International Institute of SDGS & Public Policy Research

The Real Impact of Clean Energy Subsidies - Who Gains Economically and Who Bears the Hidden Environmental Costs?

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Abstract

Clean energy subsidies occupy a central position in contemporary climate policy, widely embraced as tools for accelerating decarbonization, fostering technological innovation, and supporting sustainable economic development. Governments increasingly justify these subsidies as necessary interventions to correct market failures associated with fossil fuel dependence. However, beyond their surface appeal lies a critical and under-examined question of distribution: whether clean energy subsidies genuinely drive transformative industrial change or primarily operate as mechanisms that concentrate economic benefits among large corporate actors while displacing environmental costs across sectors, communities, and borders.

This research interrogates the economic and environmental impacts of clean energy subsidies through a critical legal and policy lens. It seeks to determine whether subsidy regimes meaningfully restructure industrial systems or merely reinforce existing power asymmetries by favoring corporations with the financial capacity, technological sophistication, and regulatory access needed to capture state incentives.

The study examines how subsidy design, eligibility criteria, and regulatory frameworks shape market participation, often marginalizing small-scale producers and local enterprises, thereby limiting inclusive growth and competitive innovation. Beyond economic allocation, it exposes hidden environmental externalities within subsidized clean energy systems. While subsidies often reduce emissions at the point of generation, they obscure significant upstream and downstream environmental costs, including intensive mineral extraction, land degradation, water pollution, waste management challenges, and cross-border ecological harm linked to supply chains. These burdens are disproportionately borne by environmentally vulnerable regions, resource-rich developing states, and marginalised communities, raising concerns of environmental injustice and regulatory displacement rather than genuine sustainability.

The research assesses the extent to which existing legal instruments adequately internalise environmental costs, prevent regulatory capture, and ensure accountability across the clean energy value chain. Particular attention is given to environmental impact assessments, corporate disclosure obligations, and transnational regulatory gaps. The study adopts a doctrinal research methodology.

The research analyses statutes and regulatory frameworks as primary sources, alongside journal articles, newspapers, and other secondary materials. Methodologically, it adopts a doctrinal and comparative legal approach to evaluate subsidy frameworks across selected jurisdictions. Ultimately, the study challenges the assumption that clean energy subsidies are inherently equitable and environmentally benign. It argues for recalibrated subsidy regimes that promote structural transformation, distributive fairness, and environmental integrity. By aligning economic incentives with robust accountability mechanisms, the study seeks to advance subsidy policies that deliver genuine clean energy transitions without exporting environmental harm or entrenching corporate dominance.

Introduction

The global shift toward a low-carbon economy has moved beyond a policy aspiration to become a central pillar of national industrial strategy. Governments are increasingly supporting this transition through large-scale public spending, particularly in the form of clean energy subsidies. These subsidies are widely promoted as tools for simultaneously addressing environmental degradation, economic stagnation, and energy insecurity. From the United States' Inflation Reduction Act and the European Green Deal to China's sustained support for solar manufacturing and electric vehicles, public capital is being deployed at unprecedented levels to accelerate green technologies and shape future growth trajectories. However, as these commitments expand into hundreds of billions of dollars annually, tensions have emerged regarding the distribution of costs and benefits within the emerging "green growth" agenda.

From an economic perspective, clean energy subsidies are designed to correct a key market failure: the underpricing of carbon emissions. By reducing investment risk and lowering the cost of renewable technologies, policymakers aim to stimulate innovation, expand new industries, and generate employment and productivity gains. However, the political economy of these interventions suggests more uneven outcomes. Complex eligibility criteria, compliance requirements, and scale advantages tend to favor large, established firms with greater financial and administrative capacity. In contrast, smaller firms, local producers, and informal actors often face significant barriers to accessing subsidy benefits, raising concerns about the inclusiveness of the transition. This raises an important question of whether subsidy-driven expansion is facilitating structural transformation or reinforcing existing industrial inequalities under the guise of green growth.

