Interplay Between Tradable Green Certificates and Carbon Emissions Trading: A Literature Review

Andita Nastasia Lazuardi[1], Hasrini Sari[2]

[1]Direktorat Retail dan Niaga
PT PLN (Persero)
Jakarta, Indonesia
[2] Program Studi Teknik Industri dan Manajemen Rekayasa Industri,
Fakultas Teknologi Industri, Institut Teknologi Bandung
Gedung Laboratorium Teknologi III,
Bandung, Indonesia
Email: andita.nastasia@pln.co.id[1]
hasrini@itb.ac.id[2]

Abstract. This study focuses on the intertwined challenges of climate change and sustainability, emphasizing the role of green energy certificates (TGCs) and carbon emissions trading (CET) as crucial instruments for mitigating greenhouse gas emissions. Countries that signed the Paris Agreement employ these mechanisms to achieve their Net Zero Emissions (NZE) goals. Green certificates promote renewable energy investment, while carbon trading sets emission limits. However, the interaction between these systems is complex and requires careful coordination to avoid misalignment and conflicting incentives. The literature review methodology used in this study highlights how different nations implement TGCs and CET, assessing their interaction in various markets. In China, TGC-CET coupling supports renewable energy growth. However, it faces policy redundancies, whereas, in Sweden-Norway, TGC and EU ETS collaboration has proven effective, though further integration with carbon policies is needed. The Netherlands illustrates the risks of poor policy alignment between TGCs and CET, potentially undermining climate goals. The findings stress the importance of harmonizing these systems, ensuring that they function synergistically to optimize emission reductions and drive global climate policy objectives.

Keywords: *net zero emissions, CET, TGC, green energy, policy*

1 Introduction

The issue of climate change intrinsically links to sustainability. Climate change has emerged as a prominent worldwide issue. IPCC [1] stated that Climate change happens progressively and affects different elements of individuals' lives. The significant impact of climate change on human existence has become a global concern for nations across the world. Under the United Nations Framework Convention on Climate Change (UNFCCC), these nations have convened to

Received _____, Revised _____, Accepted for publication _____

deliberate on optimal strategies for mitigating climate change and its effects. The UNFCCC has ratified the Paris Agreement as a definitive action to mitigate the current effects of climate change. The Paris Agreement stipulates that signatory countries must submit Nationally Determined Contributions (NDCs) to reduce greenhouse gas emissions. Countries that ratified the Paris Agreement possess distinct NDC targets and have formulated various ways to attain the Net Zero Emission (NZE) objective. The nations have implemented various measures to regulate greenhouse gas emissions to fulfill the commitment to the Net Zero Emissions (NZE) target, including green energy certificates and carbon trading mechanisms. Schuster [2] stated that the availability of green energy certificates, also known as energy attribute certificates, as a certification for green energy attributes and carbon credits in the carbon market serves the identical purpose of mitigating greenhouse gas emissions. Energy attribute certificates, carbon markets, and electricity markets have emerged as three simultaneous components in the pursuit of the NZE objective. Energy attribute certificates and carbon trading generally occupy analogous market niches. Specifically, organizations that endeavor to diminish their carbon emissions through current market-based mechanisms.

Green certificates and carbon emissions trading have emerged as significant policy instruments to mitigate global climate change. Green certificates provide incentives for renewable energy producers, such as wind and solar power, to increase capacity and investment in clean energy sources. On the other hand, carbon trading focuses on reducing greenhouse gas emissions by setting limits on the amount of emissions that companies can release and providing flexibility in how they meet those limits. The interaction between these two systems can be very complex. The Research by Karp [3] shows that these two mechanisms can reinforce each other when designed well. For example, an effective emissions trading system can increase the demand for green certificates, as companies striving to comply with emission limits can purchase them to offset their emissions. However, there is also a risk that misalignment between policies can create conflicting incentives, potentially reducing each system's effectiveness. Therefore, it is important to explore this interaction further to understand how both can function synergistically in achieving broader sustainability goals.

