“The Gasoline of the Future:” Electric Vehicles, Points of Continuity, and Making Green Capitalism

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Table of Contents

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Roshan Krishnan

Abstract

Electric vehicles (EVs) are key to U.S. plans to transition to a green economy that is powered by renewable energy rather than fossil fuels. There has been extensive research documenting the adverse socio-ecological impacts of resource extraction for EVs, including water shortages driven by lithium mining on Indigenous lands in South America and child labor in cobalt mining in the Democratic Republic of the Congo. However, little research has attended to the ways that automakers and utility companies shape the adoption of EVs through the use of corporate narratives and strategies. In this thesis, I introduce the concept of *points of continuity*, whereby specific aspects of the gasoline vehicle user experience are mimicked by the EV industry to increase adoption of EVs. This desire to adopt behavioral similarities between gasoline and electric vehicles allows for existing patterns of automobile production and consumption to be maintained. However, in order to establish points of continuity, EV industry actors must navigate material constraints imposed by the physical properties of electric power. Through this case study, I demonstrate that the production of points of continuity is a method through which the environmental violence of green capitalism is maintained.

1. Introduction

On March 31st, 2021, United States President Joseph R. Biden released the American Jobs Plan, a bill proposing massive infrastructure investment widely viewed as a cornerstone project of his administration. Particularly notable among the wide swath of planned investments is the plan's emphasis on electric vehicles (EVs). The American Jobs Plan allocates $174 billion—more than is allocated for public transportation and passenger rail combined—for point-of-sale and tax rebates for EV purchases, as well as buildout of a national network of 500,000 EV chargers by 2030 (White House 2021).

Because of these and other clean energy investments, the American Jobs Plan is already being referred to by advocacy groups as one step toward a "green economy"—that is, an economy predicated on renewable energies rather than fossil fuels (Loiseau et al. 2016, Georgeson et al. 2017). In the United States, the emergence of EVs as a means of decarbonizing transportation is a key component of the green economy. However, green economy narratives often obscure inequalities and exploitation in "green" industries, contributing to a Western-centric green capitalism that maintains and is dependent on these inequalities. Although automakers and electric utilities have begun to invest substantially in EVs, the strategies they employ may reinforce existing sociopolitical relations around car production and consumption, obscuring patterns of exploitation and ecological damage along the complex supply chains that EVs depend on. These harms can be conceptualized as environmental violence: ecological degradation and the human exploitation that often accompanies it (Lee 2016).

The materialities of energy—in other words, the physical and social properties of particular forms of energy—are influential in shaping the sociopolitical relations that lead to environmental violence. For example, scholars have drawn attention to the ways that material properties of oil, such as its depth in the earth and its viscosity, have shaped the way oil companies create infrastructure, interact with labor and regulatory regimes, and respond to criticism (Bridge 2010, Mitchell 2011, Rogers 2012). By studying oil's materialities, scholars have articulated political ecologies of oil and extractive infrastructure, contributing to a better understanding of the social formations constructed by different energy regimes (Adunbi 2020, Valdivia 2015). As transportation electrification continues to gain traction in the global energy landscape, studying electricity's materialities can help uncover the ways that these materialities shape the political and social landscape around EVs. This can contribute to an understanding of what Cederlöf (2019, pp. 79) calls "energopower:" the ways that "particular configurations of energy and political power shape the conditions of social, political, and economic possibility."

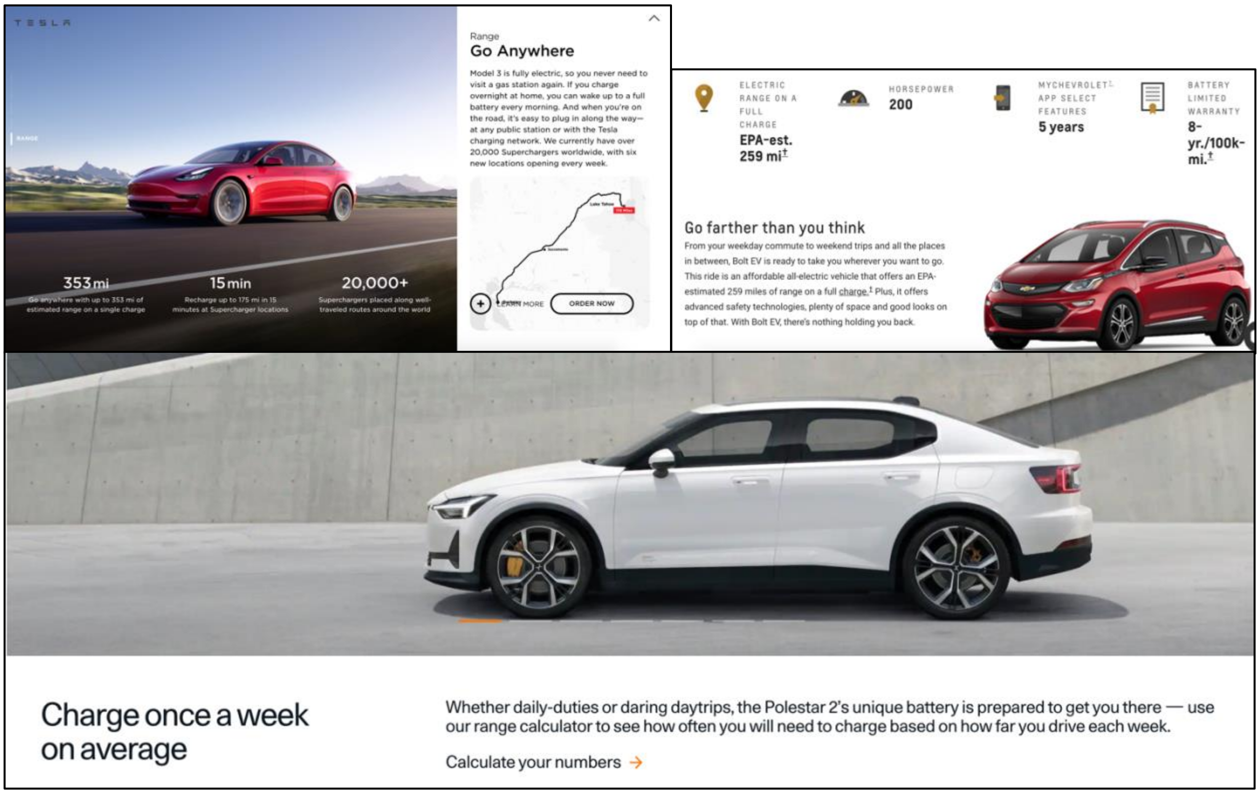
In this paper, I will show how materialities of electricity affect the ways that automakers and utilities attempt to produce the notion of a "clean" green capitalism that maintains an emphasis on existing modes of consumption. I introduce the concept of *points of continuity*: specific aspects of the gasoline vehicle user experience that the EV industry seeks to replicate in EVs in order to increase adoption. As automakers and utilities create points of continuity between gasoline and electric vehicles which allow them to maintain existing patterns of automobile production and consumption, they must navigate materialities of electricity that affect how these points can be established. Through this case study, I will demonstrate that constructing points of continuity is a method by which the environmental violence of green capitalism is maintained.

