Electric Mobility and Industrial Pollution Transfer: Rethinking Decarbonisation and Environmental Gains in the Light of Battery Supply Chains

1. Introduction

The transition of the global industry towards electric vehicles represents an especially noteworthy instance of industrial transformation, similar in scope to the motorization of the twentieth century. In this respect, data from the International Energy Agency suggests that electric vehicle sales have exceeded 14 million units on the global scale in the year 2023, accounting for 18% of the total automobile sales.

The expansion of electric vehicle adoption has been driven to a large degree by public expenditure on purchase incentives, tax credits, and subsidies for the industry, as well as individual incentives related to lower operating costs. The rationale for this spending has been the need to reduce carbon emissions from road transportation, as it accounts for nearly a quarter of global energy-related carbon dioxide emissions. The environmental rationale for the electric vehicle revolution can be considered to be based on a simple principle. Electric vehicles have zero tailpipe emissions.



Cities that have adopted electric vehicle technology have reported improved environmental conditions. However, climate change does not respect national boundaries. A tonne of carbon dioxide emitted during battery manufacturing in one jurisdiction has identical atmospheric effects to a tonne emitted from an exhaust pipe elsewhere.

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This article examines a question that has received insufficient attention in policy discourse: Do electric vehicle subsidies reduce global pollution, or do they partially shift industrial emissions across borders through concentrated battery supply chains? And is concentrated pollution better than widespread ones? First, this article examines comparative lifecycle emissions between EVs and ICE vehicles, including the crucial question of whether modern vehicles are driven sufficiently far to achieve environmental breakeven. Second, it analyses the economic geography of EV adoption and battery production, examining the contrasting economic conditions of consumer and producer economies. Third, it considers whether localised pollution, while morally troubling, may be environmentally preferable to globally dispersed emissions. The objective is not to challenge electrification itself but to understand the spatial dynamics of environmental outcomes under policy-driven technological change.

2. Lifecycle Emissions and the Breakeven Question

The environmental comparison between electric and conventional vehicles depends fundamentally on lifecycle assessment rather than operational comparisons alone. Conventional gasoline vehicles generate the substantial majority of emissions during use. Estimates suggest that approximately 80–85% of total ICE vehicle emissions arise from fuel combustion and fuel production, with manufacturing contributing a comparatively minor share.

Electric vehicles, on the other hand, exhibits a fundamentally different emission profile. Given that EVs have massive lithium-ion battery packs that involve mining and processing of minerals and energy-intensive processing, it is evident that emissions are concentrated during production.

This structural difference creates what analysts term the "carbon debt" problem. Empirical studies typically estimate manufacturing emissions of conventional vehicles at roughly 5–7 tonnes of CO_2, whereas EV production—including battery fabrication—may exceed 8–12 tonnes of CO_2, even before the vehicle is driven. The environmental advantage therefore emerges only after sufficient operational use offsets production-related emissions by countering through lower usage emissions.

2.1 Breakeven Analysis and Real-World Driving Patterns

The breakeven point—the mileage at which cumulative EV emissions fall below those of a comparable ICE vehicle—varies substantially across regions and manufacturing contexts. BloombergNEF's lifecycle modelling provides the most comprehensive recent analysis, examining five major markets: the United States, China, Germany, the United Kingdom, and Japan. Their findings reveal significant geographical variation:

For a medium-sized BEV produced currently and driven for 250,000 km, the lifecycle CO2 emissions will be 21-71 percent lower than the corresponding ICE vehicles. However, the mileage required to reach the breakeven point varies from around 41,000 km in the United States to 118,000 km in China, depending on the electricity carbon intensity used for manufacturing.

These figures assume vehicles are driven to typical end-of-life mileages. However, this assumption merits examination. Modern vehicles in advanced economies are increasingly retired earlier than their technical potential, whether through accidents, changing consumer preferences, or leasing cycles that export used vehicles to secondary markets. If vehicles are scrapped or exported before reaching breakeven mileage, the environmental rationale for subsidising their initial purchase becomes considerably weaker. This consideration is particularly relevant for premium EVs, which

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may have shorter first-owner retention periods or for first time adopters who are usually affluent owners.