Numerous signatory nations of the Paris Agreement have established green energy certificate trading systems and carbon trading within their jurisdictions. Regulations and policies pertaining to these two tools will significantly impact a nation's power industry. This project aims to gather information regarding the interplay between green certificate trading and carbon trading within a nation.

2 Literature Review

2.1 Overview About Literature Review

The existence of a research study is certainly inseparable from the literature review that is conducted. To produce a good research, a researcher conducts a literature review to gather facts from previous findings and the theoretical foundation of a discussion topic. Baumeister [4] stated, the literature review is characterized as a systematic method for gathering and synthesizing prior research. Relevant literature studies will help researchers to accurately construct a conceptual framework. Snyder [5] stated there are several types of methodological of literature reviews that can be used: systematic, semi-systematic, and integrative approaches, contending that each methodology can be highly beneficial depending on its aim and the quality of its implementation. Systematic reviews impose rigorous criteria for search strategies and article selection, effectively combining findings from a body of studies on a specific subject and offering evidence of effect that can guide policy and practice. A semi-systematic review approach may effectively map theoretical frameworks or topics while also exposing knowledge gaps. In certain instances, a research question necessitates a more innovative data collection method; in such scenarios, an integrative review strategy might be advantageous when the objective is not to encompass all articles ever written on the subject, but rather to amalgamate viewpoints to formulate new theoretical models.

2.2 Green Certificate and Carbon emission trading

The exchanged instruments are commonly known as carbon credits in the carbon trading market. Schusser [2] stated that carbon credits and energy attribute certificates share the same objective of reducing greenhouse gas emissions. Nonetheless, each of these instruments possesses distinct duties and functions. In mitigating a company's emissions US [6] explains that carbon credits can be utilized to decrease emissions from Scope 1, which stem from the company's operational activities; Scope 2 emissions resulting from electricity procurement; or Scope 3 emissions associated with the company's supply chain activities. Energy attribute certificates can only mitigate the company's Scope 2 emissions. Furthermore, a distinguishing factor between carbon credits and energy attribute certificates is that carbon credits are quantified in tons of carbon dioxide, whereas energy attribute certificates are assessed in megawatt hours. Despite their differences, energy attribute certificates and carbon credits produced and exchanged in the energy industry are derived from renewable energy sources. In actuality, energy attribute certificates and carbon credits exchanged in the energy sector originate from renewable energy-generating plants. In selecting tradable

instruments, a generator that has been exchanged as an energy attribute certificate cannot be transacted as carbon credits.

2.2.1 Carbon emission trading

The economic theory of cap-and-trade serves as the foundation for carbon trading. This system establishes a limit on total permissible emissions and allocates or sells emission permits to corporations. Companies that successfully reduce their emissions below the established limit can sell surplus permits to other companies that are having difficulty achieving their targets. Tietenberg [7] stated this approach aims to offer economic incentives for reducing emissions, encourage clean technology innovation, and optimize market cost efficiency. Furthermore, Newel [8] studies indicate that carbon emissions trading can result in more significant emission reductions than conventional regulatory methods, such as direct limiting regulations. Nonetheless, the obstacles in its execution, such as appropriate pricing and fraud prevention, necessitate meticulous consideration to guarantee the system's efficacy in attaining long-term sustainability objectives.

2.2.2 Green Energy Certificate

The system of trading renewable energy certificates aims to encourage the production and use of renewable energy. The theory of incentives underpins this notion, as renewable energy certificates provide renewable energy producers with economic value by certifying their clean energy generation. Each certificate signifies one megawatt-hour (MWh) of produced renewable energy and is tradable in the market. Wiser [9] stated that this hypothesis incentivizes investors to allocate their capital towards renewable energy initiatives, fostering industry expansion and diminishing reliance on fossil fuel sources. Studies by Menz [10] stated that the certificate market fosters openness and accountability in quantifying the impact of renewable energy on greenhouse gas emission reduction, therefore aiding in attaining global climate policy objectives.