My findings are based on a review of the literature as well as semi-structured interviews with key informants working in EV infrastructure development for utilities, automakers, and consulting firms. I begin by tracing the EV supply chain and situating the EV industry within the green economy. Next, I provide an overview of existing conceptions of materialities of electricity. Finally, through data from my interviews, I explore the ways that automakers and electric utilities create points of continuity as they shape the EV industry, how materialities of electricity affect the ways in which this occurs, and how this affects sites of environmental violence. I conclude by discussing the implications of these findings and suggesting alternative pathways for transportation decarbonization that foreground global environmental justice.

2. The Electric Vehicle Supply Chain

Electric vehicles are manufactured relatively similarly to their fossil fuel-powered internal combustion engine (ICE) counterparts. Components are purchased through a global supply chain of vendors and sources. These components are then assembled at an automaker's plant. Major automakers typically have assembly facilities in various countries that produce different models available in their respective markets; each of these plants may source components and materials from vendors across the world.

The primary point of divergence between the manufacturing processes of EVs and ICE vehicles is the battery used to power EVs. Batteries are a key determinant of a vehicle's range, cost, and longevity: in particular, range is a key selling point for consumers, as demonstrated by its prominence in EV advertising (Fig. 1). Like internal combustion engines, the electric motors that power the wheels of an EV are typically manufactured in-house by automakers (Adams 2018). However, the batteries that power the motors are reliant on their own sophisticated supply chain and manufacturing process. This is in large part due to the raw materials required to manufacture batteries: metals such as lithium, cobalt, and nickel that must be mined from the earth.



Go anywhere with up to 353 mi of estimated range on a single charge

Recharge up to 175 mi in 15 minutes at Supercharger locations

Superchargers placed along well-traveled routes around the world

Range

Go Anywhere

Model 3 is fully electric, so you never need to visit a gas station again. If you charge overnight at home, you can wake up to a full battery every morning. And when you're on the road, it's easy to plug in along the way—at any public station or with the Tesla charging network. We currently have over 20,000 Superchargers worldwide, with six new locations opening every week.

Go farther than you think

From your weekday commute to weekend trips and all the places in between, Bolt EV is ready to take you wherever you want to go. This ride is an affordable all-electric vehicle that offers an EPA-estimated 259 miles of range on a full charge.† Plus, it offers advanced safety technologies, plenty of space and good looks on top of that. With Bolt EV, there's nothing holding you back.

Charge once a week on average

Whether daily-duties or daring daytrips, the Polestar 2's unique battery is prepared to get you there — use our range calculator to see how often you will need to charge based on how far you drive each week.

Figure 1: Advertising for the Tesla Model 3, Chevrolet Bolt, and Polestar 2 EVs that focuses on range. Captured from manufacturer websites[1][2][3]

Mining sites are geographically disparate; major lithium deposits exist in Argentina, Chile, Bolivia, and Australia, while more than 60 percent of the world's cobalt reserves are located in the Democratic Republic of the Congo. Extensive nickel reserves can be found in Australia, Brazil, and Indonesia (U.S. Geological Survey 2019). Mining operations are resource-heavy affairs that are typically handled by multinational corporations; for example, the global lithium market is dominated by a small handful of multinationals that form a non-cooperative

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[1] www.tesla.com/model3
[2] www.chevrolet.com/electric/bolt-ev
[3] www.polestar.com/us/polestar-2

oligopoly (Maxwell 2015). After extraction, these metals are purchased by and shipped to battery cell manufacturers. These facilities are typically located closer to or inside auto manufacturing facilities. For example, battery cell manufacturer LG Chem has plants in Holland, Michigan and Lordstown, Ohio that supply General Motors plants in the midwestern United States (Kim 2020), while Tesla has a contract with Panasonic to produce battery cells within their Nevada Gigafactory (Lambert 2020). The battery packs are assembled from these cells and installed into production vehicles onsite by automobile manufacturers, as the size and weight of the completed packs would make them difficult to transport (Coffin and Horowitz 2018). Figure 2 shows a map of EV manufacturing facilities and sites of lithium, nickel, and cobalt extraction from which their batteries are sourced.

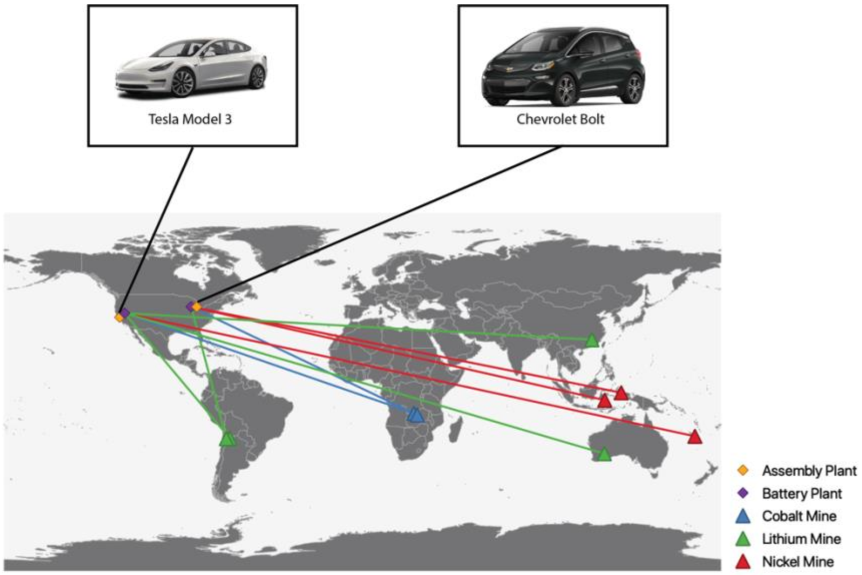

Figure 2: Map of assembly plants, battery plants, and mines. List of mines is inexhaustive; data from various web sources.[4][5][6][7][8]