2.2 The Rebound Effect and Behavioural Responses

A further consideration that complicates the breakeven analysis is the possibility that behavioural responses could change the assumed patterns of use. For example, electric cars have much lower running costs per kilometre driven than conventional cars, with the cost of electricity to power the electric motor substantially less than the cost of petrol or diesel per unit energy content, and with the electric motor requiring less maintenance than the conventional engine. Where the government provides subsidies both to the buyer of the electric vehicle and to the cost of electricity to power the vehicle, the cost per kilometre driven is reduced further. The conventional economic response to such a price decrease is that the quantity demanded will rise, a phenomenon that is sometimes termed the rebound effect. The possibility that the price decrease will lead to an increase in the quantity driven, with the electric vehicle replacing the conventional vehicle, could mean that the emissions savings that drive the breakeven analysis will be less than assumed, with the possibility that the vehicle may never reach the breakeven point if the quantity driven increases substantially.

2.3 Manufacturing Location and Emissions Intensity

Geographical insights can be gleaned from recent research carried out by German Aerospace Centre (DLR) on the lithium-ion battery supply chain for electric vehicles in Europe. To be precise, it has been found that in 2019, China accounted for 44% of global battery cell production and 54% of CO2-equivalent emissions generated by the supply chain. Moreover, Canada and Europe showed a much lower emission intensity per unit of production owing to a cleaner electricity mix and stricter industrial regulations. Lithium mining also takes place at Latin American and certain African countries as well.

This finding has profound implications for environmental accounting. An EV sold in Germany but containing a battery manufactured in China embodies emissions that appear in Chinese territorial inventories while enabling German transport emission reductions. The environmental outcome depends not on the vehicle's registration location but on the industrial geography of its production and resource mining.

3. The Economic Geography of EV Adoption and Production

Understanding pollution transfer requires examining the economic conditions characterising major EV consumer and producer economies. The geography of electric mobility reveals a sharp disjuncture between adoption and production.

3.1 Adoption Patterns and Economic Conditions

As per the 2025 assessment by S&P Global, there is a wide disparity in the electric vehicle market uptake in various parts of the world. For instance, Norway has the highest electric vehicle uptake in the world, with more than 80% of new car sales comprised of battery electric vehicles. This can be explained by the consistent support for electric vehicle uptake and high per capita income in the country, which enabled the early adoption of electric vehicles. Mainland China has recorded a historic milestone in 2025, where for the first time, new energy vehicle sales have surpassed 50% of total new vehicle sales, thereby overtaking internal combustion engine vehicle sales. The

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EU5 major markets, including France, Germany, Italy, Spain, and the United Kingdom, have collectively recorded 23% of new energy vehicle sales by mid-2025.

3.2 Production Concentration and Industrial Conditions

Battery manufacturing shows a high geographical concentration, different from the geographical dispersion found in electric vehicle adoption. Based on International Energy Agency (IEA) evaluations, a majority of global lithium-ion cell manufacturing and mineral processing capacity are located in East Asia, with a dominant proportion of refining and manufacturing located in China.

There are a range of related reasons for this high concentration. China has a highly industrialized policy that has supported the development of the battery supply chain by providing subsidies and market protection policies. This has resulted in significant economies of scale, with 2.5 times higher sales volume of new energy vehicles than the total sales volume of the next nine largest countries. This extensive scale has led to a high cost compression that provides a difficult benchmark for competitors.

Industrial conditions in major producer countries vary greatly from those in consumer countries. Manufacturing batteries require energy-intensive processes such as lithium mining, nickel refinery, cobalt refinery, cathode chemical synthesis, and high-temperature battery manufacturing. This type of industry is comparable to conventional heavy industries that are traditionally related to high emissions intensity and lenient environmental policies.

Current reporting on the sodium sulphate waste issue within the battery industry again raises the environmental challenges that can come with production concentration. Chemical & Engineering News states that "for every metric ton of precursors produced for battery cathode materials, 1.5 metric tons of sodium sulphate waste are generated. Projected production from existing battery materials factories could result in the discharge of almost 6 million metric tons of sodium sulphate waste by the end of the decade, an eight-fold increase over the 2022 rate."

