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借鏡全球綠色路徑政策-評析臺灣 2050 淨零排放路徑

Learning from Global Green Pathway Policies: An Analysis of
Taiwan's 2050 Net Zero Emission Roadmap

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An Analysis of Taiwan's 2050 Net Zero Emission Roadmap

本論文係朱學平君 (P11E42006) 在國立臺灣大學事業經營法務碩士在職學位學程完成之碩士學位論文，於民國 113 年 07 月 19 日承下列考試委員審查通過及口試及格，特此證明。

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猶記自己仍在美國埋首論文的的日子，看著滿滿的數據與報告，彷彿昨日，2022 時學院師長的始業式，諄諄叮嚀，耳提面授，一晃眼，已到了即將功成圓滿，繳交學習成果之刻，如今娓娓道來，尤其是感觸良深。

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Abstract



This study aims to explore and analyze the green pathway policies of various countries, comparing them with Taiwan's 2050 net-zero emission pathway. With the promotion of ESG (Environmental, Social, and Governance) in recent years, many countries and companies have proposed green pathway policies or strategies to achieve Sustainable Development Goals (SDGs). However, there is no clear definition of the green pathway under the ESG framework. This paper seeks to explore the feasibility and challenges of Taiwan's 2050 net-zero emissions by learning from successful global green policies.

The study includes a literature review that analyzes the importance of green development and its obstacles, such as economic, socio-cultural, and market challenges. It examines the green policies of the United States, Japan, India, Europe, and China, analyzing how these countries promote green transformation through innovation, technological development, and international cooperation. Notably, the European Green Deal, Japan's 2050 Zero Carbon Cities initiative, and China's "30-60" dual carbon policy provide valuable references for Taiwan.

Regarding Taiwan, the study analyzes its 2050 net-zero emission strategies, emphasizing the importance of technological innovation and legal regulation, and exploring the challenges of decoupling energy demand from economic growth. The results indicate that Taiwan needs to strengthen investments in green technology, improve regulations, and raise public awareness to achieve its 2050 net-zero emission goals.

Additionally, the study critically examines the legal issues and social challenges Taiwan faces in implementing green pathway policies from the perspectives of Taiwanese civil society and scholars. By comparing the green pathway policies of other countries, the study provides suggestions for Taiwan's green transition for small and medium-sized enterprises (SMEs), such as establishing green certification, providing financial incentives, and offering technical support.

The study concludes with specific policy recommendations to help Taiwan make substantial progress on its green transition path. The research also plans to further explore green transition strategies for different regions and industries, hoping to offer more suggestions for Taiwan's sustainable development.

Keywords: Green Pathway, Net-zero Emission, Green Transformation, Sustainable Development, ESG

摘要



本研究旨在探討各國綠色路徑之相關政策，並比較及分析臺灣 2050 淨零排放路徑。近年來隨著 ESG（環境、社會和治理）的推廣，許多國家和企業提出了綠色路徑之相關政策或策略，以期實現可持續發展目標（SDGs）。然而，ESG 框架下的綠色路徑並沒有明確定義，本論文通過借鑑全球成功的綠色政策，來探索臺灣實現 2050 淨零排放的可行性和挑戰。

本研究進行了文獻探討，分析了綠色發展的重要性及其面臨的障礙，如經濟、社會文化和市場的挑戰。探討美國、日本、印度、歐洲和中國的綠色政策，分析這些國家如何通過創新、技術發展和國際合作，推動其綠色轉型。特別是歐洲的綠色新政、日本的 2050 零碳城市計劃和中國的“30-60”雙碳政策，這些成功案例為臺灣提供了寶貴的參考。

