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RESEARCH ARTICLE

New Technology and Primary Energy Consumption in the Transportation Sector: A Critical Discourse Analysis

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Abstract
Global economic growth is closely tied to energy consumption, with fossil fuels still dominating the global energy mix. The transportation sector, a major energy consumer, significantly impacts global primary energy demand and CO_2 emissions. This paper critically examines the Discourse surrounding technological innovations in transportation and their potential to reduce energy consumption. Using a critical Discourse analysis (CDA) framework, we explore the promotion of technologies such as intelligent automation, self-driving vehicles, and digitalization in transportation. The study highlights a techno-optimistic narrative that often overlooks broader structural challenges, unintended consequences, and the need for systemic changes, including policy innovation and behavior modification. Although technological advancements offer potential efficiency gains, their impact on energy consumption depends on implementation, governance, and socio-economic context. This paper argues for a holistic approach, combining technological innovation with non-technological strategies to achieve sustainability in the transportation sector. Through case studies such as high-speed rail, ride-sharing, and automated vehicles, it examines how policies, user behavior, and structural barriers influence energy use. Findings stress the importance of adaptive governance and inclusive public engagement to foster sustainable, equitable mobility transitions in the evolving transport landscape.

Keywords: Energy; Technology; Transportation; CDA

Introduction

The global economy's reliance on energy, with fossil fuels still providing 81.7% of total energy consumption(Raufi & Maniat, 2024), underscores the challenges of transitioning to sustainable energy sources. Over the last 28 years, the share of non-fossil energy sources has increased only modestly by 5.3%, signaling slow progress despite global environmental goals(Raufi & Maniat, 2024). The transportation sector is a critical component of global energy consumption, and its relationship with primary energy use and CO_2 emissions is a key issue in the global effort to achieve sustainability. While new technologies, including intelligent automation, self-driving vehicles, and digitalization, are often promoted as solutions to reduce energy consumption and environmental impact, their actual effectiveness is far more complex. Although studies have shown that the energy transition toward more sustainable practices is slow, new technologies in the transport sector are seen as a potential pathway for achieving efficiency gains. However, the narrative surrounding these technologies often reflects techno-optimism, which assumes that technology will naturally lead to positive environmental outcomes. This study, therefore, aims to critically analyze the Discourse surrounding new technologies in transportation and assess their real impact on primary energy consumption. The transportation sector is undergoing significant transformations driven by technological advancements, with the promise of reducing energy consumption and environmental impacts. However, the prevailing Discourse around these technologies, such as electric vehicles (EVs), autonomous vehicles, and smart transportation systems, often emphasizes their potential to enhance efficiency and sustainability without addressing the complex socio-economic, environmental, and energy-related challenges that come with their widespread implementation. Although technologies like EVs are presented as solutions to climate change and energy consumption(Desreveaux et al., 2023), the reality is that these solutions may only provide partial benefits, especially when the energy needed to power such innovations continues to rely on fossil fuels in many regions. Furthermore, there is a lack of critical engagement with the broader implications of these technological shifts. The focus on technological solutions (techno-optimism) frequently overlooks the systemic changes required to achieve genuine sustainability(Bánkuty-Balogh, 2021; Lennon, 2024). This narrative, driven by industries such as automotive and energy, often fails to incorporate necessary adjustments in social practices, behaviors, and energy systems. The paper explores how the dominant Discourse in the transportation sector overlooks the limitations of technology-driven approaches, analyzing how these Discourses shape, and are shaped by, broader societal power structures and environmental considerations. Through critical Discourse analysis, the paper seeks to uncover how narratives around technological innovations influence public perceptions, policy-making, and the broader transition towards the study aims to address the following questions:

How do dominant discourses surround technological innovations in transportation influence public perceptions of sustainability and energy consumption?

What implicit assumptions and limitations underlie techno-optimism in transportation planning and policy?

How do these technological narratives intersect with broader socio-political and economic structures, particularly in relation to environmental justice and equity?

What are the potential social and environmental consequences of over-reliance on technological solutions in transportation systems?

This study is significant for its critical analysis of the techno-centric narratives in transportation policy, the examination of their implications for energy consumption, and their broader social, economic, and environmental impacts. It fills a gap in the literature by questioning the efficacy of technological solutions and contributing to discussions on sustainable, equitable, and effective transportation systems.

Literature Review

This study critically explores the interplay between technological advancements and energy consumption in the transportation sector. By engaging with concepts such as technological solutionism, ecological modernization, and induced demand, it examines how innovations in transportation are framed as solutions to complex issues, highlighting both their potential benefits and inherent limitations.

