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Research Article

Decarbonization Practices: Impact on EU Economy and Beyond

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Abstract

The pursuit of economic growth has resulted in a negative impact on ecology. The global development models have often overlooked environmental sustainability. The European Union (EU), however, is trying to write a different story through its Green Deal Initiative, which aims for carbon neutrality by 2050 and a legally binding 55% reduction in greenhouse gas emissions by 2030 (compared to 1990 levels). The research paper tries to explore the challenges in the path of decarbonization as well as analyze present carbon taxation practices and improvements to achieve the carbon neutrality mission. Similarly, the government can be a great contributor to addressing global warming and climate change. This study explores the impact as well as implications of the EU's environmental legislation, transition challenges, and strategic lessons for emerging economies. It analyses how instruments such as the Carbon Border Adjustment Mechanism (CBAM), EU Taxonomy, in line with global agreements like the Paris Agreement, explore trade and environmental dynamics. The comparative policy analysis and evaluation of ecological effectiveness and economic scalability, the paper sheds light on both enabling and constraining factors in the transition. The findings offer actionable insights for emerging economies seeking to align economic development with climate commitments and provide recommendations to improve existing green policies and technologies for a more inclusive and sustainable global economy. Policy and technological advancement are the Mitigation tools to deal with the threats posed by climate change. Similarly, Strategic pathways of decarbonization through renewable and circular practices offer dual benefits: environmental gains and trade resilience. However, structural shifts and sectoral vulnerability persist.

Keywords

Decarbonization, Sustainability, Circularity, Sustainable transition, Taxonomy, Strategies

1. Literature Review

The concept of 'economy' and 'environment' has been re-defined over time. Previously, the economy was only considered in terms of increasing the GDP, and the environment was limited to a conservative aspect only. However, we have evolved such that the long preceding trade-off between Environment and Economy has been increasingly reconciled by adopting a New governance structure which aims towards green Transition and becoming a carbon-neutral economy. The 'Clean Industrial Deal' as well as the 'Competitiveness Compass' both try to create harmony between economic growth and sustainability. The paper [3] explores how ecological perspective and adaptation influence sustainability results. They suggest including circular economy principles to bridge the gap between economic growth and environmen-

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tal sustainability as well as focus on community adaptation as a journey towards sustainable growth.

1.1. Decarbonization Strategies in the EU

The Green Deal is an SDG acceleration action that aims to reduce greenhouse gas emissions by 55% in 2030 compared to 1990 levels. The EU's decarbonization strategies revolve around three pivotal avenues: enhancing energy efficiency, decreasing reliance on fossil fuels, and increasing the share of renewable energy consumption [21]. The dependence on fossil fuel has been a major impediment towards the transition in European Nations as well as Hydrogen technologies hold great promise to support the decarbonization Mission [13]. Economic instruments often act as governing factors, as they directly and indirectly affect the enterprise's decisions and strategies, which positively (subsidies, tax breaks) and negatively (tax on energy or pollution) affect enterprise decisions [14]. Such instruments can direct the firm on how to produce, providing a substantial contribution to the decarbonization mission. Substantial low-carbon investments in the energy sector are seen as a major challenge in both industrialized and developing economies. So, long-term financing and policies to ensure decarbonization while contributing to economic development are required [11].

The EU as a Whole - from East to West - suffers from an energy import dependency. The key incentive for cooperation is to reduce dependency and transform the systems away from hydrocarbons. The development of renewable energy sources is a decisive factor that can make European energy more sustainable and secure [27]. Decarbonization strategies focusing on renewable energy technologies have shown the greatest co-benefit [17]. Air-pollution reduction is one of the most straightforward co-benefits of the renewable energy transition [29]. Carbon taxation is a complex phenomenon, as it addresses major market failure and the possibility of failure to price the environmental damage due to the existence of a multiplicity of markets [11]. A careful approach on the part of the government by making substantial policy related to Carbon pricing, is required. However, due to the depth of transformation, the Green Deal could meet strong opposition from the sectors and people that will be most affected by this transition. Social unrest and strong opposition to a more sustainable society could seriously undermine the positive development of the Deal [12].

