MOMENTUM KONGRESS 2024

The social impact of electric vehicles observed from two different standpoints. A comparison through Social Life Cycle Assessment

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29.09.2024

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1. Introduction

The global passenger vehicle market is currently undergoing a profound transformation. In 2023, 18% of all vehicles sold worldwide were fully electric, a 35% increase compared to 2022 (IEA, 2024). This trend is especially evident in China, Europe, and the USA, where sales of electric vehicles (EVs) are growing rapidly year on year. The shift aims to make the transport sector, which accounts for over 22% of global CO_2 emissions, more sustainable (Liu et al., 2023). Despite several environmental concerns, particularly regarding the resource-intensive production phase (Degen & Schütte, 2022) and potential issues connected to energy sources of the charged electricity (Bieker, 2021), by the scientific community, EVs are considered a cleaner alternative to internal combustion engine vehicles (ICEVs) over the entire life cycle.

In contrast to environmental issues, however, EVs' social impacts are rarely considered in scientific evaluations. In particular, the extraction of raw materials for electric vehicle batteries often adversely effects local ecosystems, workers, and surrounding communities. Although there is a significant body of grey literature discussing these issues (e.g. Amnesty International, 2023; Niarchos, 2021; Stefano, 2023), a research gap in the academic flied remains. This paper thus aims to evaluate the social impact of the EV sector from various perspectives, particularly by comparing a country of the Global North, where EVs are widely used, with a state of the Global South, which supplies important raw materials to enable their usage. Therefore, Norway, in which more than 94% of newly registered vehicles in August 2024 were electric (Mobility Portal, 2024) will be compared with the Democratic Republic of Congo (DRC), albeit portraying negligible usage of EVs, playing a major role in the global EV rollout due to its existence as the world's largest producer of cobalt, a key component of EV batteries (Gulley, 2022).

To achieve this target, a Social Life Cycle Assessment (S-LCA) of the respective EV sectors will be conducted. Here, the methodological framework based on the most recent United Nations Environment Program (UNEP) Guidelines (2020). The analysis will focus on the social impacts across the production, usage, and end-of-life phases of EVs in both Norway and the DRC.

First, Chapter 2 provides an overview of the global EV market and the scientific discourse on its environmental and social impacts. Subsequently, Chapter 3 details the S-LCA methodology, its fields of application. It further outlines the methodological framework of the four phases of the S-LCA in this study. Chapters 4 and 5 investigate the social impacts of EVs on the populations in Norway and the DRC, respectively. Finally, Chapter 6 offers concluding remarks including comparisons of the social impacts of both countries, the interpretation of the results, as well as suggestions for further research.

2. Literature Review

The global automobile industry is shifting towards electric mobility, mainly driven by government policies and incentives aimed at increasing the share of electric vehicles and reducing fossil fuel-powered vehicles. This transition is in direct alignment with the climate neutrality goals outlined in the 2015 Paris Agreement (UNFCCC, 2016). Despite a broad consensus on the environmental benefits of EVs, unresolved issues, particularly connected to the social realms, complicate their image. While consumers in the Global North largely seem to benefit, negative reports from the Global South, where raw materials are sourced, challenge the notion of social progress through electric vehicles. To provide an overview, the following chapter will thus review recent literature on the environmental and social impacts of EVs, starting by delving into the global status of the global EV market and its short- and mid-term outlook.

2.1. Status quo and future of the global EV market

With 40 million sold cars worldwide, the EV sales in 2023 globally hit 18% of total vehicle sales, a sixfold increase from 2018. China led the market with close to 60% of global EV acquisitions, while Europe and the US followed with approximately 25% and 10%, respectively (IEA, 2024). Outside these major markets, however, EV adoption is minimal. To offer an example, despite Africa’s role in supplying raw materials for EV batteries, its EV market is very small, with South Africa leading at only 0.1% of total car sales being battery electric vehicles (Lamprecht, 2023). However, there are signs of an upward trend in increasing EV manufacturing (Payton, 2024).

Until 2035, the International Energy Agency (IEA) (2024) projects an exponential increase in the global electric vehicle fleet. The Announced Pledges Scenario, for example, showcasing the adoption of EVs according to the disclosed future climate targets of all countries worldwide, foresee a growth rate of 24 % annually until 2035 and thus a global EV adoption of 585 million used cars in that year. Compared to the Net Zero Emissions by 2050 Scenario, which states the amount necessary to stay below 1.5 degrees Celsius in comparison with preindustrial periods, until 2035, an annual increase of 27 % would be necessary resulting in a global adoption of 790 million EVs. This still indicates a gap of 3 percentage points annually, highlighting the incumbent need to accelerate climate policies in the global transport sector.

2.2. Impacts of electric vehicles

The transport sector is the third-largest CO_2 emitter globally, with road transportation being the highest contributor (Liu et al., 2023). Here, electric vehicles can be an important lever to decrease emissions incurred by motorized mobility. Several arguments in favor of EVs against ICEVs can be denoted. There are no tailpipe emissions, recharging the battery does not lead to increased emissions, especially if the electricity is generated by renewable sources, and they do not emit harmful gases into the air (Guo et al., 2023).

The production phase, however, represents a more problematic issue. Especially the manufacturing of batteries is energy-intensive and often relies on fossil fuels, leading to significant environmental and social challenges (Degen & Schütte, 2022). Lithium extraction, for instance, has detrimental effects on local ecosystems and communities (Campbell, 2022). Although recycling methods are continuously improving, the disposal of lithium-ion batteries also poses risks of toxicity and pollution, (Wan & Wang, 2022). Additionally, emissions from brakes and tires, independent of the vehicle's fuel type, may increase due to the larger size of EVs (Bondorf et al., 2023).

