 1990s onward: a 2005 Ford F-series commercial depicted a motorcycle gang backing away from a bar after being intimidated by a lineup of truck grilles, closing with the line "we don't just make our trucks tough, we make you tough," while Toyota's $2.6 million 2007 Super Bowl commercial for the Tundra deliberately invoked the image of the hardworking man requiring a full-size truck. Marketing consultant Clotaire Rapaille's focus-group research for Detroit automakers in the 1990s found that SUV buyers were motivated less by practical utility than by a subconscious desire for security, wanting to appear as "menacing as possible" in what they described as a tank; parallel household interviews conducted at UC Davis found suburban mothers explicitly avoiding minivans, their own mothers' vehicle of choice, in favor of SUVs that let them project an identity as outdoorswomen or skiers regardless of whether they practiced those activities.

The same UC Davis research tracked an equivalent, opposite-valence signalling effect for the Prius between its 2000 US launch and 2006. Where buying a conventional economy car signalled that a driver was frugal out of financial necessity, interview subjects described choosing a Prius as signalling that they were frugal by choice, a symbolic act of "doing the right thing" that several described explicitly as a way to "vote with their dollars" and communicate disapproval to resistant automakers. Griskevicius et al. (2010) formalise this same mechanism theoretically: visible green purchases function as "conspicuous conservation," a costly signal that communicates both altruism and wealth simultaneously, since a vehicle that costs more and offers fewer luxury features than its conventional counterpart demonstrates that the owner is both willing and financially able to absorb a personal cost for a collective benefit, the vehicle itself, particularly when distinctively styled, operating as a "mobile billboard" for the owner's pro-environmental reputation. This effect depends heavily on visibility: their experiments show that status motives increase preference for green products specifically when the purchase is publicly observable, while the same status motives lead consumers toward self-indulgent, non-green luxury goods when shopping privately. This logic produces a counterintuitive relationship with price: because the signal's value depends on its cost, making a green vehicle cheaper can undermine rather than strengthen its appeal to status-motivated buyers, since an inexpensive green purchase risks signalling an inability to afford a luxury alternative rather than a deliberate sacrifice. Read together, the SUV and Prius cases and the costly-signalling theory that explains them form a single, historically grounded account: over the very same years, opposite vehicle choices functioned as opposite identity signals built on the same underlying mechanism.

The gendered coding traced historically through this paper finds direct quantitative confirmation in more recent consumer behavior. Plananska et al. (2023) build explicitly on Urry's (2004) account of automobility as a culturally loaded system, and on the historical work of Scharff (1992) tracing how ICE culture was constructed as adventurous and masculine while early electric vehicles were coded as quiet, clean, and confining, the same historical pattern this paper has already established through Gartman and the combustion-masculinity literature. Analysing EV market share against Hofstede's national masculinity-femininity index across 31 European countries, they find a statistically significant negative relationship: more feminine-coded national cultures show higher EV adoption, a relationship that holds after controlling for income, car ownership, national environmental policy, and fuel and electricity prices, with income the only other significant predictor. Switzerland and

Germany stand out as partial exceptions, both scoring comparatively high on masculinity yet still achieving moderate EV market shares of around 14 and 13 percent respectively; the authors attribute this to both countries also scoring highly on long-term orientation and individualism, dimensions independently associated with pro-environmental adoption. At the individual level, an implicit association test administered to a large German sample measured automatic associations between propulsion-related words and gendered terms. Men who do not consider purchasing an EV showed by far the strongest EV-feminine association of any group tested, significantly stronger than men who do consider EVs, and far stronger than women in either category. Because the test relied entirely on symbolic word associations rather than any sensory or performance-based stimuli, the authors are careful to note that this measures cultural meaning rather than product experience.