1.2. Decarbonizing Challenges and Potential Solutions Practiced

Decarbonizing the economy quickly is not trivial. It will involve large-scale structural change, with some sectors having to rapidly expand their relative production/market shares, and others having to entirely transform their technological basis or shrink and potentially disappear. This last category of sectors comprises activities directly related to the extraction and distribution of fossil fuels, but also, and perhaps most importantly, because it implicates a far larger proportion of the economy, sectors producing goods and services using fossil fuels as a crucial input in their production process [25]. In decarbonizing the energy sector, the need for flexible technologies is pivotal, especially when the penetration of wind and PV(photovoltaic) systems prevails. From the analysis conducted in Central Europe, the results show that the interconnection across borders decreases the total power generation, carbon emissions, and system costs by 8.2%, 9% and 16.3%, respectively. Also, interconnections across countries would promote the penetration of uniform power-generating technologies (such as wind, nuclear, biomass) and reduce the need for energy storage systems [9]. Renewable electricity and green hydrogen production are key to decarbonizing the energy sector, and this opportunity has already led to new energy strategies in the European Union [10]. The high volume of fossil fuel imports in the energy mix or the geographical barriers to sourcing coastal liquid natural gas (LNG) could create a situation in which energy security and rapid decarbonization might challenge each other. In the long term, the hydrogen economy comes with the promise of not only environmental (e.g., reducing greenhouse gas emissions, reducing air pollution) and economic benefits (e.g., resource abundance and prevalence, rural manufacturing jobs, investments in plants and equipment), but improved energy security due to the domestic production and distribution of the energy and reducing the dependency on import [7].

There are generally two viable approaches explored in the literature concerning achieving carbon neutrality. The first approach entails initiatives, policies, and technologies to reduce CO_2 emissions. In addition to emissions reductions, further measures are required to achieve a net-zero carbon system. A second approach focuses on carbon removal from the atmosphere, also referred to as negative emissions, via a variety of emerging engineered technologies and nature-based solutions [4].

1.3. Policy Practices and Technologies

The 1970s oil crisis shows how energy policies interact with economic, social, and environmental policies. This puts pressure on policymakers to analyze broader metrics like energy security, competitiveness, and pollution rather than simply focusing on energy availability and cost [2]. Carbon-pricing policy has been spreading globally since 2003, when the EU Emission Trading System (EU ETS) was adopted. However, in low-carbon policy mixes, green industrial policy has been adopted much more widely than carbon pricing and has mostly predated carbon pricing [19].

Low-carbon energy technologies face two enduring challenges: avoiding the lock-in of sub-optimal low-carbon technologies, and maintaining the support for government investment in low-carbon technologies. Such challenges can be

overcome through competition in technologies, with a share in the market as a reward. Along with it, the uncertainty needs to be addressed through support for experimentation and diversity through subsidies [19].

The circular economy originated from ecological and environmental Economics. The circular economy is a complex concept and involves various definitions by multiple authors. The circular economy is transitioning towards more environmentally favourable means of production and distribution, which decouple economic growth from primary resource extraction through reuse, repair, and recycling [18].

The use of non-biodegradable materials, especially plastics as packaging, needs to be replaced by biodegradable options. Similarly, there is a significant lack of legislation and control to integrate the circularity principles into the policy framework. In an organizational setting, every participant must be engaged in a circularity transition, like engaging employees in decision-making and providing training required to produce products as a transition towards a green economy [6].