Overall, while their manufacturing phase remains problematic, electric vehicles are considered more sustainable over the entire lie cycle. To underline this notion, studies calculating the breakeven point, describing the point - usually expressed in driven kilometers - after which usage intensity electric vehicles outperform ICEVs, are considered to be useful. Lienert (2021) for instance asserts that the breakeven point for environmental benefits largely depends on the energy source and varies by country as well as the automobile and can be as low as 15.000 km and as high has 70.000 kilometers. Also Guo et al. (2023) and Verma et al. (2022) argue that EVs generally have lower lifecycle emissions compared to internal combustion engine vehicles, after passing the initial production and manufacturing phases.

Also social impacts of electric vehicles differ by region and stage in their lifecycle. In the Global North, benefits include reduced air and noise pollution, less maintenance, and improved energy independence. However, electrification requires significant infrastructure changes and may not equally benefit all income groups or rural areas (Lee & Brown, 2021; Ploeg, 2022). In contrast, the Global South faces challenges related to resource extraction, including poor working conditions and environmental degradation (Peša, 2022). Consequences from end-of-life disposals, such as health issues resulting from toxic substances in landfill batteries or incineration incidents, are also important to consider (Yanamandra et al., 2022).

To dive deeper into the social aspects of electric vehicles during their life cycles, the following will explore the social impacts of EVs in Norway and the Democratic Republic of Congo, analyzing production, usage, and end-of-life stages utilizing the Social Life Cycle Assessment framework. Bevor that, the applied methodology is presented in the next chapter.

3. Social Life Cycle Assessment

The Social Life Cycle Assessment (S-LCA) is an emerging methodology used to evaluate the social impacts of goods and services throughout their entire life cycle—from production to disposal. Complementing traditional Life Cycle Assessments (LCA) and Environmental Life Cycle Assessments (E-LCA), S-LCA offers a framework for understanding not only direct impacts but also broader social implications. This chapter focuses on the methodological framework for S-LCAs as outlined in the 2020 United Nations Environmental Program (UNEP) Guidelines, with particular attention to its four phases and practical applications. Additionally, in every subchapter, the respective practical implications relating to this study are mentioned.

3.1. Methodological Framework

S-LCA involves four phases: Goal and Scope Definition, Life-Cycle Inventory, Impact Assessment, and Life Cycle Interpretation. In the following, there is a summary of each phase according to the UNEP Guidelines (2020).

3.1.1. Goal and Scope Definition

This initial phase involves setting the purpose, object, and methodological framework for the S-LCA study. It should provide a clear statement of the study's objectives and defines its breadth and depth. Key aspects include:

- **Objective and Purpose:** Define what the study aims to achieve and its intended use.
- **Scope:** Identify the study’s focus, including the product or service under assessment, system boundaries, describing the parts and limits of the product or service being assessed, and the functional unit, describing the services provided by the analyzed object in measurable terms.
- **Stakeholders:** Involve various stakeholders to ensure comprehensive decision-making.

Modifications in scope or objectives during the study should be thoroughly documented, and stakeholder involvement is crucial to address potential limitations or new information that may arise.

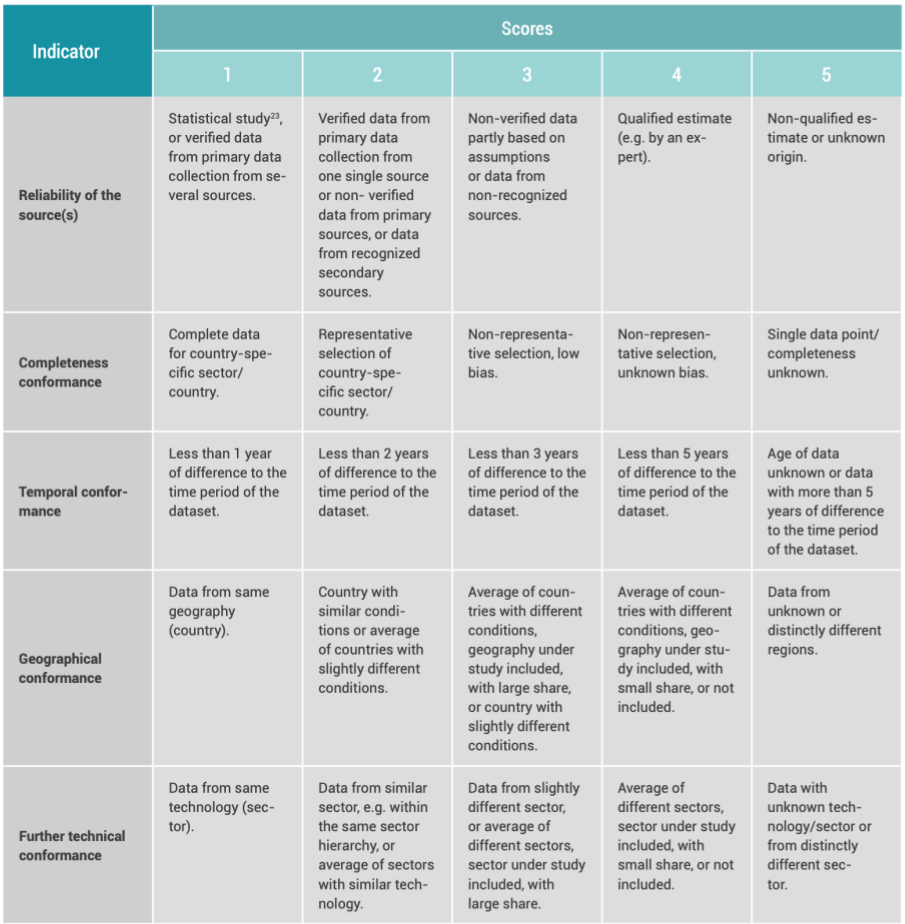
The primary goal of this SLCA is to assess the social impacts of EVs across different life cycle stages in Norway and the DRC. Norway, with its high EV usage and low resource extraction, contrasts with the DRC’s minimal usage but significant resource extraction. This study shall target the scientific community, policymakers, and other stakeholders. It further seeks to fill the gap in existing research by incorporating social aspects into EV analysis. Moreover, the analysis will cover three main phases of EVs: production, usage, and end-of-life. Hereby, the focus will vary by stage and country.