At the same time, the environmental dimensions of the clean energy transition extend beyond reductions in operational emissions. Technologies such as wind turbines, solar panels, and lithium-ion batteries rely heavily on resource-intensive extraction and processing of critical minerals. Much of this activity occurs in the Global South, where regulatory enforcement is often weaker and local communities disproportionately bear the environmental costs, including pollution, water stress, and habitat disruption. As a result, environmental benefits achieved in one region may be partially offset by ecological degradation elsewhere, highlighting the geographically uneven nature of the transition.

Taken together, these dynamics underscore a central challenge in the global energy transition. While clean energy subsidies have the potential to accelerate decarbonization and reshape industrial structures, their outcomes depend significantly on design and governance. Without careful attention to distributional impacts and environmental externalities, the subsidy-driven transition risks reproducing existing inequalities rather than transforming them. Addressing these concerns is therefore not only a matter of policy efficiency but also of equity and sustainability.

This paper adopts a political economy perspective to examine these intertwined economic and environmental dimensions. Rather than assessing clean energy subsidies solely in terms of efficiency or emissions reduction, it focuses on their distributive outcomes and structural implications. Specifically, the analysis explores how subsidy design, regulatory frameworks, and market structures interact to shape who benefits from the transition and who bears its costs.

Literature Review

The role of government policy in shaping renewable energy development has been widely examined, with strong agreement that sustained public intervention is essential for sectoral growth. Wei et al. (2010) demonstrate that subsidies, public investment, and supportive infrastructure play a critical role in expanding renewable energy capacity while also contributing to job creation and technological innovation. Their findings highlight the broader economic benefits of clean energy policies, particularly in terms of employment generation. However, the study primarily focuses on aggregate outcomes and does not fully address how these benefits are distributed across different categories of firms or regions, leaving questions about inclusivity unanswered.

Similarly, Brown (2012) shows that fiscal incentives such as the U.S. Production Tax Credit have significantly influenced the expansion of wind energy capacity, with investment patterns closely tied to policy stability. While this underscores the importance of consistent policy support, the structure of such incentives has raised concerns about unequal access. In particular, reliance on tax-equity financing tends to favor large firms with greater financial capacity, suggesting that smaller firms may be systematically excluded from fully benefiting from subsidy regimes.

Expanding on the relationship between policy and innovation, Vincenzi and Ozabaci (2017) find that government interventions, including public R&D funding and feed-in tariffs, play a key role in directing technological change in the solar energy sector. Their study shows that policy incentives can significantly influence both the pace and direction of innovation. However, the analysis pays limited attention to whether these innovation gains are broadly accessible or disproportionately concentrated among firms with stronger financial and institutional advantages.

Palage et al. (2018) further demonstrate that a combination of demand-side and supply-side policies has been effective in scaling solar photovoltaic (PV) production and reducing costs through economies of scale and learning-by-doing. While these findings reinforce the efficiency of subsidy-driven expansion, they also raise important concerns. Other scholars argue that such policy approaches may contribute to technological path dependency, where continued support for dominant technologies limits the development of potentially more sustainable alternatives (Acemoglu et al. 2012). This highlights a key tension in the literature between short-term efficiency gains and long-term innovation diversity.

More recent literature reflects a shift in government approaches to clean energy support, particularly between 2019 and 2025. Governments worldwide have increasingly combined direct subsidies with fiscal instruments such as carbon taxes and carbon pricing mechanisms. This shift represents a move toward making polluters bear the environmental and social costs of their emissions, rather than transferring these burdens to society. International institutions, including the World Bank, have documented this transition through initiatives such as the Green Subsidies Database, which highlights how subsidy programs are now designed to both promote renewable energy and correct market failures. Carbon pricing implemented through carbon taxes or emissions trading schemes places a monetary value on greenhouse gas emissions, compelling firms to account for environmental damages such as health impacts, crop losses, infrastructure damage, and climate change. As a result, companies are incentivized to adopt cleaner technologies or face higher costs.