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[4] Assembly plant locations: https://www.tesla.com/factory, https://media.gm.com/media/us/en/gm/company_info/facilities/assembly/orion.html

[5] Battery plant locations: https://www.tesla.com/gigafactory, https://nsjonline.com/article/2020/11/gm-recalling-nearly-69k-bolt-electric-cars-due-to-fire-risk/

[6] Lithium mining locations: https://www.globalxetfs.com/four-companies-leading-the-rise-of-lithium-battery-technology, https://www.reuters.com/article/us-sqm-electric-lithium/sqm-announces-8-year-deal-to-supply-lithium-to-lg-energy-solution-idUSKBN28W1DR

[7] Cobalt mining locations: https://www.reuters.com/article/us-tesla-congo-breakingviews/breakingviews-tesla-kills-three-birds-with-one-congolese-stone-idUSKBN23O1JX, https://www.argusmedia.com/en/news/2183701-south-koreas-lg-chem-posts-higher-2020-battery-sales

[8] Nickel mining locations: https://www.bbc.com/news/business-56288781, https://www.bloomberg.com/news/articles/2020-10-14/top-battery-makers-in-talks-over-20-billion-indonesia-ev-plans

There remain many sites of exploitation along this global supply chain. Increased lithium mining has led to water shortages, soil contamination, and the dispossession of Indigenous peoples that live near lithium extraction sites (Dominish et al. 2019). Due to the concentration of lithium deposits on rural and Indigenous land and in the Global South, these exploitative effects are unevenly distributed. Although Tesla is pursuing lithium extraction in the United States (Huguley 2020, Scheyder 2020), these efforts are in their infancy and will likely only supplement global lithium extraction for the foreseeable future. Additionally, environmental justice and Indigenous land rights remain significant concerns at these sites as well: the Fort McDermitt Paiute-Shoshone Tribe and local ranchers are fighting the Thacker Pass lithium mining project in northern Nevada over concerns about the project's threats to water and sacred lands (Deep Green Resistance 2021).

The extraction of other metals presents similar concerns. Amnesty International (2016) documented extensive human rights violations in cobalt mining in the DRC, including hazardous working conditions and the use of child labor. Due in part to extensive human rights concerns around cobalt mining, some EV manufacturers such as Tesla are moving away from cobalt and toward nickel (Calma 2020). However, nickel mining is also fraught with environmental and human rights concerns; Indigenous communities in Russia are campaigning Tesla directly to dissuade the company from contracting with a nickel mining firm that is polluting their land (Stone 2020), and nickel mining companies in Indonesia spurred by the EV boom are pursuing ecologically destructive waste disposal methods that involve dumping tailings into the ocean (Morse 2020). At the other end of the supply chain, electric vehicles produce considerable amounts of electronic waste (e-waste), which is often disposed of in the Global South, resulting in public health and safety concerns for local residents. For example, battery disposal and recycling facilities in Ghana that use techniques such as acid leaching and burning have been linked to kidney failure and cancer in children and pregnant women (Sovacool et al. 2020).

The EV supply chain is thus dependent on the exploitation and ecological degradation endemic to the extractive industries. The projected growth of the EV industry is expected to necessitate increased extraction of these metals; Deutsche Bank predicts that electric vehicles alone will make up 38 percent of all global lithium demand by 2025 (Coffin and Horowitz 2018). Overall, EV growth is expected drive significant increases in demand for lithium, cobalt, and nickel that will only be minimally offset by recycling and will require significant expansion of extractive infrastructure (Xu et al. 2020). In the following section, I explain how the EV industry's projected growth and dependence on resource extraction are representative of broader trends within the green economy.

3. Electric Vehicles and the Green Economy

The green economy has become a widespread concept among climate policy and advocacy professionals, and increasingly the general public. I begin this section with a historical review of the green economy and green growth. I next describe how the EV industry growth outlined previously fits into green economy narratives and policy programs. This is followed by an overview of prominent critiques of the green economy, and the role of EVs in these alternative framings. I conclude this section by situating the EVs' role in green economy within the framework of environmental violence.

3.1 Origins of Green Growth and the Green Economy

The idea of a green economy has its roots in development paradigms devised by global financial and governance institutions in the 1980s. Institutions such as the World Bank and the

United Nations began to incorporate ecological concerns into their practices, coining the term "sustainable development" to describe economic development practices that took into account environmental sustainability (Brundtland et al. 1987). The term "green economy" emerged from this context, first in *Blueprint for a Green Economy*, a book prepared by the London Environmental Economics Center that proposed market-based policy solutions for limiting pollution and environmental degradation (Pearce, Markandya, and Barber 1989).

Although sustainable development became widely recognized in subsequent decades, discourses around the green economy remained largely dormant until the global financial crises of 2008, when institutions such as the United Nations Environment Programme (UNEP) and the United Nations Framework Convention on Climate Change (UNFCC) began to adopt "green economy" policy prescriptions as part of economic recovery programs. The UNEP asserted that achieving a green economy was necessary for sustainable development, noting that "The concept of a 'green economy' does not replace sustainable development, but there is now a growing recognition that achieving sustainability rests almost entirely on getting the economy right" (UNEP 2011, pp. 2).

Organizations	Green Economy/Green Growth Definitions
UNEP	"Moving towards a green economy has the potential to achieve sustainable development and poverty eradication on a scale and at a speed not seen before" (UNEP 2011, pp. 38)
World Bank	"Inclusive green growth is the pathway to sustainable development" (Fay 2012, pp. xi)
OECD	"Supporting sector restructuring towards fairer, greener economies …[would] be in line with national and international commitments made under the Paris Agreement, Sustainable Development Goals and other international environmental agreements" (OECD 2020, pp. 7)

Box 1: Organizations relating green economy and green growth to sustainable development.

"Getting the economy right," as defined by the UNEP, hinged on effective capital valuation of natural resources and ecosystem sources, market-based approaches to decarbonization, and perhaps most importantly, increasing economic growth. In fact, the report argued that a green economy would catalyze economic growth to an even greater degree than the alternative. The idea of "green growth" has subsequently become a dominant paradigm, touted as a key "pathway" to sustainable development by international financial institutions and governance organizations such as the World Bank and OECD (Gurría 2011, Fay 2012, OECD 2020).