Technological Solutionism

The ideology of technological solutionism assumes that technology can address complex social and environmental challenges, often viewing innovations as the ultimate path to progress. Rooted in techno-optimism, this perspective portrays technological advancements as inherently beneficial and capable of solving systemic issues. However, this approach tends to oversimplify multifaceted problems by framing them as purely technical, neglecting critical political, economic, and social dimensions. For instance, promoting electric vehicles (EVs) as a climate solution without addressing systemic car dependency and unsustainable consumption fails to resolve underlying environmental issues. while electric vehicles are presented as a solution to climate change, focusing solely on vehicle technology without addressing broader issues like unsustainable consumption patterns, car dependency, and the environmental impact of battery production will not result in meaningful long-term change(Taffel, 2018). Complementary strategies, such as improving public transit and fostering walkable urban spaces, are necessary for lasting change. This reductionist tendency within technological solutionism can inadvertently reinforce existing inequalities and unsustainable practices. For instance, promoting advanced technologies like autonomous vehicles or renewable energy systems without addressing their affordability or accessibility risks excluding vulnerable populations and perpetuating inequities. Thus, while technology can play a critical role in addressing global challenges, it must be integrated into broader strategies that prioritize systemic, inclusive, and sustainable transformations(Sætra, 2023).

Technological solutionism can foster a belief that humans have the power to control and shape their destiny through innovation and technological advancements. This can be particularly appealing in the face of complex societal issues that can often feel overwhelming and intractable. Consider solutions that address the root causes of problems, even if they do not involve cutting-edge technology. This might involve challenging dominant paradigms of economic growth and consumption, exploring alternative models of social organization, or promoting behavioral changes that reduce our reliance on technology(Marinelli, 2023). An example of technological solutionism can be seen in the global response to the COVID-19 pandemic(Maniat et al., 2024; Taylor, 2021). Governments and policymakers frequently turned to technological interventions, such as contact-tracing apps and surveillance systems, as rapid solutions for managing the crisis and containing the virus. While these technologies offered certain advantages, such as streamlining contact identification and enhancing data collection, they often overshadowed or undermined the importance of traditional public health measures like social distancing, mask-wearing, and community-driven efforts. This reliance on technology revealed the limitations of addressing a multifaceted public health emergency with predominantly technical fixes. It highlighted how neglecting broader social, behavioral, and structural factors can hinder comprehensive and sustainable responses(Taylor, 2021). Maniat et al. demonstrated a significant reduction in air pollution during COVID-19 lockdowns(Maniat et al., 2023; Maniat et al., 2024), highlighting the potential for reduced human activity to benefit the environment.

However, these findings also underscore the complexities and potential conflicts between sustainable development goals and the pursuit of technological progress (Maniat, Elmie, Feli, & Mansouri, 2023; Maniat, Hayati, Talifard, & Rustaie, 2023), While advancements in technology often promise solutions to environmental challenges, they can sometimes clash with broader sustainability objectives, particularly when underlying systemic issues are not addressed. This duality highlights the need for integrative approaches that balance technological innovation with sustainable practices.

Ecological Modernization

Ecological modernization emerged in the late 20th century as a response to growing concerns about the environmental impacts of industrialization and economic growth. This Discourse reflects a shift in thinking from an antagonistic view of the economy-environment relationship to one that sees potential for synergy between economic development and environmental protection(Berger, Flynn, Hines, & Johns, 2001). Ecological modernization refers to a perspective that suggests societies can reduce ecological impact through rationalization, industrialization, and changes in coordinative structures while maintaining economic growth (Andersen & Massa, 2000). Historically, environmental concerns have developed alongside three key trends: the rise of environmental awareness, exemplified by events like the Chernobyl disaster and the growing consensus on climate change; the limits of traditional "command-and-control" policies in addressing complex environmental challenges; and the emergence of sustainable development, as emphasized in the 1987 Brundtland Commission report. Earlier scientific concerns, such as those raised by Rachel Carson in *Silent Spring* (1962), set the stage for the modern environmental movement.(Rachel, 1962), set the stage for the modern environmental movement. Ecological modernization highlights technological innovation as a critical driver of sustainability, advocating for cleaner production, resource efficiency, and renewable energy. It also emphasizes market-based instruments, such as carbon taxes and emissions trading, to internalize environmental costs and incentivize sustainable practices. Collaboration among governments, industries, and civil society is central, promoting voluntary agreements and stakeholder dialogues (Mol, 1996). The discourse reflects a belief in human ingenuity and the adaptability of modern institutions to solve environmental issues, positioning ecological modernization as a necessary step in societal evolution(Berger et al., 2001; M. A. Hajer, 1995). Ecological modernization, despite its influence, has drawn criticism for its narrow focus on economic efficiency, technological fixes, and market-based approaches, which can overshadow broader social and ethical considerations(Morgan, 2018). Critics argue it often neglects environmental justice(Mol, 2000), equity, and the intrinsic value of nature(Spaargaren & Mol, 1992). By prioritizing corporate and affluent interests, it may reinforce existing power structures and marginalize vulnerable communities, limiting its capacity for transformative societal change. Additionally, its emphasis on incremental improvements risks addressing symptoms rather than systemic drivers of environmental degradation, such as consumerism and economic growth. Critics also caution against the risk of "greenwashing," where entities use ecological modernization language to mask unsustainable practices. The circular economy, a central EU policy concept, exemplifies ecological modernization's principles. It promotes resource efficiency, waste reduction, and closed-loop systems, aiming to decouple economic growth from resource use(Leipold, 2021). By emphasizing durable, reusable, and recyclable product designs, it challenges linear economic models. While aligned with ecological modernization's goals of innovation and collaboration, the circular economy faces criticism for perpetuating overconsumption and failing to address systemic inequalities. To enhance ecological modernization's utility, it must acknowledge the complexity of environmental problems, prioritize equity, challenge entrenched power structures, and embrace transformative changes. By moving beyond incremental fixes and tackling unsustainable consumption and growth, ecological modernization can better support sustainability and justice(Mol, 2000, 2002, 2003; Spaargaren & Mol, 1992). Such critical engagement allows its strengths to be harnessed while addressing its shortcomings. Ecological modernization in transportation emphasizes integrating cleaner technologies, such as electric vehicles (EVs), cleaner fuels, and intelligent transport systems, to reduce environmental impacts while promoting economic growth(Kanyepe & Chibaro, 2024). Proponents highlight technological innovation and efficiency as pathways to sustainability, aiming to minimize congestion and reliance on private cars without significantly altering existing mobility patterns(Vergragt & Brown, 2007). Critics, however, contend that this approach oversimplifies transportation challenges by focusing on technical fixes while neglecting systemic issues such as the environmental costs of vehicle production, resource overconsumption, and the persistence of high trip volumes(Buchmann, Robison, & Foulds, 2017; Morgan, 2018; Robèrt, 2000). They emphasize that relying on technology alone risks perpetuating unsustainable practices and reinforcing inequalities, as these solutions often benefit affluent groups over marginalized communities(Thakuriah & Geers, 2013). Critics advocate for a paradigm shift to address deeper sustainability barriers, including reducing car dependency and rethinking consumption-driven economic models. While ecological modernization offers a hopeful vision for aligning growth and sustainability, achieving meaningful change requires addressing social equity and systemic issues alongside technological advancements. Broader strategies should challenge unsustainable mobility patterns, prioritize transformative urban planning, and promote equitable access to sustainable transport options. This integrated approach could lead to transportation systems that are both environmentally responsible and socially inclusive.