In addition to economic concerns, the literature highlights significant environmental implications within renewable energy supply chains. Although renewable technologies reduce operational emissions, their production depends on resource-intensive extraction processes. For example, lithium mining in Chile's Atacama Desert has been linked to severe water depletion and ecological stress, while cobalt mining in the Democratic Republic of Congo raises concerns about environmental degradation and unsafe working conditions (World Bank, 2020). These cases indicate that clean energy transitions often shift environmental burdens geographically rather than eliminate them. At the same time, over 75 carbon pricing policies are in place globally, generating more than $100 billion annually, with revenues often reinvested into renewable energy and development goals, strengthening the link between environmental sustainability and economic growth. However, their effectiveness remains uneven, as developed countries have stronger institutional and financial capacity to implement carbon taxes and green financing, while developing countries face fiscal constraints and competing development priorities that limit large-scale adoption. Consequently, countries such as India, Brazil, and Turkey continue to struggle with mobilizing sufficient investment for full energy transitions. Moreover, widening global climate policy disparities, including carbon border adjustment measures from developed economies, place additional pressure on developing countries pursuing industrial growth despite historically low emissions contributions.

Overall, existing research suggests that governments are increasingly relying on a mix of subsidies and taxation instruments to promote clean energy transitions. While these policies have driven technological innovation, cost reductions, and job creation, their outcomes remain shaped by global political dynamics, economic disparities, and institutional power structures. This broader perspective raises important questions about the distribution of economic benefits and environmental costs in the global shift toward clean energy, particularly regarding who gains from these policies and who bears their hidden consequences.

Research Methodology

This study adopts a qualitative approach centred on an extensive review of secondary literature. It synthesises findings from peer-reviewed journals, government policies, and international publications (including those from the IEA and UNEP). Adopting a political economy lens, the research examines the distributive effects of clean energy subsidies across firms of different scales and social classes. It also integrates assessments of concealed impacts related to mineral extraction, employment, earnings, and development, while evaluating the balance between economic efficiency and environmental protection.

To strengthen analytical rigour, the study employs a comparative framework that systematically contrasts outcomes across: (i) developed and developing economies; (ii) firms of varying sizes and market power (large incumbents versus SMEs); (iii) different policy instruments (subsidies, carbon pricing, feed-in tariffs, and regulatory standards); and (iv) technology pathways (mature versus emerging clean energy solutions). By triangulating these multiple data sets, the research conducts a comparative assessment to determine whether existing policies induce genuine structural change or merely displace environmental and social burdens from one region, sector, or social group to another.

Research Objective

This research aims to examine the real economic and environmental impact of clean energy subsidies by studying whether they lead to genuine and long-term industrial transformation or do they simply increase dependency on government support. It seeks to understand whether industries would continue to adopt clean energy technologies if subsidies were removed and how existing regulatory frameworks balance economic efficiency with environmental accountability. The research further aims to study how clean energy subsidies shape technological choices within the energy sector including whether they create a "lock-in effect" that favors certain technologies while discouraging the development of potentially more effective and sustainable alternatives. The research examines how benefits of clean energy subsidies are distributed across firms of different sizes and market power and whether larger corporations get higher benefits. Finally, the study aims to assess the broader socioeconomic outcome of clean energy subsidies by examining its effect on employment, income generation and industrial growth across different socioeconomic groups to determine who ultimately gains and who gets left behind in this clean energy transition.

Research Findings

To what extent do clean energy subsidies contribute to genuine industrial transformation?
Clean energy subsidies have accelerated the deployment of renewable technologies and lowered costs, yet their contribution to genuine industrial transformation remains uneven and context-dependent. While installed capacity has grown, subsidy-driven expansion has largely been incremental, often reinforcing existing industrial hierarchies rather than reshaping production systems, value chains, or labour markets.

From an industrial perspective, subsidies tend to favour capital-intensive firms with technological expertise, finance, and regulatory influence. Large multinationals and established conglomerates are better positioned to navigate subsidy mechanisms and absorb risks, thereby strengthening incumbent players instead of fostering broad-based upgrading or new domestic industries. In many developing economies, renewable growth still relies heavily on imported technologies and foreign capital, limiting local value addition and learning-by-doing effects. Consequently, output rises but underlying industrial structures change little.