3 Methodology

This article employs a semi-systematic literature review to examine the comparative implementation of Carbon Emision Trading and Tradable Green Certicificate across several countries, focusing on the interplay between the two systems inside those nations. We conduct national and international article searches using ScienceDirect, Springer, and Google Scholar databases. We

conducted article searches using keywords such as "tradable renewable certificate," "carbon emission trading," and "interaction between tradable renewable certificates and carbon emission trading." We filtered the papers by restricting the publication years to between 2000 and 2024. The preliminary phase yielded a total of 102 articles with pertinent titles. We performed additional screening based on topic and context criteria that include research related to the interaction between Tradable Green Certificates and Carbon Emission Trading, and ensured full access to these articles, resulting in a total of 8 papers. An analysis and synthesis of these papers were carried out, highlighting the implementation of Tradable Green Certificates and Carbon Emission Trading, how the two instruments interact, and the impacts caused by both on related aspects.

4 Discussion

4.1 Tradable Green Certificates & Carbon Emission Trading in China

China is addressing climate change by reforming structures and systems. One method involves the utilization of tradable green certificates (TGCs) and carbon emission trading (CET). From Chang [11], a prior study employed an interactive System Dynamics (SD) model to elucidate the internal linkages among these subsystems, informed by the prevailing market conditions in China. The TGC pricing was originally steady during the construction of new units but experienced a continuous increase from 2022 to 2023. This escalation persisted until 2030, owing to elevated demand for RPS quotas, after which it steadied. CET prices vary and are affected by the CET market and electricity demand. The TGC and CET coupling mechanism reduces the duration of elevated CET prices, influencing the deployment of renewable and conventional energy sources. The installed renewable energy capacity surpassed the target through dual methods, while thermal electricity generation diminished. According to Yu [12], the rise in TGC pricing results in an enhanced profit margin for renewable energy generation, incentivizing environmentally conscious electricity providers to invest further in sustainable power plants. This benefit compels the government to distribute additional TGCs to eco-friendly electricity providers, which ultimately adversely affects TGC rates. The prices of TGC and CET influence conventional energy production and the actions of coal electricity providers in reaction to fluctuations in demand and pricing. The growing significance of renewable energy in China's power system poses issues in grid integration and consumption. One factor is China's electricity system, which comprises multiple areas. Establishing a cross-regional system incorporating TGC and CET processes leads to diminished shipping and operational expenses, alongside a notable reduction in pollutant emissions. Additionally, the collaborative trading

system for interregional commerce enhances renewable energy consumption via market-driven approaches, influencing China's energy framework and facilitating energy reform. Examining intricate relationships among diverse market entities from a market standpoint leads to the formulation of suitable scheduling strategies via the global distribution of TGC and carbon emission allowances. To mitigate the consumption uncertainty of quota subjects, equilibrate the interests of diverse market participants, and incentivize more participation in TGC transactions. The TGC and CET processes can enhance the electricity supply framework, diminish CO_2 emissions, and fulfill China's emission reduction objectives for 2030. Liu's [13] research indicates that the integration of CET and GCT mechanisms in the management of Multi-District Integrated Energy Systems (MDIESs) to support low-carbon operations can reduce operational costs by up to 21.5%, increase renewable energy consumption, and lower carbon emissions. With this approach, cross-district systems can optimize energy efficiency and promote sustainability through more integrated energy management.

In the study conducted by Wang [14], the combination of both (CET and GCT) proved to be more effective compared to a single policy, with impacts including a reduction in carbon emissions, optimization of the energy structure, and an increase in renewable energy investments. Synergistic policies enhance CET and GCT, stimulate market activity, but require management to balance economic costs and environmental benefits. The optimal sequence for implementing low-carbon policies suggests focusing on carbon trading policies from 2021 to 2030, combining carbon trading policies and green certificates from 2030 to 2050, and focusing on green certificate trading from 2050 to 2060 to ensure a sustainable and efficient carbon transition. Nonetheless, from the research given by Feng [15], potential policy redundancy exists between TGC and CET, necessitating a stepwise policy integration to prevent superfluous conflicts and duplications. Enhancing legislation pertaining to carbon emission monitoring and the creation of carbon markets is essential, as existing laws lack obligatory provisions for monitoring the carbon emissions of electric firms. Furthermore, it is essential to establish suitable carbon quota targets and allocation methodologies, including a gradual shift to a market-based auction system to reinstate the scarcity of carbon permits. Concerning the renewable energy certificate (TGC) mechanism, it is essential to implement appropriate quotas and distinguish trade procedures for different renewable sources while progressively eliminating electricity price subsidies as the trading system develops. Another factor requiring attention is evaluating the synergistic impacts and conflicts between the CET and RPS programs. Furthermore, the government must manage the implementation expenses of the policies and provide a dynamic, collaborative regulatory framework. Li [16] stated that improper management of policies related to CGT and CET can lead to price instability and market failure risks. This study suggests