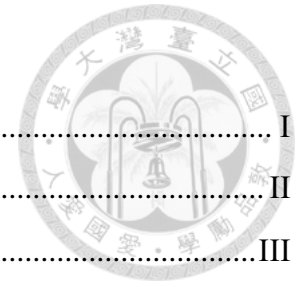
臺灣方面，本研究則分析了臺灣 2050 淨零排放策略，強調科技創新和法律規範的重要性，探討了能源需求與經濟增長脫鉤的挑戰。結果指出，臺灣需要在綠色技術投資、法規完善和社會公眾意識提高方面進行加強，以實現其 2050 淨零排放的目標。

此外，本研究還從臺灣民間社會和學者的批判性視角，審視了臺灣在實施綠色路徑政策過程中面臨的法律問題和社會挑戰。通過比較其他國家的綠色路徑政策，提出了臺灣在中小企業綠色轉型方面的建議，如建立綠色認證、提供財政激勵和技術支持等措施。

本研究最後提出了具體的政策建議，以幫助臺灣在綠色轉型的道路上取得實質性進展。本研究也計畫進一步探討不同區域和產業的綠色轉型策略，期望為臺灣的可持續發展提供更多建言。

關鍵字：綠色路徑，淨零排放，綠色轉型，可持續發展，ESG

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Chapter One Introduction



1. Research Motivation

The term "Green Path" is currently very popular under the strong influence of ESG (Environmental, Social, and Governance), with many countries and companies proposing Green Paths suitable for their operations, in hopes of guiding their organizations towards achieving SDGs (Sustainable Development Goals). Within the ESG framework, the term "Green Path" does not have a comprehensive definition. However, related concepts and practices within the ESG framework can provide some insights into the "Green Path."



Figure 1. The 17 SDGs Goals from the United Nation¹.

ESG encompasses sustainable and ethical considerations that can be central to an organization's financial and corporate interests. It includes a wide range of practices and strategies aimed at promoting environmental stewardship, social responsibility, and effective governance. Key aspects include climate adaptation, resilience, mitigation, and the reduction of greenhouse gas emissions.

In the realm of ESG, practices such as avoiding "Green Washing" (also called "Green sheen") (making misleading claims about the environmental benefits of a product, service, or company's operations), "Green Hushing" (refusing to publicize ESG efforts due to fear of criticism), and "Green

¹ Webpage : United Nations: The 17 GOALS , <https://sdgs.un.org/goals>, (last visited June 19, 2024)

Washing" (setting ambitious sustainability goals without a realistic plan to achieve them) are crucial to maintaining integrity and transparency in sustainability efforts.

Moreover, regulatory frameworks and disclosure requirements are becoming increasingly stringent to enhance the quality of ESG reporting, aiming to reduce the risks associated with improper sustainability claims and to promote transparency and trust. These efforts include regulations and standards set by bodies such as the U.S. Securities and Exchange Commission and the European Union's Sustainable Finance Disclosure Regulation.

While the term "Green Path" was not directly mentioned, the principles and practices within the ESG framework suggest that it would involve a strategic, transparent, and accountable approach to sustainability, focusing on real, measurable environmental benefits and improvements. This would include setting realistic sustainability goals, avoiding misleading claims, and adhering to emerging regulations and standards designed to ensure the credibility and effectiveness of ESG efforts.

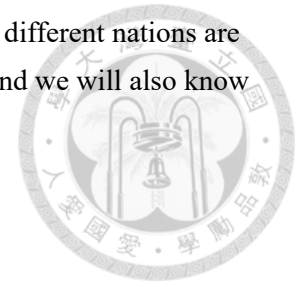
As an important part of the world, what is Taiwan's Green Path? How to guide Taiwan towards Sustainable Development Goals is the issue this study intends to explore. This research will use the sustainable plans of various countries as examples to discuss the current situation, future, and potential challenges that Taiwan may face.