The circularity principles adopted in business can positively impact the profit, social impact, and sustainable development [1]. More precisely, the adaptation of circularity enables the transformation in the business Model with increased innovation [5]. The Adaptation of circularity principles in business models has shown enhanced regulatory compliance with EU and global regulatory frameworks like ESG disclosures [28]. The Reputational risk of business is highly mitigated with the adoption of circularity principles, which can reduce environmental liability and boost the trust of stakeholders. So, adopting circularity in business strategies will improve sustainability performance metrics as well [24].

1.4. Sustainable Transition and Risk Associated

Sustainability transition aims to understand how transitions evolve, and often generate explicit policy recommendations to support progressing transitions [15]. Transition management is a governance concept specifically developed for the management of sustainability transitions [16]. It has a focus on learning, on system innovation alongside system improvement, and on keeping a large number of options open [8]. However, the risk associated with transition includes policy risks, liability risks, and technology risks. Policy risks concern the ‘risk’ of policy changes intended to mitigate climate change, which will certainly impact in varying degrees on different sectors and individual corporations. Liability risks may take the form of investors suing corporations or directly the board members for loss of profit for failing to anticipate or adapt to climate change or other environmental degradation. The change in technology often disrupts the business and requires clear guidelines for the transition to new renewable fuels from fossil fuels. There is a high chance of loss-bearing or loss of corporate profit anticipated by old technology, i.e., fossil fuel [26], due to the transition.

2. Research Methodology

The Research is majorly qualitative in Nature. The Research will be based on policy analysis, scenario analysis, and considering the transition. The research method is primarily based on secondary data, which includes research journals, articles, and chapters of books related to sustainable transition, circularity principles, and decarbonization strategies. The Research aims to study how green deal instruments affect external trade dynamics and lessons that can be drawn from EU practices in terms of decarbonization and sustainable practices for the emerging economy.

3. Policy Analysis

The analysis is focused on policy analysis, which helps us conclude how the implementation of various decarbonization practices over the years has impacted the trade and contribution of such practices. The policies are analysed based on impact on competitiveness and effectiveness in ensuring environmental sustainability.

The policies analysed here are three EU policies: Carbon Border Adjustment Mechanism(CBAM), EU emission trading system(ETS), Paris Agreement(NDC), and the EU Sustainable Financial Taxonomy.

CBAM has been considered as a great equaliser between the various economies with varying degrees of carbon pricing, through rebates and excise duties. The EU emission trading system(ETS) has been a great catalyst in preventing leakage from unilateral climate actions. The CBAM has been shown to have restored the lost competition and reduced carbon leakage. However, the CBAM has been facing challenges on the part of the WTO (World Trade Organization) and free trade philosophy compatibility as well as compatibility with NDC of the Paris Agreement [30].

The EU sustainable finance taxonomy is a Science-based classification system that determines which economic activities are environmentally sustainable. It directs the flow of capital towards low-carbon and environmentally friendly investments, which aids the carbon neutrality mission by 2050. The EU taxonomy covers sectors responsible for 80% of EU greenhouse emissions. The taxonomy is a great signal for investment as it enhances transparency and reduces information asymmetry. Along with it, it can be a global benchmark for standards and disrupt global trade norms by influencing sustainable finance rules in other jurisdictions as well [23].

The Paris agreement NDC and EU taxonomy are both based on evidence-based thresholds, green transition as a cross-sectoral challenge, and focus on early and consistent action. The EU taxonomy is bound by EU regulation, which targets economic activities and investments, with a focus on company-level and sectoral level, defining green transitions. The jurisdiction of the EU Taxonomy, being EU-specific, has the potential to influence global finance. Similarly, the

Paris Agreement is an international political agreement with global frameworks focused on policy intervention with a focused commitment towards government [22].

Below is the table that evaluates the key EU and international climate policies with a focus on impact on competitiveness, environmental effectiveness, and impact on global south trade.

