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Reconfigurations of Life Cycle Assessment: Valuing Life over Lithium

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Introduction

The engineering of the unjust distribution system of Global Racial Empire has driven centuries of human suffering and environmental devastation that have perturbed Earth systems to the point where the Holocene epoch may come to an end. Táíwò describes how Global Racial Empire is constituted from the combined historical processes of the trans-Atlantic slave trade and colonialism, functioning to reproduce a global, unjust distribution system via accumulating advantages and disadvantages [1]. These interconnected historical processes established the capacity and social institutions of colonial powers to exploit territory, plunder, and produce captive markets as three key advantages. The construction and expansion of White supremacy has maintained the Global North as a location of accumulated advantage and production of wealthy countries contrasted with the Global South as a location of accumulating disadvantage while locally dictating patterns of accumulation via distributions of power away from people of color and Indigenous people toward people racialized as white. Although records indicate Homo sapiens have existed on Earth for roughly 300,000 years, our species has flourished under the relatively stable climatic and ecological conditions of the past ~11,700 years known as the Holocene epoch [2].

The rise of industrial capitalism in the 19th century ushered in increased capabilities for Man to engineer technologies that further entrenched Global Racial Empire and reinforced the narrative that Man was separable from the constellation of life-giving relationships constructed of nature. Confluently, the Western Bourgeois construction of Man was redefined in purely secular, biological, liberal mono humanist terms that framed symbolic life as accumulated wealth and White physical traits contrasted with symbolic death as poverty and Black physical traits [3,4]. It is this construction of Man that the increased capabilities of fossil fueled industrial capitalism have insatiably been leveraged by and for. Dominant engineering education exists as the normalized 'technical' education and manufactured ignorance those professionalized as engineers receive that is foundationally structured to maintain Man's relationships of domination via Global Racial Empire [5].

The critical material infrastructures of the settler colony of the United States, the present hegemon of Global Racial Empire, have overwhelmingly remained reliant on fossil fuels. The corporate supply lines of the transportation sector generate about 27% of all greenhouse gas (GHG) emissions from burning fossil fuels within the territorial bounds claimed by U.S. states [6]. Electric vehicles (EVs) have been framed as a technological solution to transition from the fossil fueled economy and recent endeavors such as the Biden administration's Infrastructure Investment and Jobs Act (IIJA) attempt to tackle transportation pollution by investing in EV industries [7]. About $7.5 billion was allocated to increase EV charging stations across the U.S. to stimulate the transition towards electric cars [8]. Wealthy countries and the transportation corporations they support have advanced numerous technological solutions for vehicle electrification, whether it is through more efficient EVs, ubiquitous stationary charging stations, or wireless charging roads. One such endeavor is the Advancing Sustainability through Powered Infrastructure for Roadway Electrification (ASPIRE) Engineering Research Center (ERC), with a goal "to improve health and quality of life for everyone by catalyzing sustainable and equitable electrification across the transportation industries," through "a holistic approach to eliminate range and charging as barriers to electric vehicle use," [9].

This desire to electrify transportation systems is driving a significantly increasing demand for minerals critical to the construction of lithium-ion batteries (LIBs) like lithium and cobalt. As the predominant electrochemical energy storage technology for EVs, the demand for LIBs has tripled from 2015 to 2020, and it is expected to grow to "2.2 million tons by 2030" [10]. One means of projecting and legitimizing the notion that transitioning to electrified transportation systems improves quality of life and is sustainable is through the use of life-cycle assessment (LCA). Yet there are a plethora of crucial factors LCA either has not or cannot consider [11, 12]. In this paper, we leverage an interwoven framework of abolition, degrowth, and environmental justice to elucidate nominally death-making practices and onto-epistemic formations legitimized and operationalized through life-cycle assessment (LCA). LCA is but one of a plethora of quantitative environmental assessment analytics leveraged to strengthen the ongoing, vacuous violence of Global Racial Empire. These analytics are leveraged by engineers, corporations, and nation-states alike to maintain Global Racial Empire as a juridical-narrative epoch [13] worthy of maintenance, seemingly indestructible structure comprised of institutions, and process of leveraging human capacity to further unjustly accumulate advantages and disadvantages. This interwoven framework offers a lens to look at LCAs of LIBs in the context of the climate-focused and growth-oriented narratives surrounding them.