3.1.2. Life-Cycle Inventory (S-LCI)

The S-LCI phase involves data collection within the defined system boundaries established in the Goal and Scope Definition phase. Key tasks include:

- **Data Collection:** Gather data for relevant stakeholders and subcategories, focusing on both site-specific and generic data.
- **Prioritization:** Prioritize data collection efforts based on its relevance and impact.
- **Indicators:** Use over 100 inventory indicators quantifying 31 Methodological Sheets and 6 Stakeholder Groups described in the UNEP 2021 Methodological Sheets to guide data collection and analysis. An example could be in the stakeholder category *Worker*, the subcategory *Child Labor* and further the percentage of working children under the age of 15 years old in a country, region, or certain facility.

For this analysis, the mainly used data sources are secondary literature and open-access databases. The relevant secondary data sources include, for instance, government reports, academic publications, and NGO reports. Primary data, such as surveys and interviews, were also exclusively sourced from existing literature and from open access sources in order to not exceed the scope of this task. The data prioritizing was based on the criteria depicted in pedigree matrix below (Figure 1), attempting to reach an average of 2 or lower.



Indicator	Scores				
	1	2	3	4	5
Reliability of the source(s)	Statistical study[23], or verified data from primary data collection from several sources.	Verified data from primary data collection from one single source or non- verified data from primary sources, or data from recognized secondary sources.	Non-verified data partly based on assumptions or data from non-recognized sources.	Qualified estimate (e.g. by an expert).	Non-qualified estimate or unknown origin.
Completeness conformance	Complete data for country-specific sector/ country.	Representative selection of country-specific sector/ country.	Non-representative selection, low bias.	Non-representative selection, unknown bias.	Single data point/ completeness unknown.
Temporal conformance	Less than 1 year of difference to the time period of the dataset.	Less than 2 years of difference to the time period of the dataset.	Less than 3 years of difference to the time period of the dataset.	Less than 5 years of difference to the time period of the dataset.	Age of data unknown or data with more than 5 years of difference to the time period of the dataset.
Geographical conformance	Data from same geography (country).	Country with similar conditions or average of countries with slightly different conditions.	Average of countries with different conditions, geography under study included, with large share, or country with slightly different conditions.	Average of countries with different conditions, geography under study included, with small share, or not included.	Data from unknown or distinctly different regions.
Further technical conformance	Data from same technology (sector).	Data from similar sector, e.g. within the same sector hierarchy, or average of sectors with similar technology.	Data from slightly different sector, or average of different sectors, sector under study included, with large share.	Average of different sectors, sector under study included, with small share, or not included.	Data with unknown technology/sector or from distinctly different sector.

Figure 1: Pedigree-matrix to assess data quality considering different criteria components (Eisfeldt, 2017)

3.1.3. Impact Assessment (S-LCIA)

During the S-LCIA the social impacts of a product system, considering both potential and actual impacts, are illustrated. The 2020 UNEP Guidelines describe two main approaches:

- **Referencing Scale Approach (RS S-LCIA):** This method assesses social performance or risk using ordinal scales representing various levels of social performance. Reference points are based on international standards or industry best practices.
- **Impact Pathway Approach (IP S-LCIA):** This approach provides general indicators for social impacts through midpoint and endpoint indicators. It focuses on the causal chain of processes and their social consequences.

Each approach has distinct applications, with the RS approach often used in practice and the IP approach primarily in research.

The selected approach for this paper is the Impact Assessment, because it is highly useful to explore cause-effect chains to assess how activities affect various stakeholders when it comes to comparisons of two countries throughout different life cycle stages. While in Norway the primary focus will lie on the usage phase examining societal impacts like pollution levels and urban satisfaction, in the DRC, the production phase with a clear focus on workers' conditions, such as fair remuneration or Health and Safety issues, will be thoroughly investigated.

3.1.4. Life Cycle Interpretation

The final phase involves reviewing all previous phases to ensure completeness, consistency, and data quality. Key steps include:

- **Completeness Check:** Ensure all aspects of the Goal and Scope Definition are addressed.
- **Consistency Check:** Verify that methodology and data use are consistent throughout the study.
- **Sensitivity and Data Quality Checks:** Assess the validity and reliability of the data, considering potential uncertainties.
- **Discussion and Recommendations:** Provide conclusions and recommendations based on the interpretation of the data.

The interpretational stage will verify that all aspects of the Goal and Scope Definition are addressed, maintaining methodological consistency. Uncertainty and sensitivity analyses will be conducted to validate data reliability. Conclusions and recommendations will be based on the findings, with a focus on improving the social impact assessments of EVs. The entirety of this will be provided in Chapter 6.