Induced Demand

Induced demand is the phenomenon whereby increasing the capacity of transportation infrastructure such as adding more lanes to highways or building new roads, leads to an increase in traffic over time, thereby negating the initial improvements in congestion and travel time (Lee Jr, Klein, & Camus, 1999). This concept challenges the traditional paradigm in transportation planning, which assumes that expanding infrastructure will reduce congestion and improve efficiency(Næss, Nicolaisen, & Strand, 2012). Acknowledge that more lanes means more capacity (Manual, 2000; Noland, 2001; Roess & Prassas, 2014)more traffic(Leutzbach, 1988; Maerivoet & De Moor, 2005; Mathew, Dhamaniya, Arkatkar, & Joshi, 2017). Induced demand demonstrates that expanding road capacity without addressing underlying factors, such as the dependence on private cars or urban sprawl, is unlikely to provide lasting solutions to congestion or environmental problems (Cervero & Hansen, 2002). In fact, induced demand can exacerbate environmental impacts, as it encourages more car usage and increased energy consumption, undermining the environmental goals of transportation planning (Raufi & Maniat, 2024). Empirical evidence, indicate that expanding road infrastructure often generates additional traffic, particularly over the long term, with elasticity estimates of -0.5 in the short term and up to -1.0 in the long term. This results in a 10% increase in base traffic shortly after improvements and up to 20% over time. The effect is especially pronounced during peak periods and on alternate routes originally intended for congestion relief(Goodwin, 1996). Technological solutions like autonomous vehicles and electric cars, while promising in reducing emissions and improving efficiency, may unintentionally exacerbate induced demand if they sustain or intensify car dependency. These advancements can increase accessibility and convenience, encouraging more travel rather than addressing the systemic issues of unsustainable mobility practices(Lee Jr et al., 1999; Speck & Speck, 2018).

Transportation Sector and Energy Consumption

The transportation sector is a major global consumer of primary energy, contributing substantially to greenhouse gas emissions and energy demand. It accounts for approximately 33–39% of global energy consumption(EIA, 2016). Understanding energy use patterns in this sector is crucial for assessing the effectiveness of technological innovations aimed at reducing emissions. Road transport dominates energy consumption, accounting for over 61% of the sector's energy use in 2012 as illustrated in Figure 1, primarily due to the widespread reliance on internal combustion engine vehicles (ICEVs) powered by gasoline and diesel(EIA, 2016).

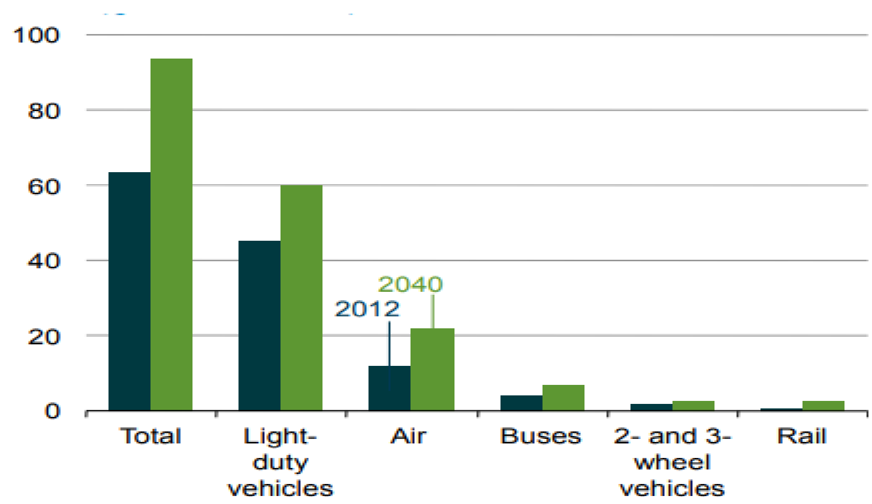

Figure 1.World transportation energy consumption 2012 and 2040 (quadrillion Btu)(EIA, 2016)