Theoretical Framework

Abolition can be incompletely understood as a creative, imaginative, and speculative collective labor constantly remaking sociality, politics, ecology, place, and being as a practical organizing strategy towards an end to systemic violence, an unfinished project of performing liberation under and against conditions of systemic, state-sanctioned violence, and a collective intertwined theory and praxis inextricably grounded in Black liberation and Indigenous anticolonialism/decolonization [13, 14]. Abolitionist movements have and continue to exist as worldmaking, life affirming collective formations restructuring societies so that needs foundational to personal and community safety are met [14, 15]. The vacuously violent nature of Global Racial Empire upheld through carceral power has long functioned to inhibit the growth of abolitionist movements and worlds. Abolition has often been mischaracterized as a purely or predominantly negative process, however as Dylan Rodriguez articulates,

> "abolition is not merely a practice of negation — a collective attempt to eliminate institutionalized dominance over targeted peoples and populations — but also a radically imaginative, generative, and socially productive communal (and community-building) practice. Abolition seeks (as it performs) a radical reconfiguration of justice, subjectivity, and social formation that does not depend on the existence of either the carceral state (a statecraft that institutionalizes various forms of targeted human capture) or carceral power as such (a totality of state-sanctioned and extrastate relations of gendered racial-colonial dominance)" [13].

Here, the gendered racial-colonial dominance Rodriguez speaks of is discussed as Global Racial Empire. Scholars of abolition have proposed specific intersections between abolitionist and environmentalist thought in the form of "abolition ecologies," which seek to "enrich, expand and extend the logics (and thus possibilities) of the political ecology and environmental justice literatures with a capacious understanding of abolition geography" [16]. Environmental justice (EJ) offers a juridical-narrative form rooted in spiritual interdependence to the sacredness of Mother Earth and the ecological unity of all species [17]. Pulido discusses how in the time since the rise of the EJ movement in the 1980s EJ activists have succeeded in blocking new projects of environmental injustice and the expansion of existing ones [18]. At the same time, she argues that the scope of these successes and tangible impacts on improvements to the environments of vulnerable communities have been limited. She attributes these limited impacts to a fundamental mischaracterization undergirding much EJ activism and research, a failure to theorize environmental racism as a constituent element of racial capitalism that leads to a circumscribing of solutions within the juridical bounds of the state. Drawing from Cedric Robinson's [19] argument in *Black Marxism: The Making of the Black Radical Tradition* that racism was a structuring logic of capitalism as well as the Black Radical Tradition's (BRT) epistemic legacy and historical commitment to racial justice, she asserts that the state is ”actively sanctioning and/or producing racial violence in the form of death and degraded bodies and environments,” [18]. Following this assertion, Pulido and De Lara argue that EJ organizing among multi-racial groups acts as an extension to BRT’s legacy through a linking of struggles against environmental racism to a longer history of abolitionism [20]. Such linkages offer generative connection points to the conception of EJ Kyle Powys Whyte argues for in *Indigenous Experience, Environmental Justice and Settler Colonialism*, where injustice

> “occurs when the social institutions of one society systematically erase certain socioecological contexts, or horizons, that are vital for members of another society to experience themselves in the world as having responsibilities to other humans, nonhumans and the environment. Injustice, here, involves one society robbing another society of its capacities to experience the world as a place of collective life that its members feel responsible for maintaining into the future,” [21].