3.2. Applications

Applications of S-LCA can span diverse areas, including electronics (Ekener-Petersen & Finnveden, 2013), clothing (Zamani et al., 2018), waste (Vinyes et al., 2013), buildings (Hosseinijou et al., 2014), and automotives (Pastor et al., 2018). In general, S-LCAs have seen increasing adoption across various sectors since the early 2000s, with significant growth in publications from 2017 onward (Pollok et al., 2021). The renewal of the UNEP Guidelines in 2020 standardized the methodological framework and thereby helped to foster greater coherence and applicational array, which will likely correspond to an increase in the number of studies throughout the 2020s. The general rise in interest and legislation related to Corporate Social Responsibility (CSR) and Environmental, Social, and Governance (ESG) indicators further emphasizes the importance of social impacts in supply chains and industries.

In the 2020 Guidelines, the Social Organizational Life Cycle Assessment (SO-LCA) was introduced, focusing on social hotspots within organizations. Examples include studies on Italian wine production (D'Eusanio et al., 2022) and academic activities at the University of the Basque Country (Erauskin-Tolosa et al., 2021).

The most relevant studies in providing content and potential manuals for this paper stem from the sectors fuel production (Macombe et al., 2013), general mobility (Gompf et al., 2020), and a study comparing several nations of the Global South (Venkatesh, 2019). It is in general notable, however, that there is a gap in S-LCA studies specifically related to electric vehicles, rendering this analysis a pioneering effort in assessing their social impacts across different contexts.

4. S-LCIA in Norway

Norway's electric vehicle market is among the most advanced globally, with EVs making up more than 94% of the country's vehicle sales in August 2024 (Mobility Portal, 2024). Furthermore, the IEA (2023) states that the Scandinavian country also leads in EV ownership per capita, with 117.3 BEVs per 1,000 people, far ahead of other countries as per the end of 2023. The success of EV adoption is driven by long-standing policies, including tax exemptions and incentives, although most of the measures have been gradually reduced since 2018 (Norsk elbilforening, 2023). Furthermore, the intense use of EVs has caused a sharp decline in fossil-fueled car usage, with electric vehicles expected to surpass diesel as the most used vehicles by during the current decade (Andrew, 2023).

This chapter now intends to provide an overview of the social impacts associated with the life cycle stages of electric vehicles in a mature market like Norway's, utilizing the Impact Pathway Assessment methodology. First, Section 4.1. covers the EV market in Norway as well as potential social implications throughout the EV life cycle. Second, Section 4.2. examines the usage phase of electric vehicles in the Nordic country. Finally, Section 4.3. discusses the specific impacts on stakeholders involved in the end-of-life stages.

4.1. Production

The literature addressing the social impacts within the supply chain of electric vehicles in Norway is notably limited, particularly concerning the production process and its subsequent effects. Understanding the complexities of EV rollouts in Norway requires a closer examination of the early stages of the EV life cycle. Henceforth, this section aims to highlight several problematic aspects, ultimately leading to the causal effect chain presented in Impact Pathway 1 (Table 1).

One crucial factor in the production phase of EVs is cobalt, a crucial raw material for modern batteries. Around 70% of the world's supply comes from the second country of this analysis, the Democratic Republic of Congo (Gulley, 2022). Here, the literature reveals significant issues in DRC's cobalt mines, including hazardous working conditions, child labor, low wages, and ecosystem degradation (Niarchos, 2021), which will be displayed in more detail later on. Other raw materials, such as lithium and copper, also raise environmental and social concerns. Lithium extraction often leads to water depletion and wildlife disruption (Chaves et al., 2021), while copper mining can cause deforestation and water pollution, potentially inflicting harm on the local population (Chen et al., 2022). The burdens of this high-level resource extraction disproportionately affect lower-income nations, as emphasized by Sovacool et al (2020). The authors, argue that the "cleanness" of low-carbon technologies is called into question when they rely on problematic mineral extraction practices. This inequality in the extraction process will be further examined in Chapter 5.

After raw material extraction, refining and battery manufacturing predominantly occur in China, which processes over half of the world's lithium, cobalt, and graphite. Here, concerns repeatedly arise regarding the working conditions in Chinese-run mines, especially in the DRC (Tae, 2021; Wu, 2023).

To display the connection to Norway, the following example shall shed light on the typical value chain of EVs. The Tesla Model Y, best-selling electric vehicle in Norway in 2022, relies on batteries from the Chinese enterprise Contemporary Amperex Technology Co., Limited (CATL), a major player in the cobalt supply chain linked to DRC mines (Williams, 2023). Keeping in mind the aforementioned issues, this connection raises ethical questions about the environmental as well as the social implications and taints the utilization of such vehicles in Norway.

In response to these challenges, Norwegian authorities emphasize the need for 'clean,' 'ethical,' and 'sustainable' supply chains (Remme et al., 2023). However, despite advocating for ethical practices, specific plans for implementation remain vague. The Norwegian government's Battery Strategy (2022) mentions enhancing the sustainability of supply chains but lacks detailed action plans. Potential solutions include exploring newly discovered raw materials in Norway's seabed to improve self-sufficiency and developing cobalt-free batteries. However, technological constraints may hinder immediate progress (Braw, 2023). The recycling and repurposing of batteries are also emerging as significant fields, although challenges regarding their short-term feasibility remain (Figenbaum, 2020). Furthermore, while these approaches may succeed in improving the overall sustainability, there is a risk that they may excuse a reduction in commitments to address social impacts in the raw material extraction site, as noted by Sovacool et al. (2020).

The Social Life Cycle Impact Assessment (S-LCIA) in this section results in several potential the impact pathways, of which one is shown in Table 1, focusing on the stakeholder group local communities, the area of protection safe and healthy living conditions in line with UNEP Methodological guidelines (2021).