Table 1. *A Tabular illustration of the impact of policy instruments.*

Policy Instrument	Economic Competitiveness	Environmental effectiveness	Global south trade Impact	Scalability
CBAM	Moderate - Protects EU industry but risk retaliation	High-able to target embedded emissions	Negative-Increased trade cost for non-compliant countries	Moderately scalable as it requires global buy in
EU ETS	High- Market based, Cost-effective	High - with proven emissions reduction	Neutral- As it depends on capital engaged and trade adopted	High - due to adaptability into multiple regions
EU Taxonomy	Medium - Provides clarity but existence of compliance cost	Medium - Indirect affected by investment flow	Positive - Aligns capital toward SDG goals	High - due to modular and updatable framework
Paris agreement NDC's	Low due to non-binding and voluntary participation	Medium - promotes transparency and ambition	Positive - common but differentiated responsibility based economic and development parameter of country	High- Global acceptance and varying ambition depending on country's economic status

The interrelational angle between national-level climate policies in relation to the Paris Agreement and SDG is essential as they share the common goal of ensuring sustainable development and mitigating as well as preventing damage from climate deterioration. Most Nationally Determined Contributions (NDCs) have strong overlaps with the SDGs, such as Energy(SDG-7), Water(SDG-6), Climate action (SDG-13), and food security(SDG-2). However, the partial misalignment is due to the focus of donors on their own strategic interests. So, integrating SDG parameters in local climate policy reflects global priorities. Similarly, it is essential to align donor intention with SDG priorities to make a holistic and global-oriented carbon policy [20].

4. Lessons from Sustainable Practices in the EU for Emerging Economies

The emerging economies that are still developing in terms of infrastructure, economy, and industries, as well as means and ways of production, can learn from the sustainable practices adopted in developed countries. The following are the lessons that developing countries can learn from the policies and practices adopted to ensure sustainability and decreased emissions from manufacturing to distribution channels;

1) Firms or projects in developing countries that want to export to the EU must align with EU Taxonomy standards. Similarly, such alignment will help in attracting investment.
2) EU taxonomy might help to establish a framework by serving as a reference.
3) Developing countries require investment in institutional capacity with enhanced regulatory frameworks and capacity building.
4) Emerging economies can manage risk and increase resilience by mapping carbon risk in key sectors, avoiding lock-ins, and ensuring long-term economic resilience.
5) Aligning National taxonomies or sustainable finance tools in line with the Paris Agreement and the EU taxonomy enhances credibility and access to global finance. Such alignment must be based on scientific methods.

5. Findings

The key findings that we distill from the above discussion are given as:

1) The EU Green Deal has positioned Europe as a global leader in terms of transitioning towards sustainability as it integrates climate targets with regulatory and financial mechanisms.
2) Decarbonization pathways through renewable and circular practices offer dual benefits: environmental gains and trade resilience. However, structural shifts and sectoral vulnerability persist.
3) Aligning national policies with SDGs and Paris Agreement is crucial; however, due to donor agenda and institutional limitations, it has hindered the global south's integrated climate-finance progress.

6. Conclusion

The overconsumption of non-renewable energy has created energy scarcity, greenhouse gas emissions, climate change, and environmental degradation, posing threats to mankind. Such threats are often countered by adopting principles and technology that reduce carbon emissions. The above discussion has pointed out how technological advancement has helped us in our low-emission mission. The use of policies and technologies has provided a framework as well as tools to reduce emissions at various stages of the product life-cycle. However, the limitations of policies and technologies need to be overcome with encouraged experimentation and enhanced research to make carbon neutrality a living reality.

Abbreviations

EU	European Union
CBAM	Carbon Border Adjustment Mechanism
ESG	Environmental, Social and Governance
SDG	Sustainable Development Goals
PV	Photovoltaic
LNG	Liquid Natural Gas
ETS	Emission Trading System
CBAM	Carbon border Adjustment Mechanism
NDC	Nationally Determined Contribution
WTO	World Trade Organization
NDC	Nationally Determined Contributions

Author Contributions

Kiran Bhatta is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares no conflicts of Interest.

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