Electric vehicles (EVs) are often highlighted as a promising solution for reducing energy use and emissions. However, their environmental benefits depend heavily on the electricity generation mix. In regions powered by fossil fuels, EVs provide limited emission reductions compared to regions utilizing renewable energy. Furthermore, induced demand, where increased EV availability encourages more car use, can paradoxically raise overall energy demand. The critique of greenwashing highlights the risk of misrepresenting technologies like EVs and intelligent transport systems (ITS) as unequivocally sustainable. This can obscure systemic issues such as overconsumption, urban sprawl, and unequal access to green technologies. While promoting its EVs as zero-emission vehicles, critiques reveal environmental harms linked to lithium-ion battery production, such as ecological damage and water scarcity in mining regions like the Atacama Desert. Tesla's portrayal as a "green" company aligns with technological solutionism, masking the environmental and social costs of EV production while oversimplifying climate solutions. Moreover, reliance on fossil fuel-based electricity for charging diminishes the actual emission reductions of Tesla's vehicles(Hickman & Hannigan, 2023). According to data from the Trancik Lab at the Massachusetts Institute of Technology (MIT), the lifecycle emissions of electric vehicles (EVs) challenge the perception that they are inherently "zero-emission" vehicles. The lab underscores the importance of evaluating lifecycle emissions, which include all emissions generated during various stages of production. For instance, the manufacturing of EVs, particularly their batteries, can produce substantial emissions due to the energy-intensive processes involved in mining and manufacturing(Miotti, Supran, Kim, & Trancik, 2016).

Methodology

Discourse analysis is fundamentally interdisciplinary, and it is better described as a "methodology" rather than merely a "method"(Fairclough, 2013). In this study, Critical Discourse Analysis (CDA) is employed to examine the dominant narratives surrounding new technologies in the transportation sector. CDA is instrumental in revealing how these technologies are framed within the broader context of economic growth and environmental sustainability. Technological innovations such as intelligent transportation systems (ITS), autonomous vehicles, and the digitalization of transportation infrastructure are analyzed to understand their discursive framing as solutions to the challenges of energy consumption and CO_2 emissions. Discourse encompasses not just individual words or sentences but also broader communication patterns that shape our perceptions and interpretations of the world. Michel Foucault conceptualizes Discourse as a "way of speaking" embedded within the broader societal structure (Foucault, 2013; Hickman & Hannigan, 2023). Similarly, scholars such as Hajer and Versteeg define Discourse as an ensemble of ideas and practices that give meaning to social and physical phenomena(M. Hajer & Versteeg, 2005). Dryzek also emphasizes that Discourse frames how we understand and engage with these phenomena(Dryzek, 2022). The methodology follows a variant of Bhaskar's 'explanatory critique'(Chouliaraki & Fairclough, 2021; Fairclough, 2013), Fairclough's framework is organized into four stages (Fairclough, 1992), beginning with examining a social issue from its symbolic or communicative dimensions. The next step involves identifying the barriers that hinder resolving the identified social issue. Subsequently, the framework evaluates whether the existing societal structure depends on the persistence of this issue. Finally, it explores potential strategies to address and overcome these barriers(Fairclough, 1992). Fairclough's three-dimensional model is a foundational framework within Critical Discourse Analysis (CDA) and is illustrated in Figure 2. It links the linguistic features of texts to broader social and cultural contexts, enabling researchers to investigate how language both reflects and shapes power dynamics and ideologies(Fairclough, 1992).

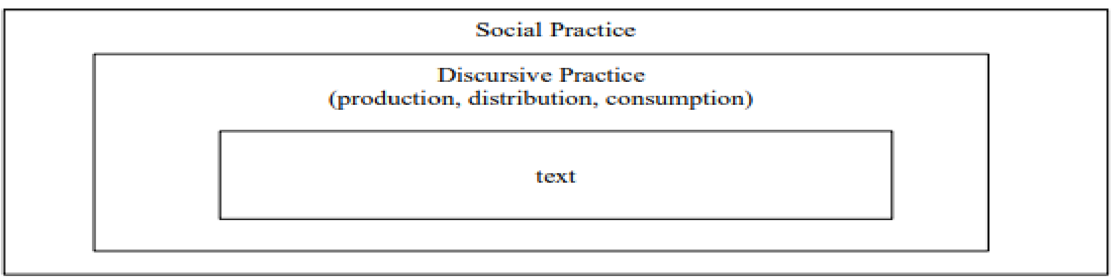

Figure 2. Three-dimensional Model (Fairclough, 1992)

The model consists of three interrelated dimensions:

A. Textual Analysis (Description)

This dimension focuses on analyzing the linguistic features of a text, examining both what is said (or written) and how it is conveyed. It seeks to answer questions such as: What specific words are chosen? Are there recurring patterns, connotations, or metaphors? For example, in a policy document on new technologies in transportation, phrases like "green future" or "sustainable growth" may reveal underlying values or priorities, potentially indicating an implicit alignment with ecological modernization ideals.