Owing to a commonality in points of departure within the various functionings of the carceral/nation-state as well as analysis of global political economy, we suggest that augmenting this conversation with threads of degrowth may be mutually beneficial. Degrowth presents a counter-hegemonic challenge to narratives of “green growth” that dominate institutional approaches to climate change, ecology, and development [22]. Originating in the understanding that continued economic growth in industrialized nations threatens planetary ecological boundaries, degrowth argues for “a democratically led redistributive downscaling of production and consumption in industrialized countries as a means to achieve environmental sustainability, social justice, and well-being” [23]. In practice, this typically means a rejection of economic growth and Gross Domestic Product (GDP) as markers of human well-being, and a holistic reduction of resource use in wealthy nations coupled with an increase of resource use in “developing” nations while transitioning to sustainable practices, ultimately arriving at a sustainable equilibrium [24].

In keeping with abolitionist thought, degrowth is not solely a negation of economic growth but rather a call for a radical reconfiguration of human-environment relations in order to provide public, sustainable abundance for all. It is a “movement in motion,” containing diverse currents including but not limited to feminist, decolonial, and commons-based approaches [25]. Singh [26], in a discussion of degrowth and environmental justice, notes that “both assert or aspire for other ways of being and belonging to the world and open possibilities for post-capitalist futures.” In this way, synthesizing degrowth, abolition, and environmental justice may lead us to fuller understandings of the social transformation required to achieve just sustainability.

Life Cycle Assessments

Comparative Life Cycle Assessment has been used since the 1960s as a way to study environmental impacts of consumer products, when it was mostly an analysis of energy inputs and outputs of a product [27]. The history of LCA is a messy one, with decades of widely divergent approaches, terminologies, and results applied by corporations attempting to substantiate market claims about products. Since the 1990s, international scientific organizations have attempted to make LCAs more common and standardized. LCAs have even become essential in policy documents and legislation. However, the International Organization for Standardization (ISO) has expressed that LCAs could not ever be fully standardized since there exist various methods to conduct them.

Today, LCAs are used for far more than simply comparing which product is more efficient than another. It is framed as a more holistic analysis of a product’s environmental impacts from its essential raw material extraction phase through manufacture, distribution and use, to its disposal. Often LCA is performed through the generation and interpretation of a goal and scope, an inventorying of what is scoped as relevant energy and material requirements, and the calculation of corresponding resource use, human health impacts, and ecological consequences through an impact statement. LCA has grown to become an essential element of production as the “go-to” environmental assessment tool that is used by governmental institutions and corporations to inform policies and regulations in wealthy industrialized economies like the European Union, the U.S., Japan, Korea, Canada, and Australia [27]. Owing to its status as an environmental assessment tool, LCA is ubiquitously taught in environmental engineering and related majors.

Life Cycle Assessments and Lithium-based products

When it comes to sustainability and environmental impacts, LCAs are often overly "focused on environmental problems as seen from the perspective of industrialized countries" [28]. Of the 80 LCA studies relating to LIBs assessed by Arshad et al., 63 came from the U.S. and Europe, with much of the remainder coming from China, Canada, Japan, Australia, and Brazil [29]. Arshad et al. found 73 studies reporting on the impacts of global warming greenhouse gases (GHG) in their environmental impact assessments, often reported through metrics such as kilograms of CO_2 equivalent emissions per kilowatt hour of battery capacity ($kgCO_2eq/kWh$) [29]. Of the 80 studies, they found 32 touched on more than 6 impact categories aside from GHG, with the other most popular being acidification (AP), human toxicity (HTP), and eutrophication (EP), see Table 1.

Table 1: LCA impact categories, descriptions, typical units, and number of LIB studies leveraging each impact category [29].