If subsidies were reduced or removed – Would industries still opt for clean energy?
Secondary research strongly supports that while some level of clean energy adoption may continue without subsidies, the inclusiveness of industrial transformation would decline significantly if subsidies were to be removed. Taking insights from the projections related to the potential repeal of the Inflation Reduction Act of the USA clearly supports our statement. The first graph(Figure 1) shows that under a continued policies scenario, annual additions of solar, wind and battery storage rise sharply over time showing strong investment confidence due to subsidies and tax incentives. In contrast, the full IRA repeal scenario showcases a complete slowdown in new capacity additions across all energy sources and also showcases the renewable energy development to be halved by 2035. This suggests that industries rely heavily on subsidies to reduce upfront cost, manage investment risk and predict returns.

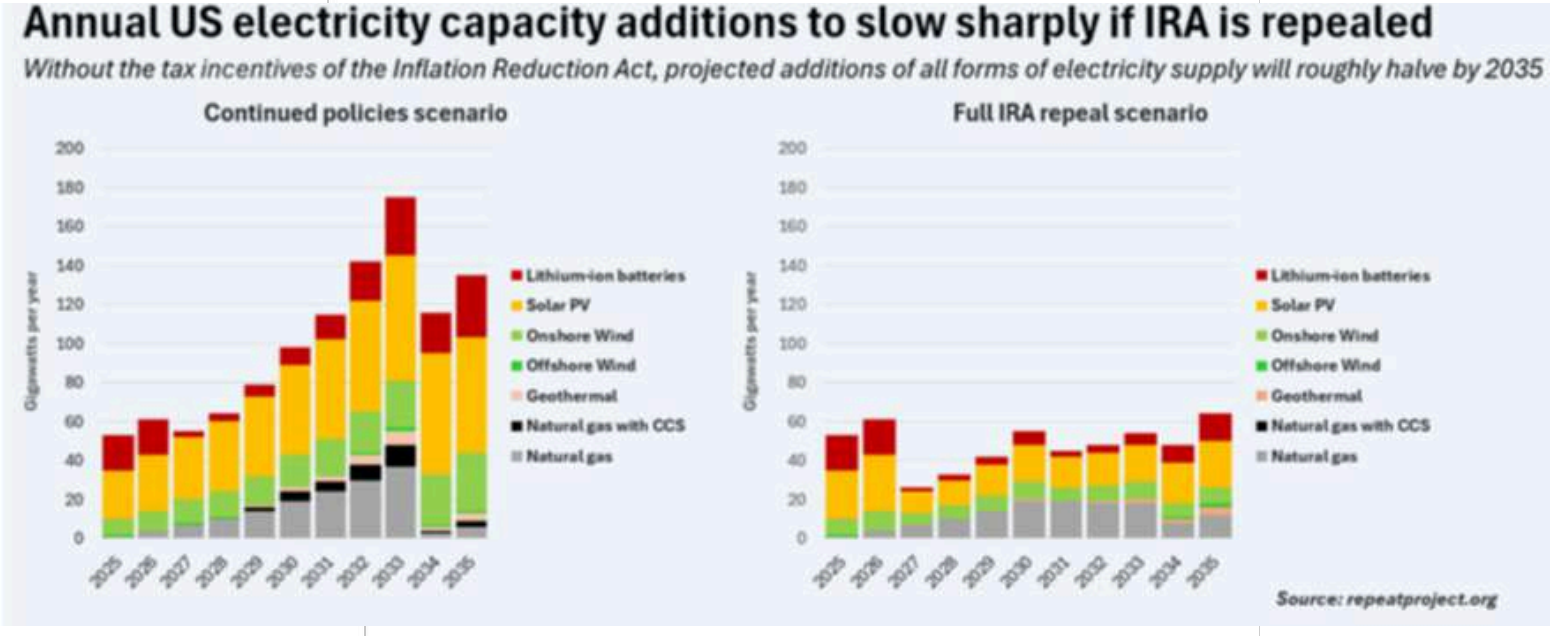

FIGURE 1