Stakeholder Group in Focus	**Inventory Indicator**	**Midpoint Indicator**	**Endpoint Indicator**	**Area of Protection**
Local Communities	Increasing Share of EV Purchases in Norway	Rising Raw Material Extraction	Advanced Degradation and Health Issues	Safe and Healthy Living Conditions

Table 1: Impact Pathway 1 – Local Communities affected by Norway

4.2. Usage

In this section, potential impact pathways related to electric vehicle adoption in Norway are analyzed, relating to consumer effects, societal impact, and consequences for urban communities.

During the usage phase, the financial benefits for consumers are notable. Norway’s large-scale EV incentivization has allowed early adopters to gain significantly from subsidies, with charging electricity generally costing less than fueling an ICEV (Figenbaum, 2020). However, fluctuations in electricity prices—due to general price dynamics as well as geopolitical tensions—could impact these benefits (Jåstad et al., 2022; Statista, 2023). Therefore, sustainable policies and increased energy autonomy are essential for maintaining lower electricity costs, thereby supporting affordable mobility for EV users.

Environmental benefits of EV usage include reduced noise pollution and decreased exposure to greenhouse gases, which are beneficial for communities with EVs driven in their residential areas. Here, the ‘neighborhood effect’, stated by Yang et al. (2023), suggests that one EV purchase can encourage others nearby to follow suit, enhancing local air quality and noise levels. Furthermore, increased EV adoption may strengthen local electricity grids via vehicle-to-grid technology, resulting in broader infrastructure improvements (Yu et al., 2022).

However, the purchasing price of battery electric vehicles remains a barrier. Figenbaum (2022) reported a price difference of 20,000 to 30,000 NOK (approximately €1,700 to €2,600) between EVs and ICEVs. Recent government tax implementations on vehicles exceeding 500,000 NOK (around €43,500) have further increased EV prices (Norsk elbilforening, 2023). Henceforth, while total ownership costs are often lower for BEVs due to reduced fueling and maintenance expenses, initial purchasing costs can deter potential buyers.

On a societal level, the rollout of EVs in Norway brings forth significant social implications. One major concern in the literature is the socioeconomic disparity linked to EV adoption. Fjørtoft and Pilskog (2020) demonstrated a correlation between BEV ownership and income levels, revealing that in 2019, the top 20% of earners owned nearly 60% of all electric vehicles. This disparity suggests that access to EVs is a critical factor for individuals to reap the associated social and environmental benefits.

Yang et al. (2023) further emphasized societal inequalities in EV adoption, noting that urban residents—who tend to have higher incomes and access to more charging stations—are more likely to adopt electric vehicles. Their research indicated that a 10% increase in urban population could boost EV utilization by 5.5%. Additionally, lower temperatures negatively affect BEV performance, with each 10-degree Celsius rise in minimum temperature correlating with a 5% increase in EV acquisition. The aging population, particularly those aged 60 to 80, also plays a role in, reducing usage by 3.3%. All these factors indicate potential challenges for the future of EV adoption in Norway.

Another group of stakeholders affected by rising EV adoption is local communities. In that regard, various potential issues have been emerged. For instance, Oslo, known as the ‘capital of electric vehicles’, has experienced a reduction in greenhouse gas emissions attributed to the shift from ICEVs to EVs. This is highlighted with a 30% decrease in overall emissions from 2009 to 2021 (KlimaOslo, 2023). A different report indicated a 15% reduction in direct GHG emissions from road transport between 2009 and 2020 (City of Oslo, 2022). These transitions underscore the positive contribution of EVs to public health and the local community.

However, despite the environmental and social benefits of EVs, cars continue to pose challenges in urban settings. Key concerns include potential increases in fatal accidents due to the quiet operation of EVs and spatial issues resulting from the need for more parking spaces. Interestingly, data from Riaz et al. (2020) indicate a decline in fatal accidents in Oslo from 41 in 1975 to just one in 2019, countering fears of increased fatalities due to EVs. Conversely, the distribution of parking spaces has become a larger issues and sparked debate among residents. Bjerkan et al. (2021) highlighted that Oslo has removed over 700 parking spaces in the city center to create bus lanes and pedestrian areas, causing dissatisfaction among residents. In contrast, Bergen has embraced EVs by providing free parking and charging in the city center, where EV users constitute 60% of parking but only pay 1% of fees. This disparity is still causing controversies in the Scandinavian country and generates heated discussions.

As a result of increased automobile purchases and problems with urban parking situations mentioned above, according to Remme et al. (2023), the Norwegian government initially aimed at reducing private vehicle usage altogether. The authors reported that in 2019, however, a panel of mobility technology experts and e-mobility lobbyists advised the Norwegian government to prioritize a zero-emission target over a no-growth objective for individual traffic. This shift, incorporated into the Norwegian National Transport Plan, may obscure the goal of reducing car numbers, with potential implications for spatial planning in urban areas. The emphasis on emissions-free vehicles could detract from efforts to create car-free cities. While the government officially aims to reduce car numbers, the EV industry's influence, public sentiment, and social unrest among car users could slow this progress. Here, the director of Norway's Institute of Transport Economics (TØI) urged the government to curtail the growth of electric vehicles to promote more sustainable transport modes, like public transit and cycling.

Concluding from the S-LCIA undertaken in this section, two potential Impact Pathways are illustrated. Impact Pathway 2 (Table 2) shows the relevant stakeholder group society. The area of protection comprises social equity among members of Norwegian society. Because the S-LCIA revealed certain discrepancies in the consumption behavior of individuals due to their levels of income, location, and age, accessibility to EVs is the starting point of the IP. The endpoint indicator is the degree of segregation in EV usage after analyzing the shares of EVs among various groups according to their socioeconomic characteristics. Ideally, EV adoption should be evenly spread out in order to maintain a favorable level of social equity.