LCA Impact Category	**Description**	**Typical Units**	**Number of LIB Studies**
Global Warming Potential (GWP)	Comparison of global warming impacts of different gasses based on energy absorbed by emissions of 1 ton of gas relative to emissions of 1 ton of CO2, typically over a 100 year time period.	kg CO_2-eq	69
Acidification (AP)	Ability of a substance to build and release H+ ions into soils and waters	kg SO_2-eq	39
Human Toxicity (HTP)	Potential toxic harm generated by a chemical substance. It is the ratio of the exposure to a chemical substance over its toxicity benchmark.	Varies depending on the compound and its exposure route.	32
Eutrophication (EP)	Enrichment of nutrients in an aquatic or terrestrial location through emissions of nitrogen and phosphorus to air, water, and soil as well as of organic matter to water	kg PO_4-Eq; kg N-Eq	31
Photochemical Ozone Formation	Potential of a gas to produce products like ozone in the presence of radiation from the sun, nitrogen oxide, and hydrocarbons	kg C_2H_4-eq; kg O_3-eq	29
Cumulative Energy Demand (CED)	It is the totality of energy inputs throughout the life cycle of a product.	MJ	26
Ozone depletion potential (ODP)	Comparison of potential for a substance to destroy ozone gas relative to chlorofluorocaron-11	kg CFC-11-eq	24

Ecotoxicity (ETP)	Potential toxic environmental harm of a chemical substance.	CTUe	23
Particulate matter formation	Concentration of particulate matter in the air generated from an activity.	μg/m³	23
Abiotic depletion potential (ADP)	Reduction in the global amount of non-renewable raw materials based on remaining reserves and rate of extraction	MJ	19
Fossil Depletion Potential (FDP)	Estimation of reduced future fossil availability based on fossil extraction data.	MJ	13
Metal Depletion (MDP)	Estimation of reduced metal availability based on metal extraction data.	tons	13
Ionizing Radiation (IR)	Amount of radionuclides emissions damaging to the ecosystems and human health.	Bq	10
Resource Depletion (RDP)	Reduction of resources stocks before it can get replenished.	tons	6

When it comes to LCA of LIBs specifically and EVs more broadly, the main critique found in the literature is that the environmental impacts primarily cover the "production and end-of life" phases [30]. Disregarding or minimizing the impacts generated from the raw material extraction phase misrepresents the actual environmental impacts of LIBs. For example, Flexer et.al, had mentioned the lack of literature regarding the fate of "spent brine after lithium recovery" [31]. In instances where the raw material extraction phase is touched upon, the environmental impacts are often decoupled from the socioeconomic impacts around sites of extraction and geopolitics related to resource availability.

Lithium Extraction Process

Lithium extraction primarily happens through three different processes: brine extraction, ore mining, or LIB recycling. Although more research is being done on lithium recycling, currently the U.S. lacks policies and regulations that would make the process economically viable, less hazardous, and produce less hazardous materials as byproducts hazardous [32]. Although it is less common than brine extraction, lithium ores can be extracted from quarries, roasted, and cooled down [33]. The ore can either go through an acid, alkaline, or chlorination process, but these methods can require tons of sulfuric acid and generate a multitude of environmentally hazardous byproducts [34]. The more conventional lithium extraction method is through brine recovery. Brine is extracted from salt lakes, seawater, or even aquifers. The brine is then placed in shallow ponds where the water will naturally evaporate over one to two years allowing for the salts to precipitate and get treated [33]. These mining and brine extraction methods both have environmental, socio-economic, and health impacts all around the world that escape the scope of many LIB LCAs conducted in wealthy nations. Below are a few of these impacts that play out on the continents of South America and Africa.

South America

Some estimates place 70 to 75% of the world's lithium reserves in the "lithium triangle" Andean region where the states of Chile, Bolivia, and Argentina meet [9, 26]. This region is extremely arid with low precipitation, which makes it ideal for the natural evaporation process of lithium brine extraction.

These lithium extraction processes have brought significant environmental, socio-economic, and health issues to the region.