B. Discursive Practice (Interpretation)

This dimension explores the processes surrounding the production, distribution, and consumption of the text. It examines how meaning is shaped through these practices. It seeks to answer questions such as: Who created the text, and what were their goals or intentions? Through what channels is the text disseminated (e.g., media, policy briefs)? For example, A transport company might present marketing materials framing new technology as a solution to climate change. Here, the analysis would consider how the materials are distributed (e.g., advertisements, social media campaigns) and how various stakeholders—such as consumers and policymakers—respond to or reinterpret these messages.

C. Social Practice (Explanation)

The third-dimension places the text within its wider socio-political and cultural framework, examining how Discourse both influences and is influenced by societal structures, power dynamics, and ideologies. It addresses questions such as: What societal factors shape the Discourse? What are the social impacts of the Discourse?

Does it reinforce existing inequalities, or does it promote change and challenge the status quo? For instance, framing autonomous vehicles as the future of sustainable transport might reflect broader societal narratives like techno-optimism or a focus on economic growth over comprehensive reforms in energy consumption. By analyzing the Discourse in its context, this approach reveals the underlying assumptions and power relations that inform it. Using Fairclough's model, this study systematically analyzes the textual, discursive, and social dimensions of dominant narratives in the transportation sector. It delves into linguistic choices to uncover how new technologies are framed as solutions to environmental challenges. The research also explores how these narratives are crafted, disseminated, and interpreted by various stakeholders. Furthermore, it situates these narratives within broader socio-economic and cultural contexts, examining their implications for sustainability and equity. This holistic approach enables a critical evaluation of how Discourses surrounding new technologies both influence and are influenced by societal structures, shedding light on their potential and limitations in addressing complex issues like energy consumption and environmental sustainability.

Analysis methodology and data

This section examines the discourse surrounding transportation technologies, particularly the pervasive narrative of techno-optimism and its implications for energy consumption and sustainability. By analyzing the language used to frame these technologies, the study seeks to uncover the underlying power dynamics and ideological assumptions that shape policy decisions and public perceptions.

Table 1. Database and search tool analysis for CDA

Database/Search Tool	Boolean Phrases, Keywords, and Journals	Organizational Authors Identified
ScienceDirect	"energy consumption AND transportation sector" OR "new technology emissions reduction"	International Energy Agency (IEA), IPCC
Web of Science	"Primary energy use in transportation" AND "technological innovations emissions"	MIT Energy Initiative, WRI, ICCT
SpringerLink	"sustainable transport technology" AND "energy transition"	European Commission, UNEP, Fraunhofer Institute
PubMed	"impact of emissions reduction technologies" AND "health benefits of reduced transportation emissions"	EPA, WHO
JSTOR	"socioeconomic impacts of energy transition" AND "transport sector emissions trends"	Harvard Energy Initiative, RAND Corporation
IEEE Xplore	"electric vehicles" AND "renewable energy integration transportation"	IEEE Smart Grid Initiative, SAE International
ResearchGate	"decarbonizing road transport" AND "technological adoption barriers"	European Academies of Science Advisory Council

The investigation focuses on three interconnected dimensions: discursive strategies, knowledge production, and power dynamics. Discursive strategies involve analyzing the rhetorical devices and persuasive techniques used to present technological solutions as universal remedies. Knowledge production explores the role of expert knowledge, scientific research, and industry interests in shaping the discourse. Power dynamics identify the stakeholders who benefit from techno-optimistic narratives and examine how these narratives reinforce existing power structures. The analysis began by refining data sources to ensure alignment with the study's objectives, concentrating on materials directly addressing the research questions. To conduct the analysis, we employed keywords and Boolean search phrases tailored to the research focus, as detailed in Table 1.

We primarily employed top-down critical Discourse analytical procedures, emphasizing "issues of power and ideology" to interpret the narrative. These methods aim to reveal underlying assumptions, biases, and power dynamics embedded in Discourse. The goal is to understand how dominant perspectives shape societal and institutional norms. This analytical lens is particularly relevant for examining narratives in areas such as environmental policy, technological adoption, and sustainable development, offering insights into the influence of specific ideologies on decision-making and public perceptions.