Stakeholder Group in Focus	Inventory Indicator	Midpoint Indicator	Endpoint Indicator	Area of Protection
Society	Accessibility of EVs	Share of EVs across Diverse Socioeconomic Groups	Degree of Segregation in EV Usage	Social Equity

Table 2: Impact Pathway 2 – Society in Norway

Impact Pathway 3 (Table 3) illustrates a potential cause-effect chain discussed in this section involving local communities. To highlight the focus on urban areas, the stakeholder category of the UNEP Guidelines was altered to urban communities, and the area of protection, namely safe and healthy living conditions, was taken verbatim therefrom. The IP begins with the use of electric vehicles. According to their intensity and rate of substitution with ICEVs, a city experiences a decline in GHG and noise emissions, as demonstrated previously in the case of Oslo. This emission reduction leads to the endpoint indicator, which displays the diminished levels of overall pollution resulting from broad EV adoption.

Stakeholder Group in Focus	Inventory Indicator	Midpoint Indicator	Endpoint Indicator	Area of Protection
Urban Communities	Intensity of Usage of Electric Vehicles within the City	Reduction of harmful emissions	Diminished Levels of Air and Noise Pollution	Safe and Healthy Living Conditions

Table 3: Impact Pathway 3 – Urban Communities in Norway

4.3. End-of-Life Phase

The end-of-life phase of electric vehicles raises critical environmental concerns, primarily due to the lithium-ion batteries they contain. These batteries can release toxic substances upon disposal, posing risks to human health and local ecosystems. Additionally, incidents of fires related to lithium-ion batteries have increased significantly, rising from two in 2013 to 68 in 2019 in the U.S. alone (EPA, 2021). In Norway, battery-related fires have also been reported, for example in passenger ferries (Schuler, 2019). Extinguishing such fires can be challenging , due to the batteries' tendency to burn quickly and the high risk of reignition (Yuan et al., 2021).

To address battery waste, extending battery lifespan is crucial. While batteries can ideally last up to 25 years, typical replacements occur between 8 and 14 years (Huster et al., 2022). Once batteries reach the end of their effective life, options include, in order from best to worst, reusing for other energy purposes, recycling their components, and putting them on landfill sites. Challenges, like the complication of disassembly and material recovery, complicate the increase of the share of the first two and thus impede longer batter utilization (Kamath et al., 2020).

Norway is considered a leader in battery recycling, with facilities like Hydrovolt capable of processing 8,000 tons annually (Remme et al., 2023). Nonetheless, systemic barriers, including high repair costs imposed by manufacturers like Tesla, hinder effective reuse and recycling efforts. In 2019, approximately 1,400 EVs were scrapped in Norway, many less than five years old (Myklebust, 2021). Consequently, achieving circularity in the Norwegian EV market remains a significant challenge. This directly affects the consumer and their decision whether to repair the current or purchase a new vehicle. IP 4 (Table 4) illustrates this dilemma, with the inventory indicator being the existence of cost-effective repairing opportunities and the resulting possibilities for an EV to contain reused parts. The endpoint indicator is then the total cost after the potential repairments. If they decrease in the long run, this could prolong the lifespan of electric vehicles significantly, which portrays the area of protection for this case.

Stakeholder Group in Focus	Inventory Indicator	Midpoint Indicator	Endpoint Indicator	Area of Protection
Consumers	Cost-Effective Repairing Opportunities	Number of Reused Parts in the Vehicle	Total Costs after Damages	Prolonging the Lifespan of Electric Vehicles

Table 4: Impact Pathway 4 – Consumers in Norway

5. S-LCIA in the DRC

The Democratic Republic of Congo has a negligible market for electric vehicles, with only 979 cars of that type sold in 2022 (Focus2Move, 2023). This is in part due to a lack of infrastructure and electrification, as only 24% of its population has access to electricity (Ayetor, 2022) and solely a low single-digit percentage of the entire road system is tarred in the Central African nation (Muhebwa et al., 2024). The limited adoption is contrasted by the DRC's dominance in cobalt production, supplying 70% of the world’s cobalt, a key material in EV batteries (Gulley, 2022).

While ongoing research explores alternatives to cobalt, short-term reliance on the DRC for this material is expected to continue as it remains essential for lithium-ion battery production. The social implications of this dependence are substantial, as the DRC's cobalt mines have been linked to human rights violations such as child labor, unsafe working conditions, and environmental degradation. China's dominant role in refining and owning cobalt mines further complicates the situation, as economic benefits to the DRC are limited while the social costs remain high. The Social Hotspot Analysis identifies these social impacts across three EV life-cycle stages: production, usage, and disposal. However, the minimal presence of EVs in the DRC complicates an assessment of the usage phase. The disposal of batteries also presents challenges, particularly with the improper handling of batteries contributing to environmental harm, affecting local population. Therefore, the following sections shall underscore the need for addressing human rights and environmental issues linked to cobalt mining, while recognizing the DRC's continued importance in the global EV market.

5.1. Production

The increasing global demand for electric vehicles has significant social consequences, particularly in the DRC, the main producer of the world's cobalt. This raw is essential for lithium-ion batteries, and as EV production rises, the demand for cobalt is projected to grow simultaneously. While the DRC is a central supplier, its cobalt sector is largely dominated by foreign companies, particularly Chinese firms that control 82% of the country's cobalt production (Tae, 2021).

The cobalt industry in the DRC has been facing challenges for more than 100 years. The country's cobalt production dates back to 1914 under Belgian colonial rule, it then became integral to global conflicts like World War II due to its use in military materials. Since gaining independence, the sector has suffered from political instability, economic turmoil, and the dominance of foreign powers, with China now playing a leading role in the industry (Gulley, 2022). Consequently, the DRC's cobalt mining industry is characterized by neocolonial structures that exacerbate social issues for workers and communities.