The most significant environmental impact associated with lithium extraction in the “lithium triangle” area is water depletion. This area is one of the driest regions in the world. Yet mining companies need to extract significant volumes of groundwater to recover the lithium, causing significant “ecosystem degradation” [26]. In order to produce one ton of lithium, it is estimated that about “half a million gallons” of water is needed [26]. Considering that lithium production exceeded 100,000 tons in 2021 and that about 31% of it came from Chile and Argentina, about 15.5 billion gallons of water were pumped out of the Lithium triangle region alone that year [31]. Almost none of that water can be recovered since about “95 percent of the extracted brine water is permanently lost to evaporation” [9].

This water depletion is also impacting nearby protected ecosystems containing endangered and threatened species [26, 32]. Leaks from evaporation ponds can happen when PVC liners fail and introduce unwanted chemicals such as softeners into the soil and environment [9, 26, 33]. Water pollution in the lithium triangle has been associated with an increase in microbes such as cyanobacteria which can generate toxins fatal to “humans and biodiversity” [32]. Finally, the fate of the saline spent brine at the end of the extraction process pose additional environmental concerns. Conventionally, spent brine is either re-injected into the basin it was extracted from, or disposed of in evaporation ponds [34]. Re-injecting lithium-deprived brine underground could alter its conductivity and even a drop in its pH [27]. There is very little research on spent brine and very little is known about how this characteristic change could impact life in these environments. However, they remain points to take into consideration because this method is altering the living conditions of the biodiversity in those environments. Air, water, and soil pollution are not the only concerns associated with lithium brine extraction.

The water scarcity impacts caused by lithium extraction drive forced displacements. Lithium mining is on a trajectory to render the ancestral homelands of indigenous Andean Altiplano communities uninhabitable, forcibly removing communities who have existed on those lands since time immemorial and whose cultures are inextricably linked to the environments those lands sustained [26]. Corruption of local governments by international mining companies and the interests of wealthy nations has been a powerful force in ensuring mining commences in the face of abuses to the rights of indigenous communities , and companies have been accused of “extracting more than their legal quota” [26, 35]. During a consultation event between local communities, the provincial government, and a mining company, in Northern Argentina, locals demanded answers regarding the considerable water depletion, but the few people who attended were interrupted and almost forcibly removed by the police [36]. In Chile, some communities have been made responsible for monitoring mining companies, forcing communities to hire external professionals or interpret extremely technical and niche data themselves [26]. Shifting the responsibility onto the local communities without sufficient power to counter multinational corporations is a tactic that gives the illusion of empowerment while forefronting the futurity of mining. This disregard for human rights in the name of sustainable and equitable electrification in wealthy nations is widespread, since “of the 5 biggest lithium mining companies in the world, only one has a publicly available human rights policy and all have allegations of human rights abuse against them.” 37]. Finally, health issues are also important to take into account regarding lithium extraction from brine. Although the consequences are still being researched, it is known that a concentration of lithium in blood “greater than poses a risk of death” and health deteriorating consequences [10, 30].

Africa

Many of the minerals indispensable to electronic devices are mined in Africa. As demand for lithium soars, more and more African countries are starting to invest in lithium, and at the moment, Zimbabwe is the largest producer of lithium on the continent [42]. Zimbabwe holds the fifth largest lithium reserve in the world, but the Democratic Republic of Congo (DRC), Mali, and even Namibia are also aiming to play a bigger role in the lithium market. These four countries alone ”represent between 10% and 27% of lithium resources coming from minerals at the global level” [43]. Most of the lithium reserves in Africa are extracted through ore mining and not brine like in South America. This mining method has environmental damages similar to any other ore mining operation. Peoples are forcibly removed, large areas of culturally significant lands are exploited, explosives are used to form exploitable quarries, a considerable amount of dust is generated reducing surrounding air quality, runoff from the mine poisons waterways and groundwater, tons of greenhouse gasses are emitted, and the conditions that sustain life around the mining sites are undermined [44].