2. Research Scope

The potential research scopes of this research are as below:

- (1) **Comparative Policy Analysis:** Start by comparing the Green Path policies across a diverse range of countries, including both developed and developing nations. This can highlight different approaches to sustainability and how cultural, economic, and environmental factors influence policy formulation.
- (2) **Implementation Strategies:** Look into the specific strategies and initiatives that countries are employing to follow their Green Paths. This includes renewable energy adoption, conservation efforts, sustainable urban planning, and green technology investments.
- (3) **Challenges and Solutions:** Identify common challenges that countries face in implementing their Green Path policies, such as financial constraints, technological limitations, and public resistance. Additionally, explore innovative solutions that have been successful in overcoming these challenges.
- (4) **Policy Evolution:** Study the evolution of Green Path policies over time to understand how they have adapted to new scientific findings, technological advancements, and shifting public opinions.
- (5) **Best Practices and Lessons Learned for Taiwan:** Identify best practices from successful Green Path policies and lessons learned from less effective initiatives. This can provide valuable guidance for policymakers and advocates in Taiwan.

I believe this research can provide a comprehensive overview of how different nations are navigating the transition to sustainability through their Green Path policies. And we will also know the best practices and lessons Learned for Taiwan.



3. Research Steps

The research steps are as follows:

- (1) Literature Review: Begin with a comprehensive review of existing literature on Green Path policies, sustainability frameworks like the SDGs, and environmental governance. This will help to establish a theoretical foundation and identify gaps in current research.
- (2) Policy Collection: Gather Green Path policy documents, strategic plans, and related legal texts from a wide range of countries. This might involve accessing governmental websites, international environmental organizations, and academic databases.
- (3) Cross-policy Synthesis: Compare the findings from the policies from the countries to identify common themes, differences, and lessons learned. This synthesis can highlight effective strategies and common obstacles in pursuing Green Path policies.
- (4) Results and Recommendations: Based on the comparative analysis, formulate recommendations for policymakers in Taiwan. Also, suggest areas for future research to address unresolved questions and emerging challenges.
- (5) Due to the broad scope of this topic, the final discussion primarily focused on the impact of Taiwan's island environment on its green pathway and issues related to local autonomy in Taiwan. The discussion concluded with directions for future discourse.

Chapter Two Literature Review

“Green Path” refers to industrial change associated with environmentally beneficial products and services². The concept is part of a broader discussion on path development in regional studies and economic geography, which seeks to understand how economies evolve and embed over time, potentially leading to the creation of new industrial paths.

The idea of Green Path Development emerged from a need to address urgent industrial changes required for decarbonization and sustainability transitions. It involves the transformation of industries to produce environmental benefits while considering socio-economic outcomes, such as reducing inequality and promoting justice in these transitions. This concept is rooted in the literature on path development, which traditionally focuses on innovation and economic growth, but Green Path Development emphasizes environmentally sustainable economic practices

"Green Path" is not a simple concept but rather a complex one closely related to various green concepts. Below, we will provide detailed introductions to several green concepts.

1. Green Path Development and Green Energy

In the quest for sustainable development, green energy emerges as a pivotal solution, offering a cleaner alternative to traditional energy sources and aligning with global sustainability goals. The concept of the Green Path delves into the strategic importance of green energy, its contributions to sustainable development, the barriers to its deployment, and the necessary policy strategies to foster a green energy transition.

1.1 Explanation of nouns of Green related

Before continuing the discussion, we must first understand some basic definitions. Below are some commonly confused technical terms.

(1) Net Zero(淨零):

Achieving a balance between the amount of greenhouse gases emitted into the atmosphere and the amount removed from it. This can be achieved by reducing emissions and implementing measures to offset any remaining emissions, such as carbon capture and storage or reforestation.

(2) Negative Carbon Emissions(負碳排):

Refers to the removal of more carbon dioxide from the atmosphere than is emitted, effectively reducing the overall concentration of CO₂ in the atmosphere. This can be achieved through methods such as reforestation, soil carbon sequestration, and direct air capture technology.