The effects of the raw material mining in the DRC extend across various vulnerable groups. Workers, particularly those in artisanal small-scale mines (ASMs), face dangerous conditions, working 10-15 hours per day, largely without safety measures. These artisanal miners, also known as creuseurs, account for 98% of the workforce but produce only 20% of the cobalt, as large-scale industrial mines (LSMs) use mechanized processes and dominate production (Sovacool et al., 2020). As a result, numerous creuseurs, despite their efforts, remain trapped in poverty, with 66% of employed individuals in the DRC falling below the international poverty line (ILO, 2022). Additionally, workers are vulnerable to theft and exploitation, further compounding their precarious situations (Niarchos, 2021).

Another significantly affected group are children, over 40,000 of them assumed to be working in cobalt mines, some as young as four years old (UNCTAD, 2020). These children are exposed to hazardous working conditions and earn extremely low wages, contributing to a cycle of poverty and exploitation (Amnesty International, 2016). Gender dynamics in the industry also place women at a disadvantage. They are primarily tasked with cleaning and transporting cobalt ores, jobs that expose them to harmful toxins. Moreover, prostitution around mining sites is prevalent, leading to higher rates of sexually transmitted diseases and violence against women, including rape and other violent atrocities (Sovacool et al., 2020).

Ethnic minorities, including internally displaced persons and refugees, are also disproportionately affected. The DRC's history of civil wars and economic instability has led to the displacement of 6.1 million people, many of whom have limited opportunities, with working in cobalt mines seemingly the only possible source of income (OCHA, 2023). These workers, however, often lack the necessary skills or networks to thrive in the mining industry, exacerbating existing social inequalities related to ethnicity and class (Sovacool et al., 2020).

The environmental and health impacts of cobalt mining are also profound. Local communities around mining areas face severe environmental degradation, including dust pollution, water contamination, and heavy metal exposure. The consequences of such pollution are particularly harmful to children, who exhibit higher rates of heavy metals in their blood and urine (Sovacool et al., 2020). Additionally, forced evictions in communities near mining sites further contribute to social disruption. Amnesty International (2023) documented hundreds of households being evicted without adequate compensation, in violation of international law.

Despite claims of sustainability and ethical practices by some cobalt mining companies, the reality on the ground often tells a different story. The adverse impacts of cobalt mining in the DRC on workers, women, children, and local communities suggest that urgent reforms are needed to address these deep-seated issues. Without such measures, the increasing demand for cobalt, driven by the global EV rollout, is likely to continue reinforcing a system of exploitation, poverty, and environmental harm in the DRC.

Two out of numerous potential impact pathways in this chapter are displayed below. The first IP (Table 5) illustrates the cause-effect chain portraying the area of protection Basic Human Rights for the stakeholder groups Workers. The starting point is the Temporal Intensity of Cobalt Extractions, while the midpoint indicators shall measure the Level of Remunerations, Health and Safety Standards, and the Number of Working Hours. The endpoint indicator is the Existence of Safe and Healthy Working Conditions and Fair wages.

Stakeholder Group in Focus	**Inventory Indicator**	**Midpoint Indicator 1**	**Midpoint Indicator 2**	**Midpoint Indicator 3**	**Endpoint Indicator**	**Area of Protection**
Workers	Intensity of Cobalt Extractions	Level of Remuneration	Health and Safety Standards	Number of Working Hours	Existence of Safe and Healthy Working Conditions and Fair Wages	Basic Human Rights

Table 5: Impact Pathway 5 – Workers in the DRC

The second impact pathway (Table 6) demonstrates the denial of opportunities for congolese citizens after their childhood. Starting from the time spent in cobalt mines instead of receiving education plus the negative health impacts from the physical labor and the toxic ores, resulting in cobalt mining negatively affecting their quality of life.

Stakeholder Group in Focus	Inventory Indicator	Midpoint Indicator 1	Midpoint Indicator 2	Endpoint Indicator	Area of Protection
Children	Time spent in the Cobalt Mines	Loss of education	Negative Health Impacts	Denial of Opportunities after the Childhood	Quality of Life

Table 6: Impact Pathway 6 – Children in the DRC

5.2. Usage

Given the near absence of electric vehicle usage in the DRC, an S-LCIA on their usage would be redundant. As such, this chapter will instead concentrate on the current state of mobility infrastructure in the DRC and potential strategies for promoting the adoption and use of electric vehicles.

The Democratic Republic of Congo is one of the most infrastructurally challenged countries in the world. The country's geographical and geological difficulties, including dense forests and complicated river flows, make it difficult to construct effective infrastructure. Furthermore, the nation’s history of conflicts and wars has resulted in the destruction of transportation routes, and many roads are still in disrepair (Gulley, 2022). Without significant action to enhance the road network, it could take a century to catch up to the infrastructure of developed countries in the Global North. Additionally, merely one fourth of the country has regular access to electricity, which is the 48th spot out of 54 on the African continent (Ayetor, 2022).

Consequently, from a technological perspective, several factors need to be considered prior to the widespread adoption of electric vehicles in the Democratic Republic of Congo. Typically, urban areas serve as the starting point for the penetration of electric vehicles. However, in both volumes of the "Project for Urban Transport Master Plan in Kinshasa" published in 2019 by the Ministry of Infrastructure, Public Works, and Reconstruction of the DRC, there was no mention of electric vehicles. On the contrary, certain enterprises have expressed an interest in transforming the mobility sector towards electrification. For instance, the electric car rental company ‘Mopepe Solutions’ aims to expand its charging station network to 500-1,000 over the coming years. However, a monthly subscription price of over 100 US dollars may impede mass usage, as admitted by the company's founder Yacine Fylla. Therefore, it can be inferred that there is a long way to go before there is a significant adoption of electric vehicles in Kinshasa, let alone the DRC as a whole (Takouleu, 2021).