policy recommendations for multi-market coupling, including setting price caps in the carbon market and establishing a lower bound on green certificate prices.

4.2 Tradable Green Certificates & Carbon Emission Trading at Swedia and Norway

Regulations undoubtedly influence prevailing market conditions in the carbon emissions trading system (EU ETS) and tradable green certificates (TGC). The European Union implemented the "20/20/20" policy to diminish greenhouse gas emissions and advance renewable energy, primarily via the TGC and EU ETS frameworks. Each EU member state has proposed diverse political instruments to attain a 20% reduction in greenhouse gas (GHG) emissions relative to 1990 levels, a 20% share of energy derived from Renewable Energy Sources (RES), and a 20% enhancement in energy efficiency. This strategy aims to stimulate investment in renewable energy and diminish carbon emissions from the power industry, with empirical evidence corroborating its short-term efficacy. Implementing the EU ETS throughout Europe governs emission thresholds for energy firms and heavy industry.

In contrast, the Swedish-Norwegian TGC system seeks to enhance renewable energy production. Schusser [2] stated that the escalation of carbon pricing under the EU ETS framework typically elevates TGC prices, incentivizing electricity firms to augment their investments in renewable energy sources. The rise in carbon pricing inside the EU ETS system positively influences TGC prices, albeit this effect is confined to the near term. Furthermore, the influence of TGC pricing on electricity and carbon costs is intricate due to variations in market size and the banking of green certificates. The findings underscore the necessity of establishing more stringent emission restrictions and improving the integration of carbon regulations with renewable energy policies to optimize their efficacy. The carbon trading system and TGC facilitate investments in the renewable energy sector alongside the European Union's implementation of more stringent emission limitations and elevated renewable energy objectives. Nonetheless, the policy remains inadequate to establish complete synergy between the carbon market and the renewable energy market, particularly regarding pricing impact on investment choices in the power sector.

4.3 Tradable Green Certificates & Carbon Emission Trading at Netherlands

The Dutch government has instituted market-oriented strategies to mitigate emissions, including green certifications and carbon trading systems. Carbon dioxide (CO_2). The Netherlands aims to decrease greenhouse gas emissions by

6% relative to 1990 levels as a component of its climate policy. In attaining this objective, the majority of reductions are anticipated to be accomplished by local initiatives, while the remainder will be secured through international emission reductions utilizing the Kyoto Mechanism. Market methods like carbon trading and green certification are employed to reduce emissions while preserving the competitiveness of industries and energy sectors impacted by global competition. Nonetheless, Boots [17] stated the absence of synergy between these two instruments is a matter of worry. Green certificates presently exclude carbon value, despite carbon prices being independently established via the emissions trading system. This poses issues concerning market transactions, the evaluation of renewable energy, and the reduction of greenhouse gas emissions. (GHG). Regrettably, the existing green certificate process in the Netherlands fails to include carbon potential, treating green certificates and CO_2 credits as distinct matters. This separation is straightforward as it circumvents the complexities involved in assessing the carbon content of a certificate. The distinction between green certificates and the CO_2 market in the Dutch trading system leads to the incorporation of CO_2 reduction costs into electricity prices, whilst the price of green certificates just represents the supplementary expenses associated with renewable energy development, particularly during the transitional phase when the green certificate scheme has been instituted.