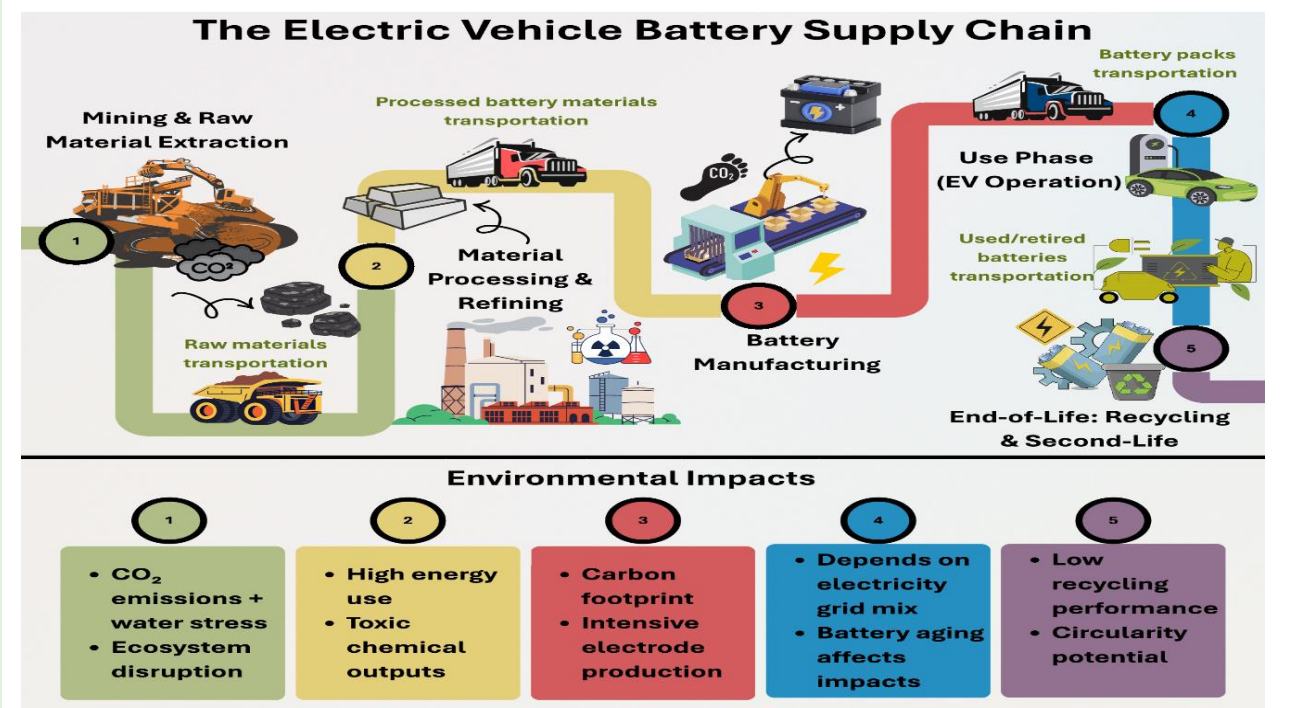
China has an established market for this type of waste product, such as in the production of detergents. However, this is not the case for Europe or North America. Disputes have occurred over ocean discharge permits and wastewater management. The BASF pCAM factory in Finland was delayed by court order over the release of sodium sulphate waste into local waterways.

3.3 The Human Cost of Concentrated Supply Chains

Apart from issues related to the environment, issues of geographic concentration in battery production raise important ethical issues related to labour practices and human welfare. For instance, issues related to the extraction of critical minerals such as cobalt, lithium, and nickel have been directly related to important social externalities that need to be taken into consideration in relation to carbon emission externalities. Investigative journalism is replete with issues related to artisanal cobalt mining in the Democratic Republic of Congo, where informal labour practices involving child labour operate in a perilous environment for economic gain.