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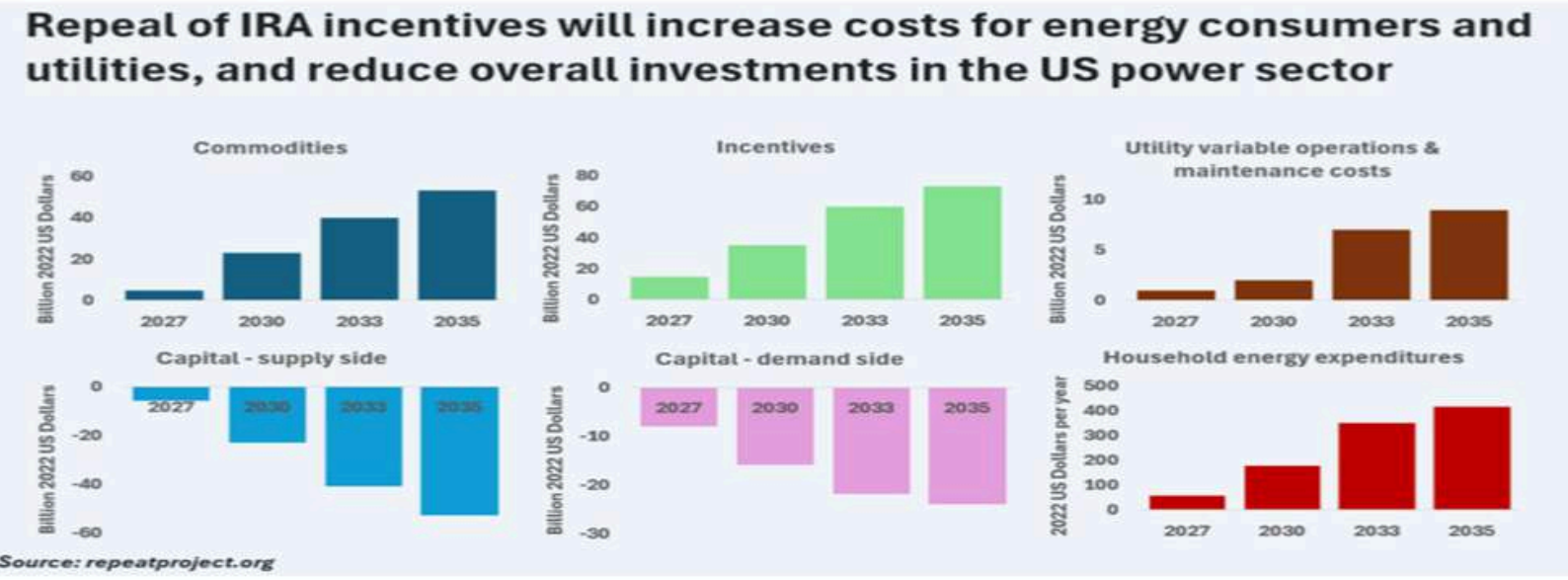

FIGURE 2

Insights from outlook business's analysis of global carbon pricing and pollution taxes further explain why subsidy removal would have uneven effects across countries. Although carbon pricing mechanisms are now included globally, they are not yet strong or consistent enough to replace subsidies. In developed economies, subsidies work alongside carbon taxes to encourage investment in the clean energy sector. However, if subsidies are withdrawn before carbon pricing can function independently, firms may face higher compliance cost and without adequate support they will withdraw their investments. This problem is even more severe in developing countries where industries are operating under tight financial constraints and weaker government support. The paper also highlights that developed countries have already industrialised by using fossil fuels and can now afford clean energy alternatives however developing countries are increasingly pressured to reduce their emission while simultaneously lacking comparable resources.