3.2 EVs as a Component of the Green Economy

Because EVs represent a considerable opportunity for both decarbonization and economic growth, they have become a key component of green economy and green growth narratives in the United States. In 2018, the transportation sector in the U.S. contributed 28 percent of the country's total greenhouse gas emissions, the largest share of any sector (EPA 2020). Light-duty vehicles and commercial trucks, almost all of which run on fossil fuels, make up nearly 80 percent of the transportation sector (U.S. Energy Information Administration 2020). The electrification of these vehicles, combined with a shift to renewable energy generation, would contribute significantly toward cutting carbon emissions.

Because of this potential, EVs also represent a significant opportunity for economic growth. The global number of electric vehicles is expected to increase from 5.1 million in 2018 to as many as 250 million in 2030 (International Energy Agency 2019). American automakers such as Ford and General Motors are making significant investments in EVs (Northrup 2019), while EV manufacturer Tesla recently became the world's most valuable car company (Klebnikov 2020). EV adoption is expected to drive increased consumption of electricity, therefore representing a growth opportunity for electric utility companies as well as automakers (Kapustin and Grushevenko 2020). The electric transportation (or "eMobility") sector in the

United States alone is expected to be valued at $700 billion by 2040—value which can be captured by utilities through charging infrastructure, commodity sales, and rate structuring (Berthon et al. 2019). By presenting pathways for both decarbonization and economic growth, EVs have become a priority for American green economy advocates; so much so that increasing the number of EVs on the road in the U.S. has become a talking point for prominent Democratic party politicians (Manchester 2020).

3.3 EVs and Green Economy Critiques

EVs are also emblematic of prominent critiques of green growth and the green economy. The green economy's adherence to growth, technological solutions, and the capitalization of nature can be seen as a sort of "green Keynesianism" that interprets "greening" as a preservation of current modes of production and consumption, facilitated by the production of new and better commodities (Goldstein 2018). EVs represent this improved commodity, the consumption of which is framed as an environmental and economic benefit. However, by preserving the U.S. auto industry's modes of production and consumption, the green economy stands to preserve the inequalities the industry creates. The U.S. car system alone exacerbates inequalities across the country in employment access, wealth inequality, and environmental health (Lutz 2014). Henderson (2020) has argued that mass uptake of EVs is an impediment to mobility justice that may crowd out more equitable and lower-carbon transit planning solutions while contributing to green gentrification and inequities in energy consumption.

Additionally, green growth dictates that these green commodities must be produced by an ever-growing economy. The OECD describes the impacts of climate change and ecological degradation as "imbalances which are putting economic growth and development at risk" (Gurría 2011, pp. 17). In other words, green growth holds that "environmental risk management is not about the risks to the environment but rather the risks to [capitalist] accumulation" (Wanner 2015, pp. 26). Thus, consumption of green commodities is framed as an environmental benefit, regardless of what risks economic growth itself might entail. Green growth is said to be enabled by "decoupling" emissions and material resource use from economic growth—in other words, maintaining or lowering emissions and resource throughput while increasing economic growth (Schandl et al. 2016). However, researchers have found little evidence of the feasibility of decoupling at a global scale or at the speed necessary to meet decarbonization targets (Vadén et al. 2020, Haberl et al. 2020, Hickel and Kallis 2020). In some cases, what appears to be decoupling in localized geographic areas is simply the relocation of emissions and material use elsewhere due to economic globalization (Moreau and Vuille 2018, Parrique et al. 2019). This suggests that green growth can be conceptualized as a variant of what Harvey (2001) calls a "spatial fix" of capitalism: it is dependent on shifting material use and emissions geographically in order to allow continued capitalist accumulation of wealth.

Finally, scholars suggest that the green economy is an engine of uneven development. Lander (2011) has described the green economy as a tool of global finance intended to give the impression of incorporating environmentalist concerns while foreclosing the possibility of altering existing power structures or pursuing more transformative change. These power structures create a "decarbonization divide" wherein availability of green commodities in the Global North rests on the extraction of labor and resources from, and the dumping of waste in, the Global South (Sovacool et al. 2020, pp. 1). The growth of the EV industry poses particular threats in this regard; as EV production increases, so too will extraction of the metals required to produce them and disposal of the waste that they create.

3.4 The Green Economy, Environmental Violence, and EVs

Taken as a whole, the green economy can be seen as an engine of environmental violence, particularly along the divide between the Global North and Global South. Peluso and Watts define environmental violence as “a site-specific phenomenon rooted in local histories and social relations yet connected to larger processes of material transformation and power relations” (2001, p. 5). The green economy is characterized by the material transformation of natural resources into value through the production of green commodities. As a result, examples of environmental violence are commonly present at these sites of transformation, such as the inadequate compensation or consultation of local communities in the construction of wind farms in Oaxaca, Mexico (Dunlap 2017) or the “bureaucratic violence” of REDD+ carbon standards in Cambodia, which has resulted in land dispossession and state punishment of local Indigenous peoples (Milne and Mahanty 2019).

The growth of the EV industry is therefore also a driver of environmental violence. The aforementioned mining of lithium, cobalt, nickel, and other substances to supply EV batteries has resulted in significant harm to local communities at sites of extraction. The harms at mining sites along with the continued exploitation of labor as mined resources flow along the EV supply chain serve as examples of violence conceptualized as a process that unfolds through spatial and scalar dimensions along commodity chains (Le Billon 2007, Springer and Le Billon 2016).

Thus, the EV industry produces particular forms of environmental violence as a constituent element of the green economy. However, the specific methods by which the EV industry perpetuates this violence are shaped by the sociopolitical relations that shape EV production. In the following section, I examine materialities of energy in order to better understand how they influence these sociopolitical relations.

4. Materialities of Energy

Recent scholarship has focused on how materialities of various energy sources—in other words, the material characteristics of a particular energy source such as its state of matter, location, dispersal, or other traits—affect the supply chain, infrastructure, and spatial distribution of these energy sources (Balmaceda et al. 2019). For example, the location of offshore oil reserves has resulted in the emergence of an offshore drilling industry that shapes social and political relations on and off the oil rig (Appel 2012), while the physical characteristics of oil wells in Russia have affected the ways that oil corporations respond to criticism and build relationships with local people (Rogers 2012). Research has shown how energy materialities have influenced prior global energy transitions, such as those from water mills to coal-fired plants during the industrial revolution and from coal to oil in the 20th century. However, there has been little examination of the energy materialities relevant to the current transition to renewable technologies. In this section, I discuss the role of energy materialities in past energy transitions, and then identify particular energy materialities that are shaping the transition to EVs.