Analysis and Discussion on Techno-Optimism

Technological Solutionism, is rooted in the belief that advancements in technology can resolve most transportation-related challenges (Shah et al., 2021). It emphasizes concepts like smart cities, autonomous vehicles, electric cars, and advanced infrastructure, positioning them as crucial for modernizing transportation systems and achieving sustainability (Nederveen, Konings, & Stoop, 2003; Vergragt & Brown, 2007). However, this narrative often assumes that technological progress inherently leads to efficiency and solutions, while neglecting the complexities of social, economic, and environmental factors. Although technology can contribute to addressing some long-term issues, it cannot be regarded as a universal remedy for immediate concerns. For example, while electric vehicles can reduce on-road emissions, they still require significant amounts of electricity, much of which is currently derived from fossil fuels, particularly in developed nations. Without a concurrent transition to renewable energy sources like solar or wind, the environmental benefits of such technologies remain limited. Moreover, the growing demand for electricity to support these innovations may, in some instances, exacerbate fossil fuel consumption. This trend is evident in countries with high energy demands, where the reliance on fossil fuels to meet increased electricity needs undermines the sustainability of these high-tech solutions(Raufi & Maniat, 2024). Following the adoption of the 1997 Kyoto Protocol under the United Nations Framework Convention on Climate Change (UNFCCC), global attention gradually shifted toward addressing environmental issues(Iwata & Okada, 2014), including the reduction of greenhouse gas emissions(Grubb, 2004). This shift has led to a rethinking of the transportation sector, moving away from the traditional emphasis on infrastructure expansion and toward prioritizing accessibility and sustainability. Historically, addressing transportation challenges like traffic congestion often meant building more roads and bridges, reflecting a paradigm that equated efficiency with reduced travel time. This perspective is deeply embedded in traditional transportation planning and project evaluation methods, such as those outlined in academic text books like "Transportation Decision Making: Principles of Project Evaluation and Programming"(Sinha & Labi, 2011). These methods often prioritize time savings as a key measure of success, viewing travel time as a "disutility" to be minimized. While such an approach can enhance operational efficiency, it frequently neglects broader societal and environmental considerations, such as the long-term impacts on quality of life or ecological degradation. Traditional environmental assessments in this framework often quantify benefits in economic terms, such as by assigning monetary values to reductions in traffic congestion. Consulting firms, which frequently conduct these evaluations, focus on metrics like pollution levels or decreased car usage and translate these into cost savings. This economic framing underscores the dominance of efficiency-oriented priorities, even in contexts ostensibly aimed at sustainability. Moreover, this approach aligns with the conventional view that substantial investments in transport infrastructure stimulate economic activity. Increased aggregate demand resulting from such investments drives aggregate supply and ultimately boosts economic output. However, this narrow focus on time savings and economic benefits can obscure critical trade-offs, such as the environmental and social costs of prioritizing car traffic over more sustainable modes of transport. Consequently, while infrastructure projects may succeed in reducing travel time, their broader implications for environmental sustainability and quality of life are often overlooked in traditional planning paradigms. A prominent example of the traditional transportation paradigm is the construction of major highways, such as the Interstate Highway System (IHS) in the United States or large-scale urban expressways worldwide. These projects were typically motivated by the need to reduce traffic congestion and travel time, operating on the assumption that expanding road capacity would resolve transportation challenges and improve efficiency(Goetz, 2023). For instance, the construction of a multi-lane highway connecting suburban areas to a city center would often focus on measurable metrics like travel time savings, economic benefits, and infrastructure investments. Initially, such projects seemed to deliver on their promises. In the short term, traffic congestion reduced as the added lanes improved travel times and accessibility. These outcomes were viewed as evidence of success, driving further support for similar infrastructure investments. However, long-term challenges often emerged due to induced demand—the phenomenon where increased road capacity leads to more driving, gradually reversing the initial benefits. In the case of the IHS, congestion returned as more drivers utilized the improved roads(Hickman & Hannigan, 2023). Moreover, the emphasis on car-centric infrastructure spurred urban sprawl, environmental degradation, and car dependency. The IHS, developed in a post-war era of suburban growth and rising car ownership, reflected the belief that highways and cars were the future of transportation. This vision, bolstered by lobbying from the automobile, trucking, and petroleum industries, gained widespread political and public support(Gutfreund, 2004; Mohl, 2008; Ross, 2006). Despite its contributions to economic growth, the IHS underscores the limitations of focusing solely on infrastructure expansion, highlighting the need for a paradigm shift toward sustainable and equitable transportation systems. The traditional assumption that faster travel automatically enhances quality of life is increasingly being challenged. Many people value increased accessibility over mere time savings, recognizing that different modes of transport offer unique experiences. This shift in perspective aligns with the growing emphasis on sustainable and inclusive transportation systems. This transition is also closely linked to technological advancements, which are often positioned as solutions to persistent challenges like traffic congestion and environmental degradation. Innovations such as intelligent transportation systems (ITS), autonomous vehicles, and digitalized transport infrastructure are frequently highlighted as critical tools for reducing the transportation sector's environmental footprint while enhancing efficiency and accessibility. Early discussions around these technologies have tended to frame them with techno-optimism, emphasizing potential efficiency gains and societal improvements. The language often implies that these innovations are inherently beneficial and will inevitably lead to a better future. This techno-optimistic perspective aligns with the principles of ecological modernization, a Discourse that suggests technological advancements can address environmental issues without necessitating fundamental changes to societal behaviors or structures. While such narratives underscore the potential of technology to mitigate environmental challenges, they often downplay the complexities of implementation and the broader systemic changes required for achieving genuine sustainability. Most journeys take place in cities, with 50% to 70% of them occurring via vehicles(Alessandrini, Campagna, Delle Site, Filippi, & Persia, 2015; Cervero, Guerra, & Al, 2017). while vehicles have seen significant technological advancements since their invention, the average speed of journeys in cities has not improved correspondingly. In many cases, speeds have stagnated or even declined due to factors like increased traffic congestion and urban sprawl. For instance, in London, average speeds in the city center dropped from 8.7 mph (14 km/h) in 2008 to 7.1 mph (11.4 km/h) in 2018(Mayor, 2019). Despite vehicle innovations, traffic conditions and rising urban populations have limited efficiency gains. Similarly, other major cities worldwide face comparable trends, where dense traffic and limited infrastructure for alternative transport modes contribute to stagnant or declining speeds.