Further evidence from The Conversation article shows that clean energy has certain hidden environmental and health costs. Production of renewable energy materials such as lithium, cobalt and rare earth elements depend upon mining intensive supply chains which are found in vulnerable regions. While renewable energy causes lesser emission, their production itself can cause land degradation, water pollution and health risks. Subsidies currently encourage cleaner supply chains, if they were to be removed, industries might still adopt cleaner energy where it is cheapest but they would have fewer incentives to invest in environmentally friendly production methods potentially shifting environmental harm rather than eliminating it. Thus, if subsidies were removed, Industries would not completely abandon clean energy but their adoption would become slower, uneven and concentrated among large firms and developed economies. Subsidies therefore remain crucial for ensuring a transition that is economically viable and environmentally accountable

Source: Brand Finance

How Economic Efficiency is balanced with Environmental Accountability?

Regulatory design plays a central role. The EU's state-aid rules, for example, mandate competitive auctions and transparency to direct subsidies toward the lowest-cost projects. Germany's former feed-in tariff system used declining rates to encourage innovation and reduce over-compensation. Many schemes now tie eligibility to measurable environmental performance such as emissions intensity thresholds in clean hydrogen programmes ensuring additionality and genuine greenhouse-gas reductions. Green banks in the US, UK, and Japan further leverage public funds to mobilise private capital while preserving market dynamics. Robust monitoring, reporting, and adaptive enforcement mechanisms help maintain accountability.

Case Study 1: Cobalt Mining in the Democratic Republic of Congo (DRC)

The clean energy transition's dependence on cobalt, a critical mineral for lithium-ion batteries illustrates how subsidised demand in the Global North can export environmental and human costs to the Global South. The DRC supplies approximately 70% of the world's cobalt, much of it extracted under conditions involving child labour, water contamination, and soil degradation around Kolwezi and Lualaba. Despite billions in EV subsidies through programmes such as the US Inflation Reduction Act and the EU Green Deal, these regimes impose no binding due-diligence obligations on upstream mining. A 2023 Amnesty International investigation revealed that major battery suppliers to subsidised EV manufacturers continued sourcing from mines linked to human rights violations. Emissions reductions at the point of use therefore do not neutralise ecological and social harm displaced across borders.

Does clean energy subsidies create a 'lock-in' effect that stifles more ecologically sustainable alternatives?

Clean energy subsidies are a double-edged sword. While essential for breaking fossil-fuel lock-in, they risk creating a new "green path dependency" by prioritising commercially mature technologies such as lithium-ion batteries and silicon photovoltaics over more radical, ecologically superior alternatives.

Subsidies accelerate deployment along the learning curve, locking in infrastructure (charging networks, grid standards) and institutional arrangements tailored to those technologies. This raises switching costs for alternatives and favours incremental improvements over systemic shifts. The resulting mineral-intensive pathways exemplified by cobalt-dependent batteries can starve R&D into circular or bio-based systems, trading a carbon crisis for resource and waste crises. As subsidised industries mature, they also gain lobbying power that can block disruptive innovations.

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How the economic benefits of clean energy subsidies are distributed across firms of different sizes and market power?

Large firms capture the majority of subsidy benefits. Their financial resources, administrative capacity, and market position enable them to apply quickly, absorb risks, and scale projects such as large solar farms or carbon-capture retrofits. Reduced costs often translate into higher margins rather than lower consumer prices, especially in concentrated markets.

Small and medium enterprises (SMEs) benefit less due to limited awareness, complex application processes, and tighter cash flows. Well-designed policies offering simplified access, technical assistance, or size-scaled support can help SMEs adopt efficiency measures or rooftop solar. In competitive markets, subsidies can spur price competition and enable smaller players to match larger rivals.

Case Study 2: Solar Manufacturing and Regulatory Capture in the United States

The US solar sector demonstrates how subsidy design can entrench large corporate actors. Under the Inflation Reduction Act's Advanced Manufacturing Production Credit (Section 45X), domestic content requirements favoured a handful of vertically integrated incumbents such as First Solar and Qcells, who already possessed established supply chains and lobbying access. Smaller manufacturers and new entrants struggled with capital intensity and compliance complexity. Industry reports from 2023–2024 show that the bulk of tax credits flowed to these established firms, functioning more as a tool for consolidating market power than for broad industrial transformation.