Recent evidence suggests this resistance is not simply a historical residue but is being actively renegotiated in current marketing. Redshaw and Condie (2025), examining electric and hybrid utility vehicle advertising in Australia, find that combustion masculinity is not disappearing with electrification so much as being reworked to survive it. Advertising for hybrid utility vehicles emphasises "no compromise" on power and off-road capability despite EVs' inherently quieter operation, and traditional masculine markers such as engine roar are being supplemented, rather than replaced, by high-tech features that still emphasise technical mastery. Manufacturers deliberately distance electrified utility vehicles from "eco-feminine" associations, instead marketing them as equally or more "relentless" than gasoline equivalents. Beyond gender, Redshaw and Condie (2025) identify a second, distinct dimension to this marketing: the "freedom" these vehicles sell is frequently depicted as a lone white male's ability to dominate and occupy "unchartered" natural spaces, which the authors read as continuous with settler-colonial entitlement to Indigenous land. This suggests the identity-based resistance traced through Sections V and VIII is not a fixed historical obstacle EV adoption must simply outlast, but an active site of cultural contest that industry marketing itself is currently attempting to manage.

## IX. CONCLUSION: TOWARD SUSTAINABLE MOBILITY POLICY

Plananska et al. (2023) argue that the association of EVs with lack of masculinity is strongest among the male non-adopters whom policy most needs to reach. For them, purely environmental messaging is unlikely to work in high-masculinity contexts and may even reinforce the association that the policy intends to break. They instead propose embedding EVs within masculine car culture by emphasizing speed, power, and technological strength, linking EVs to motorsport and other masculine sporting contexts, and converting high-profile government fleets to premium electric models that signal status rather than restraint. This aligns with the marketing shift documented by Redshaw and Condie (2025), where manufacturers rework combustion masculinity to survive electrification rather than retire it. Together, these sources suggest that the non-economic barrier traced here is not fixed, but already being addressed by renegotiating what an electrified vehicle can symbolise.

This paper has traced a continuous thread from the open technological contest around 1900 through a century of infrastructural, industrial, and cultural lock-in to a present in which EVs remain culturally anomalous despite growing economic and technical competitiveness. The historical lesson is not that path dependence has been overcome, but that it can recur if policy ignores this history. Sperling and Gordon (2009) make this warning explicit: America's subsidized corn ethanol industry became an entrenched constituency resistant to phase-out, replaying at a smaller scale the same mechanism traced here for the ICE. They therefore argue that governments should avoid mandating or subsidizing any single fuel or technology in advance, and instead set predictable, technology-neutral performance targets, such as the Low-Carbon Fuel Standard's lifecycle emissions intensity requirement, so electric, hydrogen, and biofuel pathways compete on outcomes rather than early political favor.

Sperling and Gordon (2009) extend this logic into a broader 2050 vision they term "Futurama III," built not from a single vehicle technology but from an integrated system: electric-drive vehicles alongside neighbourhood electric vehicles, e-bikes, and smart paratransit and ridesharing, coordinated through real-time digital matching and fed into upgraded transit infrastructure, aiming at a 50 to 80 percent reduction in transport emissions below current levels. This is framed not as pure speculation but as the scaling-up of pilots already running in cities such as San Francisco, Stockholm, Curitiba, and Portland. The authors pair this technical vision with structural accountability mechanisms, including municipal carbon budgets tied to local zoning and road-building decisions, and individual carbon allowances of the kind the United Kingdom explored under a formal government proposal – mechanisms that shift responsibility for emissions outcomes onto the institutions and individuals actually making transportation choices, rather than relying solely on manufacturer-side regulation of the kind traced in Sections VI through VIII.

Crucially, Sperling and Gordon do not treat the identity-based resistance documented here as something that will simply fade with generational turnover. They warn that purely punitive measures, such as fuel taxes imposed without any shift in what a low-carbon vehicle is allowed to mean, can provoke backlash – citing commuters who threw nails onto newly designated carpool lanes in protest. Their alternative aligns with the shift traced through Redshaw and Condie (2025) and Plananska et al. (2023): rather than asking drivers to surrender the identity and status historically invested in the automobile, policy and industry should construct new symbolic markers around efficient driving itself, making fuel economy visible and competitive through real-time dashboard feedback, as in early hybrid "hybridfests," where drivers competed for status as the most efficient operator.

Read against the full arc traced here, this suggests a necessarily open conclusion. The century-long dominance of the internal combustion engine was not a verdict on inherent superiority, but the product of contingent early advantage reinforced by infrastructure, political power, and cultural investment in what a "normal" car should sound, feel, and mean. That history offers caution rather than guarantee for the EV's future: adoption driven by mandate or subsidy alone risks recreating the lock-in. Whether the private EV displaces the ICE, or is absorbed into the more diversified mobility system Sperling and Gordon envision, may depend less on further battery or charging gains than on whether the identity and status once built around combustion can be rebuilt, rather than simply prohibited, around its replacement.