² Binz, C., & Gong, H. (2022). Legitimation dynamics in industrial path development: New-to-the-world versus new-to-the-region industries. *Regional Studies*, 56(4), 605–618. <https://doi.org/10.1080/00343404.2020.1861238>

(3) Carbon Neutrality (碳中和):

The state where the carbon emissions produced by a person, organization, or country are completely balanced by carbon offsets or removal efforts, resulting in a net zero carbon footprint. This includes both reducing emissions and investing in projects that absorb or capture carbon dioxide.

(4) Climate Neutrality(氣候中和):

Achieving a state where all greenhouse gas emissions are balanced by equivalent measures to offset them, not just carbon dioxide. This includes reducing emissions across all sectors and implementing strategies to offset the remaining emissions, encompassing all greenhouse gases that contribute to climate change.

1.2 The Urgency of Green Energy

The advent of green energy marks a significant shift in how societies fulfill their energy needs. As traditional energy sources increasingly strain our planet's ecological balance and public health, the transition to green energy presents an urgent and necessary shift towards sustainability. This transition not only addresses the environmental and health impacts associated with fossil fuels but also aligns with the broader objectives of sustainable development by promoting economic growth, social inclusivity, and environmental stewardship.

1.3 Contributions of Green Energy

Green energy, sourced from natural, renewable resources like the sun, wind, and geothermal heat, stands at the forefront of sustainable socio-economic development. It enhances energy access, especially in underserved rural areas, boosts energy security by diversifying energy sources, and mitigates environmental impacts, contributing to a reduction in greenhouse gas emissions and the fight against climate change. The adoption of green energy technologies fosters job creation, supports economic development, and improves the quality of life, making it an integral component of sustainable development. The demand for green energy is also steadily rising worldwide.

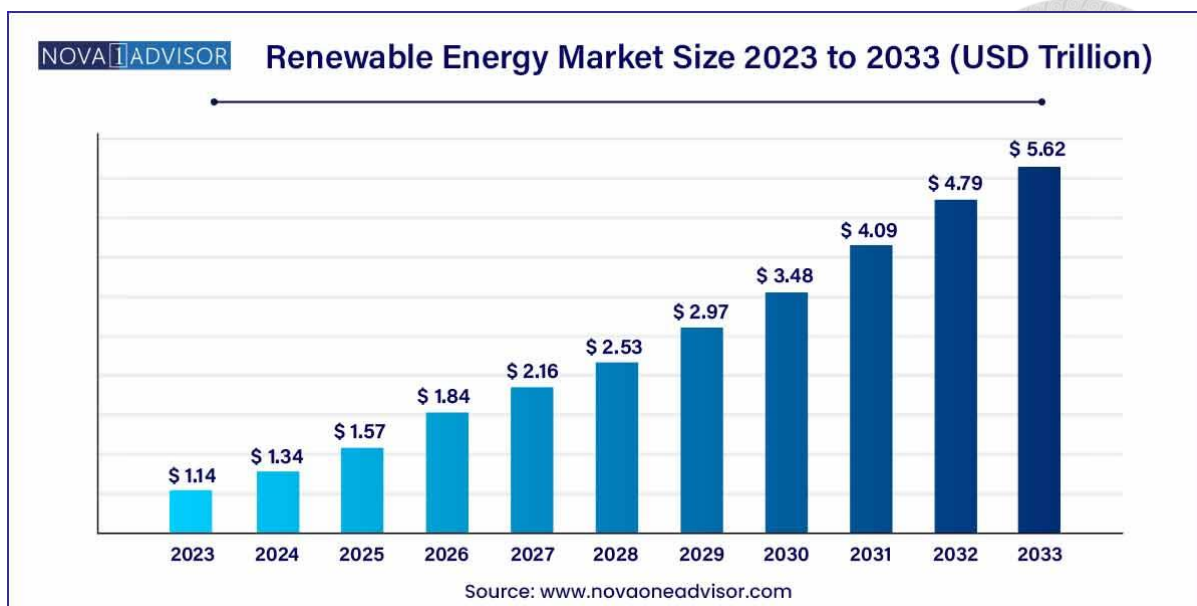


Figure 2. The global green (renewable) energy market size³.