The residues of colonial political structures and sustained interventions by wealthy nations have made the implementation and enforcement of laws and regulations focused on environmental protection difficult many African countries. In some East African countries, gold mining for example "has lead to exorbitant mercury concentrations in rivers", which severely fragilized biodiversity and health of the communities nearby [37]. Workers' rights, pay, and practices can be horrendous when it comes to resource mining in Africa, for example in the DRC, child labor is common practice for cobalt extraction [45]. In 2019, large tech firms were named in a human rights lawsuit where they were blamed for their lack of supply chain regulations [45]. These firms were held responsible for not supervising how the extraction of cobalt found in their products led to the deaths and severe injuries of several Congolese child workers [45].

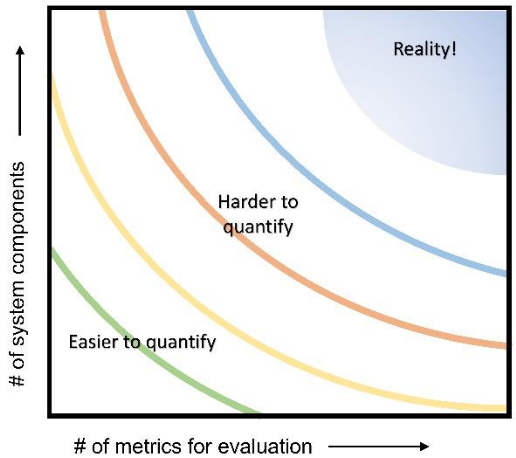
More and more foreign companies are investing in lithium operations in Africa, but some of these countries lack essential environmental regulations and human rights laws. In a still politically unstable Mali, an Australian and Chinese firm jointly invested $130 million in a "large-scale, hard rock open pit lithium "project estimated to return $2.94 billion [46]. From what was available online, there were no mentions of socioeconomic impacts on the Malian population from this project. Additionally, there is no lithium operating company from Mali on this project, so it is unclear what environmental standards will be upheld by these foreign companies and how much of the revenue will be reinvested in Mali. In this race for lithium, it is important not to replicate the environmental and socio-economic disasters that have been done when extracting other natural resources. In 2022, Zimbabwe announced that it would stop exporting its lithium and would prioritize processing the resource into LIB locally. The Zimbabwean government claimed to have been losing 1.7 billion euros (about $1.8 billion), from exporting lithium [47]. The country is now focusing on localizing and investing in LIB production for a more sustainable economic return [47]. When it comes to extracting natural resources from certain African countries, the exploitative colonial history, lack of infrastructure, and regulations can actually make such investments extremely damaging for already fragile communities. Yet, the important issues of corruption, worker rights, and certain socio-economic inequities fall outside of the scope of LCA.

Reconfiguring LCA and caretaking economies

LCA is a process presently taught in dominant engineering education as a meaningful way to determine sustainability through a focus primarily on energy and material flows from raw material extraction through to the disposal of a product. With such a focus comes an irony of how purposefully life itself is excluded from a process named life-cycle assessment. Sylvia Wynter's articulation and historical tracing of Man as *homo oeconomicus,* the overrepresented white Western Bourgeois man fixated on material accumulation, as the present dominant and referent construction (genus) of human being in Global Racial Empire gives insight into these death-making distortions [3, 4]. LCAs are highly valued in *homo oeconomicus* social infrastructures owing to symbolic life being understood as material accumulation.

This representation is legitimized through quantification of energy and material flows in LCA. Quantification is used as a data interpretation strategy to remove an emphasis on ethical thinking and focus on the correctness of a measurement, see Figure 1a. Figure 1a offers a visual of how the validity of LCA is constructed. Increasing the number of system components and the number of metrics of evaluation is interpreted as giving harder to achieve, more rigorous results and a better representation of reality. Despite the emphasis on "interpretation" in the LCA process, dominant engineering education trains the interpreters not to question the values abstracting life into energy and material flows or the ramifications of that abstraction. Such lines of thinking require moral infrastructures that have been woefully underdeveloped by dominant engineering education through a central focus on techno-rational arguments [44]. LCA yields units of measure such as kgCO2eq/kWh, which are necessary in techno-rational arguments and consumable as capital. This abstraction of life into quantified energy and material flows, unaccompanied by locally specific social, historical, and geopolitical contexts and understandings, is itself a death-making practice supporting global environmental injustices. The quantifications become analyses of death, holding fixed a background of Global Racial Empire that assures access to land while separating land from life to plunder resources. This is reflected in the way that impact categories are all geared toward understanding damage that would result from product making, forefronting sets of relationships in which humans are inherently damaging to the environment.