In that sense, the transition to electrified mobility is unlikely to be secured by subsidies or technical improvement alone. Financial incentives and charging infrastructure matter, but neither reliably guarantees high adoption on its own. Social norms, symbolic meanings, and identity-based perceptions can shape EV acceptance as strongly as, and sometimes more strongly than cost considerations (Barth et al., 2016), (Sintov et al., 2020; Noppers et al., 2014). If resistance to the end of the ICE is partly rooted in the cultural prestige historically attached to private automobility, then effective policy must do more than make electric vehicles cheaper: it must also make them socially legible as desirable, credible, and status-bearing. That implies pairing material support with public communication, narrative framing, and visible social endorsement that can rebuild the meanings once attached to combustion around electrified mobility instead.

As discussed in the fourth sub-section of Section V, the historical normalization of internal combustion vehicles was reinforced through cultural processes that shaped mobility aspirations across generations. If electric vehicles become embedded within the media, entertainment, and consumer environments that influence the aspirations of children and adolescents, they are more likely to be perceived as the normative form of private mobility by future generations. Consequently, the long-term transition to electric mobility depends not only on technological progress and supportive policy but also on gradually reshaping the cultural narratives through which preferences for mobility are formed before first vehicle ownership.

## X. REFERENCES

Alford, S. E., & Ferriss, S. (2016). *An alternative history of bicycles and motorcycles: Two-wheeled transportation and material culture*. Lexington Books.

Amatucci, M. (2015). The world that chose the machine: An evolutionary view of the technological race in the history of the automobile. *International Journal of Automotive Technology and Management, 15*(1), 43–62.

Arthur, W. B. (1989). Competing technologies, increasing returns, and lock-in by historical events. *The Economic Journal, 99*(394), 116–131.

Arthur, W. B. (1994). *Increasing returns and path dependence in the economy*. University of Michigan Press.

Arthur, W. B. (2009). *The nature of technology: What it is and how it evolves*. Allen Lane.

Barth, M., Jugert, P., & Fritsche, I. (2016). Still underdetected—Social norms and collective efficacy predict the acceptance of electric vehicles in Germany. *Transportation Research Part F: Traffic Psychology and Behaviour, 37*, 64–75. https://doi.org/10.1016/j.trf.2015.11.011

Beauvais, S., & Robbins, W. R. (2019). *Commentary on women driving carriages, 1875–1914*. Advance. https://doi.org/10.31124/advance.11289362.v1

Belk, R. W. (1988). Possessions and the extended self. *Journal of Consumer Research, 15*(2), 139–168.

Black, E. (2006). *Internal combustion: How corporations and governments addicted the world to oil and derailed the alternatives*. St. Martin's Press.

Bladh, M. (2019). Origin of car enthusiasm and alternative paths in history. *Environmental Innovation and Societal Transitions, 32*, 153–168.

Bourdieu, P. (1984). *Distinction: A social critique of the judgement of taste* (R. Nice, Trans.). Harvard University Press. (Original work published 1979)

Burnham, J. C. (1961). The gasoline tax and the automobile revolution. *The Mississippi Valley Historical Review, 48*(3), 435–459.

Chakrabarty, D. (2008). *Provincializing Europe: Postcolonial thought and historical difference*. University of Chicago Press.

Chakraborty, S., & Gupta, S. (2025). Electric vehicles and the burden of historical narratives: Looking beyond economics. In S. Gupta & M. Chatterjee (Eds.), *Problems and prospects* *of Indian urbanisation: Employment, administration, environment and industry* (pp. 251–293). Centre for Urban Economic Studies, Department of Economics, University of Calcutta.

Clarsen, G. (2017). “Australia—Drive it like you stole it”: Automobility as a medium of communication in settler colonial Australia. *Mobilities, 12*(4), 520–533.

Clarke, D. (2007). *Driving women: Fiction and automobile culture in twentieth-century America*. Johns Hopkins University Press.