These conditions have been documented despite international attention and corporate promises of supply chain due diligence. Ethically, there are two concerns. First, the subsidy effect on electric vehicle production might inadvertently perpetuate hazardous conditions of labour in developing regions where governance is lax and economic alternatives are scarce. Second, the spatial distance between the consumer and producer regions conceals these human consequences from public view, thus facilitating what might be called "ethical leakage," where human and industrial emissions

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are separated. While this paper's focus is on environmental consequences, any evaluation of electric vehicle subsidies must consider the fact that concentrated supply chains are not only concentrated in terms of pollution but also in terms of human welfare consequences. While the question of whether localized pollution is less desirable than diffused emissions must be answered in terms of ecological consequences, the question must also consider whether the human consequences are borne voluntarily, with adequate economic compensation, and with the same degree of environmental protection that the consumer economy demands for itself.

4. Does Localised Pollution Facilitate Environmental Control?

If pollution is localised, is it still easier to control than pollution in smaller amounts spread globally? Like pollution reduction initiatives implemented aggressively at a single heavy source is potentially deemed to be more effective than reducing miniscule but abruptly spread pollution throughout globe. The question invites analytical nuance beyond simple moral condemnation of pollution transfer.

4.1 The Regulatory Advantages of Point-Source Concentration

From an environmental management perspective, concentrated industrial emissions present both risks and opportunities. The risks are obvious, and one of these is that localized pollution can exceed the assimilative capacity of ecosystems, as was shown in the Talvivaara mine disaster in Finland, where the release of sulphates led to "massive ecological disruption" in a freshwater lake. Dense water rich in sulphates settled on the lake bed, where it deprived aquatic life of oxygen.
However, concentration also enables regulatory intervention that is practically impossible for dispersed emissions. A single battery manufacturing facility can, in principle, be monitored continuously, subjected to emission standards, and required to install pollution control equipment. The Finnish court's ability to delay BASF's plant operation until wastewater management concerns were addressed exemplifies this regulatory capacity. Similarly, companies developing sulphate

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recycling technologies—such as Cinis Fertilizer's conversion of sodium sulphate to potassium sulphate fertilizer, or Aepnus Technology's electrolytic recovery of sulfuric acid and sodium hydroxide—can only address pollution where it is generated at scale.

By contrast, the global dispersion of ICE vehicle emissions presents an intrinsically more difficult regulatory challenge. Millions of mobile sources, operating across jurisdictions with varying maintenance standards and fuel qualities, generate cumulative emissions that exceed industrial sources but resist point-source control.

This argument of regulatory efficiency, it should be noted, must be distinguished from a different normative argument: that of distributive justice. The argument that concentrated pollution is easier to control is simply addressing the technical feasibility of managing the environment; it does not address the issue of whether it is morally justifiable for consumer-rich advanced capitalist nations to secure cleaner air at the expense of communities that are likely poorer, less politically influential, and already subject to cumulative environmental degradation. The distinction between efficiency and justice is important for clear policy thinking: on the one hand, we are talking about technical feasibility; on the other hand, we are talking about justice and morality. The question of justice is not simply about whether each ton of sulphate waste is perfectly regulated and each mine is running as efficiently as it should be; it is about whether we should be exporting it at all.

4.2 The Moral Hazard of Concentration

This regulatory benefit does not, however, justify complacency with regard to pollution transfer. The question at the heart of the matter is whether the concentrated production within the lower-income countries receives the same environmental scrutiny as would be the case within the consumer countries.

The dominance of battery production within China has been accompanied by high industrial pollution, though recent policy changes indicate increasing awareness of environmental performance. As production continues in regions where less robust regulatory systems are in place, even more worrisome issues could emerge. Chinese automakers are rapidly expanding production in Thailand, Brazil, Indonesia, and Hungary. Whether production in these regions is carried out in an environmentally best practices manner remains to be seen.

The analytical point is that localisation creates regulatory opportunity, but opportunity does not guarantee enforcement. The environmental outcome depends on institutional capacity and political will in producer economies—factors that vary considerably and cannot be assumed to match standards in consumer countries.

5. Rethinking Environmental Improvement Narratives

The spatial analysis of electric vehicle emissions has substantial implications for the overall progression of environmental development in developed countries. A good example of this is that many developed countries have declining emissions at home while the economy continues to grow, which can often be explained using the Environmental Kuznets Curve theory.