Discourse on High-Speed Rail (HSR)

The Discourse on High-Speed Rail (HSR) in Canada examines its potential as a sustainable alternative to air and automobile travel, reflecting global trends emphasizing environmental, economic, and social benefits. Advocates, or "enviro-optimists," highlight HSR's ability to reduce greenhouse gas emissions. However, skepticism persists, particularly from "federal skeptics," regarding HSR's competitiveness with entrenched air and automobile travel modes and its high costs. A significant concern involves induced demand, where improved infrastructure might increase overall travel rather than reducing emissions. Critics warn that technological solutions, such as HSR, might overlook systemic changes like urban planning and equitable transportation development. Contextual factors, such as population density and electricity grid carbon intensity, critically influence HSR’s sustainability. The sources advocate for a balanced approach, emphasizing the need for comprehensive, context-specific evaluations of HSR’s potential benefits and risks. Recognizing diverse perspectives, including environmental and equity concerns, is vital to informed policymaking(Hickman & Hannigan, 2023). Spain boasts the longest high-speed rail network in Europe, over 3,200 km, and second only to China globally. Its trains, exceeding speeds of 220 km/h, offer a fast and economical alternative to air travel between cities. However, critics argue that passenger demand has not justified its extensive scale. Concerns persist that significant public and EU funds have been invested in a system underutilized relative to its cost, raising questions about its economic efficiency and sustainability. Analysis critiques Spain's high-speed rail (HSR) system, highlighting its dual role as an ambitious infrastructure project and a contentious economic model. Despite being publicly funded, HSR embodies the "market order," aiming to convert infrastructure into revenue streams, rooted in a shift since the 1980s towards commercial railways. While advocates emphasize environmental benefits and territorial cohesion, critics argue it exacerbates regional inequalities, prioritizes urban hubs, and perpetuates myths about its economic benefits. Debates reveal the ideological work required to justify such large-scale infrastructure under a profit-driven framework(Buier, 2020). Spanish high-speed rail (AVE) and broader HSR discussions, emphasizing the risks of dominance without genuine consensus and greenwashing. In Spain, AVE’s expansion reflects "dominance without hegemony,"(Buier, 2022) prioritizing state-led developmentalism despite resistance, such as the Basque anti-TAV movement, and environmental criticisms. Globally, HSR claims of sustainability face skepticism over emissions reductions, induced demand, and systemic challenges, underscoring the need for integrated urban planning. Sweden's stalled HSR progress highlights contrasting narratives: the deflationary coalition favors fiscal restraint, while the Weberian coalition supports modernization via state-led infrastructure. These debates reveal struggles between financial conservatism and transformative climate strategies(Haikola & Anshelm, 2022).

Discourse Ride-Sharing

The sustainability narratives of ride-sharing platforms like Lime, Rent the Runway (RTR), and BlaBlaCar reveal a complex interplay of claims and contradictions. These platforms often market themselves as disruptors of unsustainable practices, offering alternatives to private cars, fast fashion, or inefficient travel. However, they frequently displace greener options, such as walking, cycling, or community-driven solutions. For instance, RTR’s rental model may inadvertently encourage overconsumption, while Lime’s micromobility options can replace public transport or active modes like walking, potentially increasing emissions. A central theme in these platforms' messaging is the "guilt-free" choice, which suggests consumers can enjoy convenience without negative environmental consequences. This Discourse, however, often obscures the material costs of their operations, including production, logistics, energy use, and lifecycle impacts. Lime's e-scooters, for example, require significant resources for manufacturing, maintenance, and charging, while RTR's shipping and cleaning processes generate waste. Similarly, BlaBlaCar's promotion of carpooling still depends on private car infrastructure, which carries inherent environmental costs. Adding to this critique is the use of non-commercial narratives that emphasize values like community-building, empowerment, and social responsibility. Lime positions itself as a partner in sustainable urban planning, RTR champions female empowerment through fashion accessibility, and BlaBlaCar fosters connections between users. Yet, these narratives often mask growth-driven practices that encourage overuse and expand ecological footprints(Beverland, Cankurtaran, & Loussaïef, 2022). A study examining San Francisco's traffic trends from 2010 to 2016 found that ride-hailing Empirical studies further challenge ride-sharing's sustainability claims. Research on San Francisco from 2010 to 2016, for example, found that Uber and Lyft significantly increased traffic congestion. Weekday vehicle delays rose by 62%, with transportation network companies (TNCs) accounting for at least half of this growth. This coincided with a decline in public transit use, undermining claims that ride-hailing reduces congestion. The findings highlight the need for a critical examination of ride-sharing's impacts and the integration of TNCs into urban transport systems. Policymakers must address lifecycle costs, promote multimodal solutions, and balance the platforms' convenience with their environmental consequences to ensure genuinely sustainable urban mobility and consumption practices(Erhardt et al., 2019).