Cowan, R., & Hultén, S. (1996). Escaping lock-in: The case of the electric vehicle. *Technological Forecasting and Social Change, 53*(1), 61–79.

Csikszentmihalyi, M. (1993). *The evolving self: A psychology for the third millennium.* HarperCollins.

David, P. A. (1985). Clio and the economics of QWERTY. *The American Economic Review, 75*(2), 332–337.

David, P. A. (1997). Path dependence, its critics and the quest for historical economics. In P. Garrouste & S. Ioannides (Eds.), *Evolution and path dependence in economic ideas*. Edward Elgar.

Eisler, M. N. (2024). From petroleum to power sources: Big Oil and the technopolitics of energy conversion. *History and Technology, 40*(3), 250–275.

Eli, S., Hausman, J. K., Rhode, P., & Wieland, J. (2025). The Model T. *The Journal of Economic History, 85*(1), 110–151.

Flink, J. J. (1988). *The automobile age*. MIT Press.

Flinton, M. E. (2013). *Steam, electricity & gas: Historical perspectives on what we drive today and why* [Master’s thesis, University at Albany].

Foreman-Peck, J. (1996). ‘Technological lock-in’ and the power source for the motor car. University of Oxford.

Gartman, D. (2004). Three ages of the automobile: The cultural logics of the car. *Theory, Culture & Society, 21*(4–5), 169–195.

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. *Research Policy, 31*(8–9), 1257–1274.

Geels, F. W. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions, 1*(1), 24–40.

Giucci, G. (2012). *The cultural life of the automobile: Roads to modernity* (A. Mayagoitia & D. Nagao, Trans.). University of Texas Press. (Original work published 2004)

Gössling, S. (2017). *The psychology of the car*. Elsevier.

Griskevicius, V., Tybur, J. M., & Van den Bergh, B. (2010). Going green to be seen: Status, reputation, and conspicuous conservation. *Journal of Personality and Social Psychology, 98*(3), 392–404. https://doi.org/10.1037/a0017346

Hadjilambrinos, C. (2021). Reexamining the automobile’s past. *Bulletin of Science, Technology & Society, 41*(2–3), 58–71.

Hasenkopf, B. C., & Steiner, R. F., II. (2021). *Masculinity, car culture, and carbon emissions*. Gettysburg College.

Heitmann, J. A. (2009). *The automobile and American life*. McFarland & Co.

Helliwell, C., & Hindess, B. (2011). The past in the present. *Australian Journal of Politics & History, 57*(3), 377–388.

Heng, C. (2026). A re-evaluation of the myth of the European miracle and the construction of Western civilization. *Social Sciences in China, 47*(1), 21–40.

Ivory, C., & Genus, A. (2010). Symbolic consumption, signification and the lockout of electric cars, 1885–1914. *Business History, 52*(7), 1107–1122.

Kanger, L., & Schot, J. (2019). Technological diffusion as a process of societal embedding. *Transportation Research Part D: Transport and Environment, 71*, 114–133.

Kirsch, D. A. (1997). The electric car and the burden of history. *Business and Economic History, 26*(2), 304–310.

Kirsch, D. A. (2000). *The electric vehicle and the burden of history*. Rutgers University Press.

Loeb, A. P. (2004). Steam Versus Electric Versus Internal Combustion: Choosing Vehicle Technology at the Start of the Automotive Age. *Transportation Research Record, 1885*, 1–7.

McCarthy, T. (2007). *Auto mania*. Yale University Press.

Miller, D. (Ed.). (2001). *Car cultures*. Berg.

Mom, G. (2004). *The electric vehicle*. Johns Hopkins University Press.

Noppers, E. H., Keizer, K., Bolderdijk, J. W., & Steg, L. (2014). The adoption of sustainable innovations. *Global Environmental Change, 25*, 52–62.

Penna, C. C. R., & Geels, F. W. (2015). Climate change and the slow reorientation of the American car industry (1979–2011): An application and extension of the multi-level perspective. *Research Policy, 44*(5), 1029–1048.

Plananska, J., Wüstenhagen, R., & de Bellis, E. (2023). Perceived lack of masculinity as a barrier to adoption of electric cars? An empirical investigation of gender associations with low-carbon vehicles. *Travel Behaviour and Society, 32*, 100593.