The impact pathway in this chapter (Table 7) illustrates the missing provision of mobility options, as the accessibility of EVs is very low. To enlarge actual EV usage, the road network as well the access to electricity need to be enhanced.

Stakeholder Group in Focus	Inventory Indicator	Midpoint Indicator 1	Midpoint Indicator 2	Endpoint Indicator	Area of Protection
Society	Accessibility to EV Usage	Road Network	Access to Electricity	Actual EV Usage	Provision of Mobility Options

Table 7: Impact Pathway 7 – Society in the DRC

5.3. End-of-Life

As previously discussed, there are harmful inflictions on the local population surrounding landfill sites stemming from car batteries. However, the limited utilization of these batteries suggests that they are primarily used in vehicles with internal combustion engines. Therefore, the assessment of the end-of-life stage does not consider direct impacts from the physical presence of rejected EV batteries. Nevertheless, there are impacts on the DRC to consider from the handling of batteries in countries with significant usage of EVs, such as Norway.

As decision-makers in the political and business spheres become increasingly aware of issues related to cobalt in their supply chains, they frequently express a desire to make changes and improve their sustainability and traceability standards. As such, the growing research and practical application of recycling batteries are expected to significantly contribute to greater circularity in this sector. However, this increased focus on recycled cobalt could have negative consequences for workers and the other stakeholder groups mentioned in Section 4.1. In addition to the two other major solutions presented above (increased raw material autarchy and the development of cobalt-free batteries), a greater reliance on higher recycling levels in the future could potentially undermine the commitments made by several companies and governments, such as Norway, to improve the working conditions on cobalt extraction sites, as outlined in Norway's Battery Strategy in 2022 or the legislative framework of the European Parliament in 2022. Similar conclusions have been drawn by Remme et al. (2023) and Sovacool et al. (2020).

Therefore, the impact pathway (Table 8) described here focuses on labor standards in cobalt mines, that might decline due to decreasing commitments by other value chain actors, resulting from increased recycling or independence from cobalt.

Stakeholder Groups in Focus	Inventory Indicator	Midpoint Indicator	Endpoint Indicator	Area of Protection
Workers (including children, women, and refugees)	Increased Recycling Levels in Countries with Intense Usage	Decreasing Commitments to Improve Working Conditions	Labor Practices in Cobalt Mines	High Labor Standards

Table 8: Impact Pathway 8 – Society in the DRC

6. Conclusion

This paper analyzes the social impacts of electric vehicle adoption in Norway and the Democratic Republic of Congo through a Social Life Cycle Assessment (S-LCA) framework, examining production, usage, and end-of-life phases. While EVs are environmentally cleaner than internal combustion engine vehicles (ICEVs), their production is resource-intensive, and the social impacts are ambiguous.

First, the following sentences provide an overview of the interpretation phase within the SLCA framework used to evaluate social impacts in the EV sectors of Norway Congo DRC. The study is deemed methodologically consistent, with data collected from relevant impact pathways, though some limitations, such as outdated sources and the qualitative nature of the research, are acknowledged. The primary objective of offering a comprehensive, qualitative assessment of social impacts was achieved, despite informational gaps and a focus on negative aspects in the DRC. Uncertainty and sensitivity were addressed using basic approaches, outlined by Igos et al. (2018) as quantification was not the focus.

To conclude the analysis, Norway's EV rollout reduces pollution and offers financial benefits but raises inequality issues, as EV adoption is concentrated in wealthier households. The end-of-life phase of EVs raises concerns about premature disposal and battery hazards, requiring stronger regulations for circularity. In contrast, the DRC, a major cobalt supplier, faces severe human rights violations in cobalt mines, including poor wages, unsafe working conditions, and environmental degradation. The thesis emphasizes the "decarbonization divide," where the Global North benefits from cleaner technologies while the Global South bears the environmental and social costs. This divide reflects broader global inequalities, rooted in colonial legacies and exploitative economic structures. Sovacool et al. (2020, p. 18) underline this line of argumentation:

“[...] patterns of injustice and domination are embedded in existing processes of decarbonisation, in spite of the assumption that low carbon trajectories represent a more just way of producing energy. While decarbonisation may thus contribute to cleaner air and cleaner production in the Global North, much of the environmental and social harm is simply made invisible and displaced, or spatially externalized, to the Global South. We term this phenomenon the “decarbonisation divide,” and that divide is simultaneously conceptual or epistemic, geographic, environmental, and developmental. Conceptually, it reflects an epistemic divide in that much research in the North focuses on the diffusion and use of decarbonisation technology and systems, but ignores harmful impacts and the reproduction of inequalities in other parts of the lifecycle (upstream, downstream) in the South. The term captures a geographic divide in that those impacts are split literally and unevenly across space by continents: cleaner technology is deployed in one place (East Asia, Europe, North America) whereas its manufacturing costs and wastes occur in another place (Africa and other parts of the developing world). It reflects an environmental divide, in that the Northern natural environment gets cleaner while the Southern environment gets dirtier and even locked into more polluting and at times carbon intensive activities. The term lastly reflects a relational

developmental divide, a process by which some localities are forced into Faustian pacts with other wealthier and powerful countries or firms in order to attract revenue or investment, but remain comparatively weak in poverty and perpetual disadvantage."

The study thus calls for strengthened regulatory frameworks, more focus on public transport instead of individual mobility, and improved worker rights in cobalt mines. It highlights the need for future research to focus on the broader social impacts of electric, with particular attention to battery production and recycling.

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