In contrast, the carbon trading plan remains unimplemented. During this phase, the value of green certifications may encompass the value of CO_2 reduction. This condition establishes a scenario in which certificate purchasers, such as electricity supply companies, cannot utilize CO_2 credits due to the absence of a regulatory obligation or permit system for CO_2. However, they possess the opportunity to 'sell' CO_2 credits to renewable energy consumers, which may increase consumer costs. The carbon trading system can be utilized alongside green certificates to improve the efficacy of emission reduction. Consequently, energy market prices increase in tandem with the evaluated emission costs, yet disparities persist in acknowledging emission reduction value. This condition poses a barrier to establishing a transparent and equitable market for renewable energy suppliers and consumers acquiring green certificates.

Summary of the interactions regarding the implementation of CET and CGT in several countries is listed in table 1

Table 1 Summary of literature review.

No	Researcher (Year)	Country	Conclusion
1	Schusser, S. & Jaraite, J. (2016)	Swedish Norwegian	The EU ETS framework's carbon pricing increases TGC prices, encouraging electricity firms to invest in renewable energy. However, this effect is temporary and influenced by market size and green certificate banking.
2	Chang, X. et al (2023)	China	A study used an interactive System Dynamics model to analyze the internal linkages among subsystems in China's energy market. It found that TGC pricing increased from 2022 to 2030 due to RPS quotas, and CET prices fluctuated.
3	Yu, X. et al (2021)	China	A study used System Dynamics model found the integration of TGC and CET in China promotes renewable energy, reduces CO_2 emissions, and lowers reliance on thermal power. Rising TGC prices drive investment in renewables.
4	Liu, D et al (2023)	China	A study used scheduling model that indicate the integrating CET and GCT mechanisms in Multi-District Integrated Energy Systems can reduce operational costs, increase renewable energy consumption, and lower carbon emissions.
5	Wang, H et al (2024)	China	A study used computable general equilibrium model found that combining CET and GCT can be more effective than a single policy, leading to reduced carbon emissions, energy structure optimization, and increased renewable energy investments.
6	Feng, Tian-tian et al (2021)	China	A study used System Dynamics model found the integration of TGC and CET policies is crucial to prevent conflicts and duplications. This includes improving carbon emission monitoring legislation, establishing carbon quota targets, and implementing market-based auction systems.
7	Li, J. et al (2024)	China	A study used bi level optimization modeling, the study suggests policy recommendations for multi-market coupling, including setting price caps in the carbon market and establishing a lower bound on green certificate prices, to mitigate price instability and market failure risks.
8	Boots, M (2003)	Netherlands	TGC exclude carbon value, causing issues in market transactions, renewable energy evaluation, and GHG reduction. The Dutch green certificate process treats green certificates and CO_2 credits as separate matters, incorporating CO_2 reduction costs into electricity prices. The carbon trading plan is unimplemented, allowing certificate purchasers to sell CO_2 credits to renewable energy consumers, potentially increasing costs.

5 Conclusion

This research concludes that tradable green certificates (TGC) and carbon emissions trading (CET) are crucial for mitigating greenhouse gas emissions and advancing renewable energy initiatives. Green certificates incentivize renewable energy sources, whereas carbon trading mitigates emissions by establishing emission caps and exchanging permits among enterprises. Nevertheless, in certain instances, such as in the Netherlands, there exists a deficiency in synchronization between the two instruments, which impedes the efficacy in attaining climate objectives.

The collaboration between TGC and CET in China illustrates progress in augmenting renewable energy capacity despite hurdles in policy integration and power system management. The increasing TGC prices incentivize renewable energy providers; nonetheless, the CET-TGC policy necessitates additional modifications to prevent policy overlap and redundancy.

In Sweden and Norway, the TGC and EU ETS systems collaborate to enhance investments in renewable energy; nonetheless, issues arise in aligning with the carbon market and its influence on investment choices in the energy industry.

Although TGC and CET are useful tools for promoting renewable energy and mitigating carbon emissions, improved integration across different countries is necessary to augment their efficiency and efficacy. This research underscores the necessity of formulating more cohesive policies, especially regarding price and incentive alignment, to guarantee that both mechanisms operate synergistically and attain optimal outcomes in reducing greenhouse gas emissions.