Ram, S. (1987). A model of innovation resistance. *Advances in Consumer Research, 14*, 208–212.

Ram, S., & Sheth, J. N. (1989). Consumer resistance to innovations: The marketing challenge and the underlying behavior. *Journal of Consumer Marketing, 6*(2), 5–14.

Redshaw, S. (2008). *In the company of cars: Driving as a social and cultural practice*. Ashgate.

Redshaw, S., & Condie, J. (2025). Techno-capitalist colonialism powered by combustion masculinity in the transition to electric utility vehicles: an analysis of Australian car advertising. *Continuum, 39*(5), 774–789.

Santini, D. J. (2011). Electric vehicle waves of history. In S. Soylu (Ed.), *Electric vehicles—The benefits and barriers* (pp. 35–62). IntechOpen.

Scharff, V. (1992). *Taking the wheel: Women and the coming of the motor age*. Free Press.

Seely, B. E. (2002). Review of *The electric vehicle and the burden of history*. *Isis, 93*(1), 153–154.

Sheller, M. (2004). Automotive emotions: Feeling the car. *Theory, Culture & Society, 21*(4–5), 221–242. https://doi.org/10.1177/0263276404046068

Sheller, M., & Urry, J. (2016). Mobilizing the new mobilities paradigm. *Applied Mobilities, 1*(1), 10–25.

Sintov, N. D., Abou-Ghalioum, V., & White, L. V. (2020). The partisan politics of low-carbon transport. *Energy Research & Social Science, 68*, 101576.

Sovacool, B. K., Kester, J., Noel, L., & de Rubens, G. Z. (2019). Are electric vehicles masculinized? Gender, identity, and environmental values in Nordictransport practices and vehicle-to-grid (V2G) preferences. *Transportation Research Part D: Transport and Environment, 72*, 187–202.

Sperling, D., & Gordon, D. (2009). *Two billion cars: Driving toward sustainability*. Oxford University Press.

Taalbi, J. (2025). On the gendering of the early American electric car. *Environmental Innovation and Societal Transitions, 54*, 100934.

Taalbi, J., & Nielsen, H. (2021). The role of energy infrastructure in shaping early adoption of electric and gasoline cars. *Nature Energy, 6*(10), 970–976.

Tajfel, H., & Turner, J. C. (1979). An integrative theory of intergroup conflict. In W. G. Austin & S. Worchel (Eds.), *The social psychology of intergroup relations* (pp. 33–47). Brooks/Cole.

Tarr, J. A., & McShane, C. (2007). *The horse in the city: Living machines in the nineteenth century*. Johns Hopkins University Press. https://doi.org/10.1353/book.3324

The Times-Herald motocycle contest awards. (1896, February 27). *Engineering News and American Railway Journal, 35*(9), 139.

Tranter, K., & Marusek, S. (2023). Cars and hate. In A. Wagner & S. Marusek (Eds.), *Research handbook on legal semiotics* (pp. 376–393). Edward Elgar.

Urry, J. (2004). The system of automobility. *Theory, Culture & Society, 21*(4–5), 25–39.

Vasi, I. B., & Sauder, M. (2024). Beyond petroleum? The diffusion of alternative fuels in the United States, 1994–2015. *The Sociological Quarterly, 65*(4), 427–447.

Vergis, S., & Mehta, V. (2012). Technology innovation and policy: A case study of the California ZEV mandate. In B. van Wee, R. van den Brink, & C. Macharis (Eds.), *Paving the road to sustainable transport* (pp. 140–162). Routledge.

Wachs, M. (1987). Men, women, and wheels. *Transportation Research Record, 1135*, 10–16.

Wesseling, J. H., Farla, J. C. M., Sperling, D., & Hekkert, M. P. (2014). Car manufacturers' changing political strategies on the ZEV mandate. *Transportation Research Part D: Transport and Environment, 33*, 196–209.

Xue, Y., Zhang, X., Zhang, Y., & Luo, E. (2024). Understanding the barriers to consumer purchasing of electric vehicles. *Sustainability, 16*(6), Article 2420.

Yergin, D. (1991). *The prize: The epic quest for oil, money, and power*. Simon & Schuster.