4.1 Energy Materialities and Historical Energy Transitions

Energy materialities have played a significant role in shaping energy transitions throughout history. Notably, the relationship between energy materialities and labor politics helped catalyze the transition from water-powered mills to coal-burning steam engines in 19th century Britain. Mill owners determined that being able to concentrate their factories in larger cities with plentiful labor, as opposed to investing in mills and settlements along unoccupied waterways, was worth the high cost and unreliability of coal (Malm 2016). In other words, materialities of hydropower—in particular the spatial characteristics of the waterways required to generate hydropower—were at odds with mill owners' desires for a congregated labor base. The materiality of coal as a substance transportable along railways facilitated its emergence as an alternative.

The transition to oil as a replacement for coal, which occurred gradually across much of the 20th century, featured a similar confluence of materiality, labor, and capitalist interests. Materialities of coal were such that mining and rail transport were integral parts of coal infrastructure, and both could be easily disrupted by strikes and sabotage. Oil, being a viscous liquid, relied on an infrastructure of pumps, pipelines, refineries, and ships rather than mines and railways. This infrastructure was both less fragile and less dependent on union workers. Oil could be shipped independently of railways due to pipeline infrastructure, and this pipeline infrastructure as well as the refineries themselves were reliant on a smaller number of technicians rather than a large, unionized labor force. Thus, the effort to transition from coal to oil was in no small part an effort, predicated on materialities of energy, to weaken organized labor (Mitchell 2011). It is important, then, to attend to energy materialities as they relate to the ongoing transition to renewable energies, as doing so may reveal the political directions this transition might take. I posit that two characteristics of electric energy are particularly relevant in shaping the dynamics of the transition to EVs: temporality and spatial variability.

4.2 Electricity and Temporality

Access to electric power is often perceived as instantaneous; one flips a switch and a light bulb turns on. Indeed, the use of electric power is perceived in this way in EVs as well, as instantaneous acceleration is a common selling point in EV marketing. However, the time it takes to store electricity in a battery—the process required in order to charge an EV—is different, as it is governed by the physical and chemical properties of electricity. The speed of charging an electric battery is determined by the rate at which the charger is able to deliver electricity to the battery, as well as the rate of diffusion of lithium ions from the cathode to the anode of the battery itself. Tesla's third-generation Superchargers, for example, operate at a maximum charging rate of 250 kilowatts, which can add up to 200 miles of range to a Tesla's charge in approximately 15 minutes (O'Kane 2019). Researchers and companies are exploring even more powerful chargers that operate at rates of 400 kilowatts and beyond (Meintz et al. 2017). However, these extra-high-rate chargers can produce extreme heat in a battery pack as electricity flows through the resistive materials of the battery. High levels of resistive heat can degrade the battery and are potentially dangerous to the occupants of the vehicle. Additionally, ambient temperatures can affect the rate at which lithium ions diffuse within the battery, limiting the speed at which electricity is stored. As a result, manufacturers must explore solutions such as ambient temperature management, charging rate limiting, and battery cooling systems to manage these hazards (Tomaszewska et al. 2019, Xia et al. 2017).

The technologies employed in EV batteries in order to facilitate faster charging while minimizing battery degradation and safety concerns must take into account the material properties of electricity—that is, the ways in which it interacts with the compounds within the battery. Thus, we see that the rate at which EV batteries can be charged is defined by materialities of electricity. We can think of this as a temporality of electricity, where the material properties of electricity are significant through time.

4.3 Electricity and Spatial Variation

The geographic variation of electricity generation, distribution, and regulation is also a significant component of energy materiality. In the United States, the distribution of sources of electricity varies widely by state, and is split between coal, natural gas, hydroelectric, nuclear, and renewables such as solar and wind, among other sources (U.S. Energy Information Administration 2019). Geography and ecology play significant roles in determining these distributions. For example, Alaska's energy grid is self-contained due to its relative isolation and thus largely dependent on locally feasible power sources such as hydroelectric and natural gas. Many Great Plains states such as North Dakota, Nebraska, and Oklahoma have been historically dependent on coal and natural gas, but their flat expanses of land have enabled wind energy to gain rapidly in recent years. Meanwhile, states in the Pacific Northwest such as Washington and Oregon that see heavy precipitation make extensive use of hydroelectric power (Popovich 2018). Additionally, regulatory regimes and financial considerations such as corporate tax rates and construction costs vary widely by location, which significantly influences how energy generation and transmission projects are pursued in different locations. At present, the economic competitiveness of various renewable and nonrenewable energy generation technologies varies widely based on geographic and regulatory constraints (Dell et al. 2017).

Regulatory regimes can influence local energy materiality indirectly and at a global scale as well. For example, water regulations in Chile allow the lithium mining firms that are indispensable for EV consumption in the Global North to pump water at rates that result in shortages for local residents (Babidge 2015, Sherwood 2018). The disparate effects of how the materiality of energy is felt by populations and ecosystems based on local and global power dynamics constitute "uneven geographies of energy materiality," that is, an analytical lens through which we can understand the ways that energy materiality manifests in uneven development or access (Balmaceda et al. 2019, pp. 7). This uneven development has implications not only for who is affected by resource extraction for EVs, as in the case of Chile's lithium mines, but also how EVs are priced and who has access to them.

I have previously drawn on the literature, public documents, and news articles to discuss how EVs fit into the green economy and explain how materialities of electricity stand to affect the transition to EVs. Next, I incorporate findings from my own research in order to demonstrate how EV companies and electric utilities are navigating materialities of electricity and the resulting sociopolitical implications. I outline my research methods in the following section before proceeding to a discussion of the results.

5. Research Methods

Building on previous works by Rogers (2012) and Appel (2012), the objective of this research is to examine how corporations engage materialities of environment and energy, and to uncover the politics of the green economy that emerges as a result. Having established an understanding of energy materialities and the green economy, I analyze corporate engagement with these energy materialities through qualitative research focused on corporate employees.

I conducted interviews with 11 key informants working in the EV industry. Interviewees were composed of employees at automobile companies, electric utilities, and consulting firms focused on EV applications. Interviews were conducted remotely via videoconference between May and August 2020, and each interview was approximately one hour long. All participants were located in the United States; five were in Michigan, while the remaining participants were based in California, Colorado, Georgia, Arizona, and Illinois. Interviews were semi-structured; each participant was asked the same general questions about the nature of their work, their thoughts on the current and future state of the EV industry, and how they interacted with other actors in the industry. However, discussions were open-ended and varied widely.