Currently, the energy attribute certificate instrument that has been widely circulated and transacted in Indonesia is GCT, while CET transactions in Indonesia can be said to be quite low and not as numerous as GCT. Learning from studies on the implementation and interaction of CET and GCT in several other countries, there are several points that need to be considered by the Indonesian government as policymakers regarding the existence of GCT and CET in Indonesia, including:

1. The government needs to ensure the extent to which the increase in GCT and CET prices affects existing renewable energy investments.
2. The government needs to examine how the presence of CET and GCT affects energy operational costs in Indonesia.
3. The government needs to assess whether there is a need for policies related to price restrictions on both instruments.

4. The government needs to ensure there is no redundancy or double counting of the CET and GCT instruments.
5. The government needs to further examine whether a specific strategy is needed to be implemented gradually regarding the presence of CET and GCT in Indonesia.
6. The government needs to ensure that all aspects related to CET and GCT are included in the studies conducted on these two instruments.

References

[1] Intergovernmental Panel on Climate Change (IPCC), Climate Change 2011: Impacts, Adaptation, and Vulnerability, Chapter 3, URL: https://www.ipcc.ch/site/assets/uploads/2018/03/SREX-Chap3_FINAL-1.pdf, (1 April 2018).

[2] Schusser, S. & Jaraite, J., Explaining the interplay of three markets: Green certificates, carbon emissions and electricity, SSRN Electronic Journal, pp. 1-13, 2016

[3] Karp, L. et al., The Interaction of Carbon Markets and Renewable Energy Certificates, Environmental Economics and Policy Studies, pp. 102-115, 2019

[4] Baumeister, R. F., & Leary, M. R. Writing narrative literature reviews. Review of General Psychology, 1, pp. 311–320. 1997.

[5] Snyder, H. Literature review as a research methodology: An overview and guidelines. Journal of business research, 104, pp. 333-339, 2019.

[6] United States Environmental Protection Agency (EPA), Green Power Purchasing: A Guide to Renewable Energy Certificates and Offsets, URL: https://www.epa.gov/sites/default/files/2018-03/documents/gpp_guide_recs_offsets.pdf, (1 Maret 2018)

[7] Tietenberg, T. H., *Emissions Trading: Principles and Practice*, RFF Press, pp. 38, 2006

[8] Newell, R. G. & Stavins, R. N., Cost Heterogeneity and the Potential Savings from Market-Based Environmental Policies, *Journal of Regulatory Economics*, pp. 25-36, 2003.

[9] Wiser, R. et al., The Impact of State-Level Renewable Portfolio Standards on Renewable Energy Development, *Energy Policy*, pp. 28-39, 2016.

[10] Menz, F. C. & Vachon, S., A Supply-Side Perspective on the Effectiveness of Renewable Energy Certificates, *Renewable Energy*, pp. 15-25, 2006

[11] Chang, X. et al., The coupling effect of carbon emission trading and tradable green certificates under electricity marketization in China, *Renewable and Sustainable Energy Reviews*, 187, 113750, 2023

[12] Yu, X. et al., Integration of tradable green certificates trading and carbon emissions trading: How will Chinese power industry do?, *Journal of Cleaner Production*, 279, 123485, 2021.
[13] Liu, D et al., Low-carbon dispatch of multi-district integrated energy systems considering carbon emission trading and green certificate trading. *Renewable Energy*, *218*, pp. 119312, 2023.
[14] Wang, H et al., Grappling with the trade-offs of carbon emission trading and green certificate: Achieving carbon neutrality in China. *Journal of Environmental Management*, *360*, 121101, 2024.
[15] Feng, Tian-tian et al., Induction mechanism and optimization of tradable green certificates and carbon emission trading acting on electricity market in China, *Resources, Conservation and Recycling*, 169, 105487, 2021.
[16] Li, J. et al., Analysis on the synergy between markets of electricity, carbon, and tradable green certificates in China. Energy, 131808, 2024.
[17] Boots, M, Green certificates and carbon trading in the Netherlands, *Energy Policy*, 31(1), pp. 43-50, 2003