a)



b)

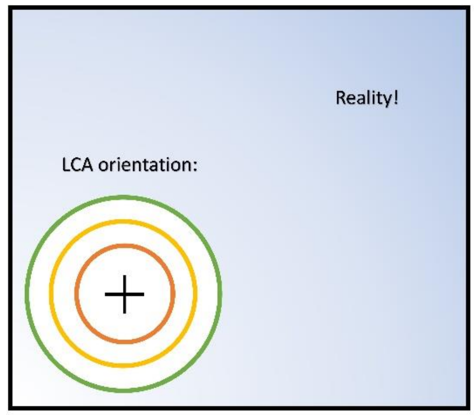


Figure 1: a) Construction of validity for LCA, where increasing the number of harder-to-quantify system components and metrics for evaluation is believed to better represent the reality of LCA targets; b) LCA creates a focus on specificity and thus misses complex realities, despite a clearly defined quantitative target.

Wynter traces the history of the "sinful by nature" descriptor of humans to the narrative used by the Church to maintain the theocentric power structure in medieval Latin-Christian Europe [3]. During medieval times that narrative was leveraged to convince subjects of their enslavement to Adam's Original Sin so as to seek redemption through the Church, whereas today the "sinful by nature" descriptor is leveraged by corporations and nation-states to subsume humans into the singular genre of *homo oeconomicus* seeking redemption through material accumulation. Since in the world of *homo oeconomicus* the social infrastructures understand the impoverished, endarkened "Other" humans as symbolic death, the life-sustaining relationships genres of human outside of *homo oeconomicus* have with nonhumans and the environment hold little value to product sustainability.

Reconfiguring life in life-cycle assessment from the symbolic life of a product toward human, nonhuman, and environmental relations offers a way to redirect the social and material infrastructures sustaining LCA toward meeting people's needs. Figure 1b offers a visual to initiate this redirection, showing how the central focus of LCA is necessarily misaligned with reality for constellations of beings that refuse to be subsumed into the destruction wrought by the worldview of *homo oeconomicus*. Wynter offers a reconceptualization of the human as hybridly bios and mythoi, biological and cultural, to describe being human as both storytelling and praxis [3]. Shifting the stories that are told of life cycles from bound within the accumulation economy of *homo oeconomicus*, represented as the target of LCA orientation in Figure 1b, toward relationships that undergird a caretaking economy offers a way to reconnect cleaning water and healing land as actions that build sustainable and equitable infrastructures.

One initial direction for practitioners of LCA to move toward is building understanding of the geopolitical implications of their studies and the perspectives they look toward to justify their recommendations. In *Achieving Zero Emissions with More Mobility and Less Mining*, the Climate + Community project "designed a novel material flow analysis paired with socioeconomic pathway modeling to determine possible scenarios for the decarbonization of personal transportation in the US," [49]. This approach focused on the frontlines of lithium mining, reducing geopolitical tensions, achieving climate targets, and designing safer communities. They looked at four scenarios geared toward reducing the impacts of mining and increasing mobility. The difference between the most resource intense path that continues current EV trends in the U.S. and a 92% reduction in lithium demand by 2050 came from "reducing the car dependence of the transportation system, decreasing the size of electric vehicle batteries, and maximizing lithium recycling." The assessment methods they used to contextualize and forefront environmental injustices of mining in conversation with organizers on the ground offer guidance for the building of international social infrastructures and solidarity towards more sustainable and equitable transportation infrastructures amongst wealthy countries than LCA has offered.