How clean energy subsidies affect employment, income generation, and industrial growth across different socioeconomic groups?

Targeted policies such as Renewable Portfolio Standards, efficiency mandates, and carbon pricing generally create more jobs than equivalent fossil-fuel investments. Renewable and efficiency projects are labour-intensive, generating direct, indirect, and induced employment. Net job gains are typically positive but vary by region, import dependence, and workforce skills; fossil-fuel-dependent areas may face displacement without adequate retraining.

Jobs range from high-skill R&D roles to blue-collar installation work, with medium- to high-skill positions producing strong local multiplier effects. In developing countries, distributed renewables can boost female labour participation when paired with training and infrastructure. Industrial growth is stimulated through economies of scale, learning-by-doing, and regional specialisation, though outcomes depend on local content rules and complementary R&D.

Poorly designed subsidies can produce low-quality jobs, widen inequality, or favour imported components, limiting domestic gains. Distributional effects are shaped by geography: renewable-rich regions and landowners often benefit most, while fossil-dependent or marginalised communities risk exclusion.

Case Study 3: Wind Energy Development and Community Displacement in Oaxaca, Mexico

Mexico's Isthmus of Tehuantepec, particularly Juchitán in Oaxaca, illustrates how subsidy-driven wind expansion can reproduce exclusionary patterns. Foreign investment and government support transformed the area into a major renewable hub, yet Indigenous Zapotec communities reported inadequate free, prior, and informed consent processes under ILO Convention 169. Land leases often bypassed broader participation, concentrating benefits among intermediaries and foreign corporations while displacing subsistence farming and traditional livelihoods. Academic studies and reports by the Business and Human Rights Resource Centre document community opposition and legal challenges, highlighting how clean energy incentives without robust consent frameworks and environmental impact assessments can displace local populations under a green label.

In summary, clean energy subsidies can accelerate the low-carbon transition and generate net economic and employment gains, but their effectiveness depends on thoughtful design. Without safeguards for supply-chain accountability, small-firm inclusion, and community participation, subsidies risk shifting rather than solving environmental and social problems.

Conclusion

This paper has examined how regulatory frameworks shape the real outcomes of clean energy subsidies, finding that the balance between economic efficiency and environmental accountability depends far less on the existence of subsidies than on how they are designed, targeted, and enforced.

Subsidies have undeniably accelerated renewable energy deployment and driven down costs. But this paper shows that these outcomes do not automatically produce fair or environmentally responsible results. Where regulatory design is strong as seen in competitive auction mechanisms in the EU or performance-based incentives in the UK, subsidies can reduce waste and attract private investment effectively. Where it is weak, subsidies risk becoming transfer payments to large corporations, rewarding scale and political access rather than genuine innovation or structural change.

Environmental accountability remains the weakest link in most subsidy regimes. Policies tend to measure success by emissions reductions at the point of energy generation, ignoring the environmental costs embedded in supply chains from cobalt mining in the DRC to land displacement in Oaxaca. These hidden costs do not disappear; they are simply shifted to communities and regions with less political power and weaker legal protections. This is not a
green transition- it is a relocation of harm.

The case studies examined in this paper make this concrete. Corporate capture of subsidy mechanisms, inadequate community consent processes, and the absence of binding supply chain accountability are not incidental failures. They reflect structural gaps in how subsidy law is written. Closing these gaps requires embedding enforceable environmental standards, mandatory disclosure obligations, and genuine access provisions for smaller firms and affected communities directly into subsidy eligibility frameworks- not as afterthoughts, but as conditions of public support.

Clean energy subsidies are neither inherently good nor inherently bad. Their impact is determined by the legal choices that govern them. A subsidy regime that drives rapid deployment while concentrating wealth and exporting environmental harm is not a success- it is a different kind of failure. The goal must be a legal architecture that ties public money to public outcomes: broad participation, accountable supply chains and a transition that is genuinely sustainable rather than merely marketed as such.

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