Limitations of this study include the number of interviewees and the disproportionate number of respondents in Michigan, both a result of “snowballing” personal and professional contact networks as a method of identifying participants. For the purpose of this study, identifying informants based in the U.S. who were closer to the consumer side was appropriate, as the scope of this study is limited to how energy materialities affect companies’ actions in relation to consumer experiences. However, including informants along the entirety of the EV commodity chain could reflect a more comprehensive picture of how energy materialities are articulated in the global economy. Future studies could benefit from a more systematic approach to identifying participants, or conversely a focus on one particular region.

6. “The Gasoline of the Future:” Points of Continuity and Energy Materialities

My conversations with informants in the EV industry elicited two main findings. First, EV industry actors seek to create what I call “points of continuity” between gasoline and electric vehicles: material and narrative aspects of the automobile that are preserved across the energy transition in order to smooth the user experience. Second, the EV industry needs to navigate materialities of energy in order to create these points of continuity. In other words, as in prior energy transitions, capitalist accumulation and energy materialities are interacting to shape the way that industry is navigating the transition to EVs.

6.1 Points of Continuity and the Gas Station Experience

When I asked an electric utility employee based in Arizona what was appealing to electric utility companies about a transition to EVs, the employee put it bluntly: “We’re going to be the gasoline of the future.” This narrative-setting rhetoric emerges from EV industry actors’ creation of what I call *points of continuity* between gasoline and electric vehicles. I define these points of continuity as features of the relationship between a consumer and an EV designed to replicate specific aspects of the experience of operating a gasoline-powered vehicle. Points of continuity can be found across the consumer experience, from ensuring that EV acceleration numbers match or exceed that of comparable gasoline vehicles to striving for an EV battery range comparable to the distance a gasoline vehicle might travel on a single tank. Box 2 displays three such examples of points of continuity between electric and gasoline vehicles and the strategies EV industry actors are pursuing in order to create them. Informants were insistent that points of continuity would be necessary for the widespread of adoption of EVs. In other words, they asserted that points of continuity could contribute to a smooth, universal experience across geographies and regulatory regimes for EV consumers, similar to that of gasoline car consumers.

	Refueling Duration	**Range between Refueling**	**Refueling Pricing**
Gasoline Vehicle	Typically under 5 minutes at gasoline pump	Dependent on fuel efficiency of vehicle and size of gas tank	Flat rate for gasoline varies by region and over short term, dependent on federal and state gasoline tax
Electric Vehicle	Varies widely based on kilowattage of charger and EV battery; fastest available is around 15 minutes	Dependent on battery size and energy density	Charging cost dependent on time of day, energy source from grid, and other factors
Strategies for Point of Continuity	Increasing kW of electric chargers and voltage of batteries; changing material composition of batteries to handle faster charging	Use of larger and more energy-dense batteries in EVs	Collaboration between automakers and electric utilities to devise simpler pricing plans, ideally flat rate, for EV charging

Box 2: Example points of continuity between gasoline and electric vehicles.

One point of continuity that came up repeatedly in conversation with informants was the “gas station experience”—being able to charge an EV in a short duration comparable to the time it takes to fill up a tank of gas. The temporality of the gas station experience is seen as a crucial point of continuity between the experiences of gasoline and EV consumers. “The important [chargers],” said a consultant based in Michigan, “will be the fast chargers so that you can operate your electric car like you do your gasoline car today.” A nonprofit and consulting employee for another firm based in Michigan, also speaking about fast charging, echoed this sentiment: “That would allow you to essentially put 200 plus miles of range in a vehicle in 10 minutes or less. That's often referred to as the gas station experience.” Perhaps most illustrative was a comment from a utility employee based in Georgia. “You never think about that with a gas car, ‘I can't put gas in as fast as I would want to’—that would never enter your mind.”

6.2 Temporality and the Gas Station Experience

The phrase “gas station experience” could refer to any number of experiences characteristic of refueling a vehicle at a gas station: the method of payment, the availability of amenities such as a convenience store or maintenance facilities, or the spatial distribution of gas stations along highways. However, EV industry actors are quite open to altering many of these other factors. Various informants highlighted automatic payment by smartphone for charging services, chargers located at office parks that could be utilized while owners went to work, and vehicle-to-grid reverse charging as changes they were pursuing in the vehicle refueling experience. The CEO of ChargePoint, one of the largest American EV charger companies, has cautioned against infrastructure plans that follow a gas station model in terms of location, instead encouraging policymakers to site chargers at businesses (Stock 2020).

The gas station experience as it relates to EV charging, then, refers specifically to the temporal aspect of refueling. The fact that charging an EV typically takes longer than refueling a gasoline car is a product of electricity and EV batteries’ materialities. Although charging at home is a solution for some consumers, it does not allay range anxiety on longer trips. As one automaker employee based in Michigan put it, “[DC fast charging] takes away a lot of concern about range anxiety it because it starts to act more like what [consumers] are used to with a gasoline powered vehicle that gets, you know, 350 to 450, 500 miles of range on a tank of gas." In other words, the gas station experience is required to allow consumers to use their EVs in the same way they would their gasoline cars. In order to enable this, researchers are developing new types of EV batteries that can better handle the demands of fast charging. These batteries have different chemical compositions from their predecessors, such as silicon or lithium-based compounds in their anodes rather than graphite (Tomaszewska et al. 2019). Thus, the EV industry's pursuit of the gas station experience as a point of continuity is a specific response to electricity's temporality—one that is literally changing the way that EV batteries are made, shaping the direction of the industry itself.

6.3 Spatiality and the Cost of Charging

Price-setting at the pump is another specific aspect of the gas station experience which is used as a point of continuity. Though gas prices differ across the country, they fall within a relatively predictable range that remains reasonably stable over the short term. Electric charging rates present a different challenge, as they are dependent on such variables as load on the electrical grid, utility rate structure, and other factors. Current EV charging services like Tesla's Supercharger network offer arrays of charging rates that may vary depending on these variables (Fig. 4). Some charging network companies such as EVGo require subscription packages in order to use charging infrastructure. Interviewees at automakers and utilities alike voiced their desire for flat charging rates similar to gas prices, echoing the gas station experience.

One utility employee based in Colorado described a number of potential solutions the utility was considering in order to achieve a flat fee for EV charging, including billing home EV charging separately from the customer's overall electric bill. The employee noted that "the market's gearing more and more towards much more predictable rates." However, some informants were skeptical of the possibility. A utility employee based in Arizona lamented, "gasoline prices are semi-consistent across the US; a lot of it depends on taxes. But EV charging all depends on what the utility's rate design is, and these people are dealing with, everybody's got something different." Despite the fact that EV charging tends to be significantly less expensive than gasoline fill-ups—an ostensible draw for consumers—interview participants still sought the continuity of a flat rate.