Turning more toward a focus on impacts to human life, social determinants of health are a public health framework for reducing health inequities that can contextualize proposed transformations to transportation infrastructure. They offer a way to center conditions in which people are born, grow, live, work, and age, including the principles and policies creating or limiting opportunities for health, through a social ecological model [50]. The socioecological model looks at levels of people, community, environment, and society as interwoven to shape health equity. Social determinants of health offers a lens into how fatal couplings of power and difference act across scales by linking impacts of social inequities, institutional inequities, living conditions, risk behaviors, disease and injury, and mortality. They situate the physical environment transportation infrastructures exist within as one component of living conditions alongside social environment, economic and work environment, and service environment. Through an understanding that community capacity building, community organizing, and civic engagement can transform living conditions, a social determinants of health framework more readily connects to qualitative participatory research methods, such as participatory action research, to justify infrastructural changes and assess environmental impacts.

Orienting understandings of life cycles around changes in biodiversity over time breaks from representations of symbolic life as product. In *The Red Deal,* The Red Nation connects a caretaking economy and biodiversity through Indigenous land, water, and treaty defense [51]. They state that "while making up only 5 percent of the world's population, Indigenous peoples protect 80 percent of the planet's biodiversity. Indigenous peoples and local communities who have distinct cultural and social ties to ancestral homelands and bioregions still caretake at least a quarter of the world's land," [51]. Rematriating land and honoring Indigenous sovereignty are key components of an intergenerational life sustaining praxis [52]. Yet at the same time, water protectors and land defenders engaging in such praxis have been heavily targeted and criminalized as "the new generation of political prisoners," [51]. This is because the police and military, as punitive protectors of the symbolic life of products, are violence antithetical to life. While LCA has been oriented to maintain an accumulation economy normalizes death-making relationships through environmental degradation, LCA can be reconfigured for a caretaking economy that supports and enriches people's "capacities to experience the world as a place of collective life that its members feel responsible for maintaining into the future," [21]. Such reconfigurations of LCA necessitate radical, intergenerational redistributions of the social, political, and economic power concentrated in the engineering act away from unrelentingly resourcing nation-states and corporations towards movements building the infrastructures of a caretaking economy.

Conclusions

Building and deepening relationships that sustain the interconnected webs of life on Earth is imperative. Despite using words that on their surface align with this imperative such as "improving the quality of life for everyone", the orientation of dominant engineering has been foundationally rooted in death-making practices opposed to such relationships. By looking at the practice of life cycle assessment (LCA) on lithium ion batteries through an interwoven framework of abolition, degrowth, and environmental justice, a window is opened into how dominant engineering has centered product as symbolic life in order to sustain Global Racial Empire. Techno-rational arguments, including those for technologies framed as green and sustainable such as electric vehicles and batteries therein, naturalize a single genre of human, *homo oeconomicus*, that understands product as symbolic life while obscuring the vacuously violent backdrop of Global Racial Empire they are nested within. This has allowed LCA to become normalized and ubiquitous in engineering fields like environmental engineering as a tool for assessing sustainability despite an orientation that inherently views human action as damaging to the environment. Rather than seeking an alternative to LCA that functions similarly in the maintenance of Global Racial Empire, engineering education can be reoriented to contest the terrain upon which this construction of LCA sits and the spaces where it is valued. Delving into the underlying assumptions of life propagated in uses of LCA, tracing the historical lineages of those assumptions of life, and recognizing genres of human being these uses of LCA are operationalized for and against are some of the acts that can reconfigure the term life cycle assessment. Orienting such reconfigurations to resource caretaking economies rematriating land and honoring Indigenous sovereignty can propagate healthier, life-sustaining relationships amongst humans, non-humans, and the environment.

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