However, the battery supply chain evidence suggests an alternative interpretation. Structural transition toward service economies, combined with outsourcing of emission-intensive manufacturing, can reduce domestic emissions without proportionate global decline. This phenomenon is well-documented in the consumption-based emissions accounting literature, which demonstrates that territorial emissions (produced within national borders) increasingly diverge from consumption-based emissions (generated globally to satisfy domestic demand).

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Recent research on territorial versus consumption-based accounting published in the journal *Land* argues that combining both approaches currently represents best practice for sub-national GHG assessment. Territorial results suit internal monitoring, while consumption-based accounting enables comparison and provides comprehensive pictures of global carbon footprints. The authors note that "setting climate targets and monitoring the success of climate action through a single net emissions figure can give false indications".

Electric mobility illustrates this principle precisely. Transport emissions decline in subsidising economies, while production emissions increase in manufacturing regions. Observed environmental improvement may therefore represent both genuine technological progress and international redistribution of industrial activity. The policy significance of this redistribution depends on whether production emissions are declining globally— which requires decarbonisation of manufacturing, not merely its relocation.

6. Policy Implications

The evidence presented does not contradict the electrification route as a means of reducing environmental impacts but proposes some enhancements to the present policy models.

6.1 Lifecycle-Based Subsidy Design

The subsidy models in place at present seem to concentrate solely on the adoption of vehicles, without any consideration of the emission impacts created during their production. A more advanced model would involve providing incentives depending on the intensity of production emissions, thus encouraging the establishment of production units in countries with lower production emission intensity or using cleaner production technologies. The differences in battery production emission intensity, as found in the research undertaken by DLR, show that production in China is significantly more carbon-intensive than in Canada and Europe.

6.2 Industrial Decarbonisation as Climate Policy

From a global viewpoint, the reduction of carbon emissions in mining, refining, and battery manufacturing has the potential to achieve higher emission reductions than increasing consumer subsidies. This emphasis on clean electricity development is just as relevant to industrial activities and electric vehicle charging. The promotion of renewable energy in industrial centers, clean industrial technologies, and global cooperation in industrial standards could offset emissions in their own right, rather than shifting them from one location to another.

7. Conclusion

Electric mobility represents a tangible opportunity for reducing emissions and our reliance on fossil fuels in transport. The review makes it clear that electric vehicles produce lifecycle emission savings compared with conventional vehicles, and that this break-even point occurs within the vehicle's lifespan in most markets.

But it's not entirely a simple story. The footprint of electric vehicles is also dependent on the footprint of battery production, which is centred in a few countries with different environmental regulations. This means that some of the savings enjoyed by drivers in one country are also linked to increased pollution in another. This is not to say that electric vehicles are not a positive step; it is simply a nuance on how and where the benefits are being felt, both between and within countries.

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The issue of local pollution versus global dispersion is at the very heart of this analysis. On the one hand, local pollution, while problematic, can at least be monitored, regulated, and controlled through technology, unlike global dispersion. This is, of course, an important point, especially in terms of real-life, real-time solutions. On the other hand, just because there is efficient control does not mean there is fair play. When clean air equals high standards of living, while dirty air equals low standards of living, this is at least worth looking into, even if overall emissions are reduced. This does not, of course, excuse outsourcing, but rather, as stated, the solution must lie in improving standards in those countries through the transfer of technology, financial assistance, and robust international agreements, rather than simply looking at the issue of outsourcing itself.
The point of this analysis was not, of course, to pass judgment on electric mobility itself. Rather, it was meant to point to the fundamental issue at hand. That issue is, of course, the very real point that, in terms of global decarbonisation, clean consumption must be matched with clean production. EVs shift emissions, but do not necessarily reduce them. This, in turn, forces us to think beyond territorial emissions, rather than consumption-based emissions, in order to ensure the decarbonisation of production in those countries where production occurs, and subsidies are structured accordingly.

THANK YOU

Please send your valuable feedback to us at sayantan.consultants@gmail.com

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