Discourse Automated Vehicles (AVs)

Discourse surrounding Automated Vehicles (AVs) often reflects a tension between techno-optimism and critical societal implications. It includes narratives about potential benefits—such as enhanced safety, efficiency, and mobility—and concerns over challenges like cybersecurity, privacy, induced demand, and job displacement. Critical analyses explore how AVs are framed in public and policy discussions, revealing tendencies toward deterministic and overly optimistic visions. These Discourses shape governance, regulatory approaches, and societal acceptance, emphasizing the need for inclusive, reflective, and adaptive policies to address broader sociotechnical, cultural, and environmental impacts of AV implementation. A study examines Finland's governance approach to self-driving vehicles (SDVs) using critical Discourse analysis of government documents (2013–2020) and the concept of sociotechnical imaginaries. The analysis reveals four imagined SDV implementation paths, emphasizing optimistic and deterministic narratives that align with the automobility regime. The Discourse shows a disconnect between envisioned applications and expected outcomes, lacking critical reflection. The findings suggest that governance processes risk entrenching car-dependence and neglecting adaptive strategies, underscoring the need for more democratic and context-sensitive policy approaches to manage the societal implications of SDVs(Olin & Mladenović, 2022).a study critiques the dominant focus on consumer acceptance in research on autonomous vehicles (AVs), highlighting a gap in understanding broader societal attitudes. Using a social constructionist lens, it analyzes over 389,000 Reddit posts (2016–2021) from communities discussing AVs. Four thematic dimensions—Social, Economic, Ethical, and Legal—emerged, revealing diverse public perspectives beyond user benefits. This approach offers insights into public Discourse, emphasizing the need for socially responsible innovation and democratic governance. It contributes to bridging technical and societal dimensions of AV acceptance and informs future research on its complex social implications(Waltermann & Henkel, 2023). Predominantly pro-automation Discourse that emphasizes safety and efficiency benefits while downplaying concerns like increased vehicle miles traveled

(VMT) and induced demand. The implications for primary energy consumption in the transport sector are nuanced, involving several key factors. Rebound effects occur when improvements in efficiency lead to increased usage, thereby offsetting energy savings. Induced demand arises as new infrastructure attracts more users, further increasing consumption. The mode shift toward sustainable transport depends heavily on the successful replacement of energy-intensive modes. Additionally, the policy context plays a critical role, with regulatory measures proving crucial in shaping outcomes. To achieve genuine energy reductions and sustainability, holistic policies that address system-wide impacts are essential.

Conclusions

The Discourse on emerging transport technologies, such as Automated Vehicles (AVs), predominantly leans toward techno-optimism, focusing on their potential to improve safety, efficiency, and sustainability. However, this optimism often overlooks critical risks, including equity challenges, job displacement, and increased travel demand. This study highlights the necessity of critically evaluating these narratives, as the mere introduction of technology does not guarantee reduced energy consumption or sustainable outcomes. Achieving genuine sustainability requires holistic assessments that account for system-wide effects, behavioral shifts, and the implementation of supportive policies. Governance of these technologies must adopt adaptive and inclusive approaches to address systemic issues such as urban planning, infrastructure development, and consumption patterns. Public engagement is equally crucial to ensure diverse perspectives are integrated into policymaking processes. The analysis reveals that dominant narratives around new technologies, including electric vehicles, autonomous vehicles, and intelligent transport systems, often emphasize efficiency gains and emission reductions, portraying them as key solutions to environmental challenges. However, this narrative risk over-relying on technological solutions without addressing systemic factors, such as induced demand. For instance, increased road capacity can lead to more traffic, potentially negating efficiency gains. Addressing challenges like car dependency and urban sprawl is essential to achieving the desired environmental outcomes. A shift in focus from efficiency to accessibility is critical for fostering truly sustainable transportation. Traditional transportation planning, which prioritizes time savings and economic benefits, often neglects broader societal and environmental concerns. Prioritizing accessibility and promoting diverse mobility options, such as public transportation, cycling infrastructure, and pedestrian-friendly urban design, can better align transportation systems with sustainability goals. Additionally, critically examining the prevailing techno-optimistic narratives surrounding new transportation technologies is vital. This includes addressing their limitations, recognizing potential unintended consequences, and ensuring ethical considerations like equity and job displacement are central to the discourse. To foster sustainable mobility transitions, an integrated approach to transportation planning is essential. This involves balancing technological innovation with robust policy interventions and encouraging behavioral changes. Policies that reduce car dependency, incentivize public transportation, and promote walkable, bikeable communities are key. Moving beyond simplistic solutions to embrace a complex and interconnected web of strategies is necessary for long-term societal and environmental well-being. Such a paradigm shift challenges traditional assumptions, promotes critical thinking, and places sustainability and equity at the core of transportation planning.

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