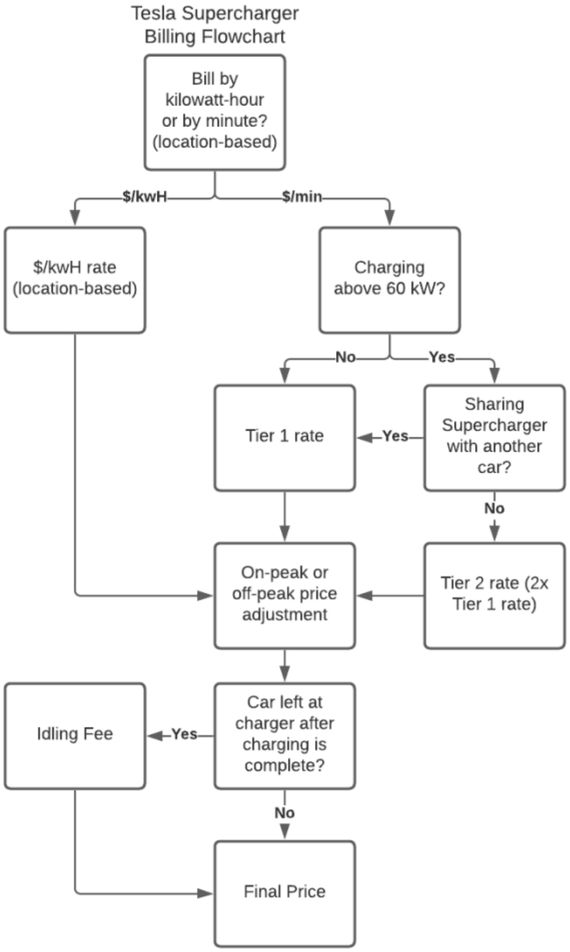

Figure 3: Flowchart illustrating how rates are determined when using a Tesla Supercharger.

Achieving this flat rate, however, can be challenging in part due to energy materialities. Varied materialities of electricity across spatial difference contribute to varied geographies of energy, with different methods of generation, patterns of use, and costs. As one automaker employee based in Michigan put it, “the recipe that works in California is not going to be the recipe that works in Texas, or Florida, or Ohio, or Maine. They all got to be different recipes.” In other words, ratemaking strategies would need to respond to spatialities of energy. Informants were intimately aware of the way that differences in energy materiality impacted their approaches to EV infrastructure initiatives. The same utility employee in Arizona who bemoaned the difficulty of establishing a uniform price for EV charging attributed this difficulty in part to climate and geography. The employee noted, “It also makes a difference whether you're in Detroit in February, or you're in Phoenix in February. Right? Because we're not supplying a lot of heating load in February here, so we've got a lot of spare capacity on our system in the springtime, whereas in countries, places where it's cooler, they don’t.” This employee noted the effects of regional climate patterns on grid capacity and electricity pricing. In other words, electricity’s materialities—in particular its spatial variation caused by differences in climate and generation type—are an impediment to establishing a flat EV charging rate as a point of continuity with gas prices.

7. Discussion

In this thesis I have introduced the concept of points of continuity: particular features of the gasoline vehicle user experience that the EV industry seeks to replicate in EVs in order to increase EV adoption. I have used this idea to illustrate how the EV industry encourages adoption and incorporates EVs into the green economy. I have also shown that points of continuity can be dependent on materialities of energy. Here, I discuss how these key findings influence: (1) the making of the green economy predicated on green capitalism; (2) the emergence of "energopower" and the politics of points of continuity; and (3) how these two strands intersect to perpetuate and maintain environmental violence. I posit that the EV industry's pursuit of points of continuity in response to materialities of electricity is an expression of political power by which this case for growth is made, and that it ultimately stands to perpetuate the environmental violence of green capitalism.

7.1 The "How" of Green Capitalism

Green economy narratives create space for the EV industry to assert its position as the dominant mode of "green" transportation in the United States, making the case for growth among automakers and utilities while obscuring concerns about the inequalities this growth would exacerbate. I have shown that the creation of points of continuity is a corporate strategy intended to facilitate the adoption of EVs without showing how energy is transformed, transported, and commodified. Extra-fast charging and a flat rate for charging serve as two such examples. Recall also the EV advertisements displayed in Figure 1: by employing phrases such as "go anywhere" and "charge once a week on average," EV manufacturers tout points of continuity related to charging and EV range. Points of continuity such as these are attempts to incorporate materialities of electricity into arrangements that enable the use of EVs in as similar a way as possible to gasoline vehicles. By minimizing potential behavioral changes demanded of consumers, points of continuity are intended to facilitate the expansion of the EV industry, and therefore the green economy.

These results have implications for the ways in which energy is transformed along global supply chains from raw material to labor to commodity. In an ethnographic study of offshore oil drilling workers, Hannah Appel finds that global capitalism requires a great deal of work from capitalists in order to corral its heterogeneities into a coherent form that allows for the maintenance of profit and power; she calls this "the 'how' of capitalism" (2012). We see that the EV industry contends with materialities of electricity in order to establish points of continuity while maintaining mainstream green economy and green growth narratives. The creation of points of continuity can thus be seen as a "how" of green capitalism. EV companies respond to materialities of electricity by attempting to create points of continuity. These materialities are shaping the contours of green capitalism, inducing extra work by EV companies in the form of establishing points of continuity. In so doing, EV companies maintain mainstream notions of the green economy. In the following section, I discuss how these strategies construct politics which discourage forms of change that might pose threats to EV industry practices.

7.2 "Energopower" and the Politics of Points of Continuity

As my results show, points of continuity are essential to sustaining EV growth in the United States. These points of continuity create political landscapes which can be interpreted as formations of what Cederlöf calls "energopower:" the ways that "particular configurations of energy and political power shape the conditions of social, political, and economic possibility" (2019, pp. 79). The creation of points of continuity by automakers and utilities can be seen as a strategy toward consolidation of political power. For automakers, growing the EV industry is a means of maintaining their existing hegemonic power over American transportation systems in the face of an impending energy transition. For utilities, it is an attempt to capitalize on this evolution of the automotive industry that renders them providers of "the gasoline of the future." In order to achieve these goals, automakers and utilities in the EV industry must facilitate a smooth transition to EVs, surmounting any obstacles that might disrupt American patterns of car use and consumption.

Ultimately, the creation of points of continuity in order to surmount these obstacles forecloses political possibilities that might threaten capital accumulation of utilities and automakers. Although points of continuity are a strategy employed by EV industry companies to attempt to navigate contradictions between energy materialities and capitalist accumulation, creating points of continuity exposes new contradictions, such as the growing evidence that mass vehicle electrification in the U.S. may not facilitate carbon reduction quickly enough to adequately mitigate the effects of climate change. Despite the growth of the EV industry being billed as a solution itself, it is unlikely that mass electrification of the existing fleet of light-duty vehicles will meet U.S. decarbonization targets; rather, adoption of EVs must be accompanied by an overall reduction in automobile use (Alarfaj et al. 2020, Milovanoff et al. 2020). U.S. President Joseph R. Biden Jr.'s recently announced plan to build 500,000 charging stations was hailed by the EV industry (Stock 2020)—despite research showing that a mass buildout of fast charging infrastructure across the U.S. is likely to see diminishing returns on greenhouse gas emissions reduction and return on investment (Levinson & West 2018).

Thus, by creating points of continuity, automakers and utilities encourage mass EV adoption without reductions in car usage, despite ambiguity as to whether this is an effective or equitable emissions reductions strategy. Through points of continuity, automakers and utilities create political conditions which leverage goodwill built through green economy narratives to maintain their power. As such, the creation of points of continuity by EV industry actors can be seen as an exercise of "energopower." As I explain in the following section, these political conditions are not limited to U.S. decarbonization strategies—they have far-reaching effects that ultimately maintain environmental violence across the globe.

7.3 Points of Continuity, Green Capitalism, and Environmental Violence

> *"This is a good story for everyone. It's good for utilities, but it's also good for the environment, and it's also good for society at large."- Michigan utility employee*

The quote above emphasizes that a defining characteristic of EVs is that they are beneficial for both industry and environment. However, an analysis of points of continuity and critiques of the green economy call these narratives into question. The growth of the EV industry, facilitated by points of continuity, stands to perpetuate the environmental violence of green capitalism.

Automakers and utilities alike leverage green economy and green growth discourses to justify their involvement in the EV industry; automakers must sell EVs to grow their business in the face of a looming energy transition, while utilities and charging infrastructure providers seek to capitalize on this growth as the new providers of "fuel" for automobiles. As we have seen in the previous section, this is an exercise of political power designed to preserve and expand the EV industry. We see in these examples a demonstration of the ways that green economy and green growth narratives are deployed not as solutions to anthropogenic climate change and ecological damage, but rather as answers to the threats that climate change and ecological damage pose to the growth and economic viability of industry. As narratives of green growth embraced by EV industry actors obscure concerns about whether EV industry growth is the optimal solution for equitable decarbonization of transportation, they also elide the green economy’s tendency toward uneven development and harms at sites of extraction.

Nations across the Global South that possess sizable reserves of crucial EV materials such as lithium, cobalt, and nickel face pressure to develop their own economies through extraction of these resources. These pressures, largely driven by increasing demand for these materials across the Global North, are creating stark divides in “sustainability” discourses as governments, Indigenous peoples, organized labor, and other affiliated parties grapple over the dilemmas of resource extraction and development (Hollender 2015, Riofrancos 2017). These conflicts engender resistance among affected peoples at sites of extraction, as demonstrated by the numerous protests by rural and Indigenous populations across the globe at mining sites that supply materials for EV batteries (Stone 2020, Morse 2020, Deep Green Resistance 2021). The 2019 United Nations Climate Change Conference (COP25) was rocked by protests led by Indigenous activists that challenged the maintenance of extractivism and North/South exploitation in climate and environmental policy typical of green economic development (Ramirez 2019). The universalist narratives of social progress applied to the green economy erase these conflicts, creating an illusion of universal benefit while extraction and displacement continue.

I have noted that green economy narratives obscure the environmental and social harms of green growth, using the example of mining for EVs. The impacts of mining expansion on communities at sites of extraction can be characterized as environmental violence; thus the green economy and green growth can be seen as drivers of environmental violence. It follows that because points of continuity are a strategy used by automakers and utilities to expand the EV industry, they contribute to the environmental violence driven by green growth. Additionally, by working to maintain and even expand patterns of car use among U.S. consumers, the EV industry's creation of points of continuity maintains "business as usual," thereby keeping the global environmental violence of the EV industry opaque.

8. Conclusion

The purpose of this thesis is to draw attention to interactions between energy materialities, corporate strategies, and environmental violence, and to introduce the concept of points of continuity into critical analyses of green capitalism, the green economy, and renewable energy transitions. As global energy systems move unevenly toward renewable technologies, many scholars, activists, and members of the public are concerned with the sociopolitical and environmental justice impacts of clean energy technologies.

The literature around the green economy and energy materialities illustrates the impacts of both energy materialities and corporate actors on prior and current energy transitions, particularly within the context of labor, human rights, and ecological degradation. Automakers and utilities utilize green economy discourses to increase EV adoption and grow their businesses. However, mainstream conceptions of the green economy and green growth prioritize capital accumulation over ecological balance and are criticized as drivers of uneven and unsustainable development. Energy materialities can shape the ways that these patterns of accumulation, consumption, and socio-ecological impacts are distributed. It is thus important to attend to the ways that energy materialities, green economy narratives, and corporate strategies might affect current and future energy transitions.

Through my research, I have shown that automakers and utilities create points of continuity by replicating specific aspects of the experience of operating a gasoline vehicle in

EVs. These points of continuity, such as extra-fast charging and flat charging rates, are a means of navigating electricity's spatial and temporal variations and materialities while facilitating a transition to EVs. By establishing points of continuity, EV industry actors minimize behavioral changes for consumers and maximize EV adoption. However, points of continuity also serve to configure political power and capitalist accumulation, ultimately perpetuating the environmental violence of green capitalism. As such, points of continuity expose social and environmental contradictions created by patterns of consumption incentivized by capitalist interests.

By thinking of points of continuity as strategies that can reveal socio-ecological contradictions in corporate and state management of a transition to a green economy, we might envision broader applications of this framework beyond the EV industry. How might points of continuity, for example, shape political ecologies of the emerging lab-grown meat industry, which is itself an effort to create continuity between traditional and lab-grown meat while reducing environmental impacts (Sergelidis 2019)? By investigating the ways that powerful entities such as corporations and states deploy points of continuity, we can uncover contradictions in the construction of green capitalism that might help activists and thinkers devise pathways toward alternative modes of production and consumption. Countering these strategies with more reciprocal relationships between humans and energy materialities will be important for building futures that avoid and address the patterns of exploitation embodied in the present green economy.

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