1.4 Barriers to Green Energy Adoption

Despite its potential, the widespread adoption of green energy faces several barriers:

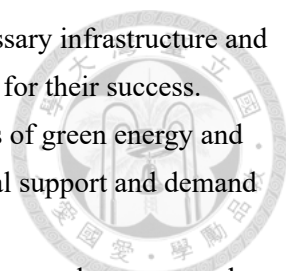
- (1) **Economic Barriers:** High initial investment costs, uncertain energy prices, and financial risks deter investment in green energy technologies, especially in developing countries. **Informational and Awareness Barriers:** A lack of comprehensive data on green energy potentials and a shortage of skilled professionals hamper the effective implementation of green energy projects.
- (2) **Socio-Cultural Barriers:** Cultural norms and societal values can influence the acceptance and adoption of green energy technologies, affecting their deployment at the community level.
- (3) **Market Barriers:** Existing market structures, often dominated by fossil fuel interests, pose significant challenges to the entry and growth of green energy alternatives.

1.5 Policy Strategies for Green Energy Transition

Addressing these barriers requires a multifaceted approach, encompassing strong government commitment, organizational and technical support, public awareness campaigns, and national and international collaboration. Key policy strategies include:

- (1) **Strengthening Commitment to Green Energy:** Governments must prioritize green energy in their national agendas, setting clear targets and providing stable policy environments to attract investment.

³ Webpage : NOVA1 ADVISOR: Renewable Energy Market, <https://www.novaoneadvisor.com/report/renewable-energy-market>, (last visited June 23, 2024)

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- (2) Enhancing Institutional and Technical Support: Building the necessary infrastructure and providing technical assistance to green energy projects are crucial for their success.
 - (3) Raising Public Awareness: Educating the public about the benefits of green energy and how it contributes to sustainable development can increase societal support and demand for green energy solutions.
 - (4) Fostering Collaboration: National and international partnerships can pool resources, share knowledge, and scale up the deployment of green energy technologies.

The transition to green energy is not just an environmental imperative but a cornerstone of sustainable development. It offers a path towards a more sustainable, equitable, and prosperous future, addressing the pressing challenges of climate change, energy security, and socio-economic development. Achieving this transition requires concerted efforts from all sectors of society, including governments, businesses, communities, and individuals, to overcome existing barriers and embrace the opportunities presented by green energy for a sustainable future.

2. Green Path Development and Asset Modification and Agency

In recent years, there has been a growing acknowledgment of the need to integrate structural accounts of new path development with perspectives on agency, focusing on the roles of economic and other actors in shaping, transforming, and creating new paths.⁴ The concept of agency, defined as actions undertaken by actors to achieve specific outcomes^{5 6}, is central to our Systemic Integrative (SI) approach to understanding regional restructuring. Scholars such as Garud and Karnøe⁷ that argue that knowledgeable inventors and innovators are crucial in establishing new paths by intentionally diverging from established practices and introducing new technologies, thus catalyzing change and overcoming barriers in the regional landscape.⁸

This perspective is further developed by Bristow and Healy⁹, who contend that purposive adaptation in regions involves a wide range of self-organizing institutions and collective agency

⁴ Martin, R. (2014). Path dependence and the spatial Economy: A key concept in retrospect and prospect. In M. M. Fischer, & P. Nijkamp (Eds.), *Handbook of regional science* (pp. 609–629). Berlin: Springer.

⁵ Mustafa Emirbayer, Ann Mische. *American Journal of Sociology*, Vol. 103, No. 4 (January 1998), pp. 962-1023 <https://doi.org/10.1086/231294>

⁶ Sotarauta M, Suvinen N (2018) Institutional agency and path creation: institutional path from industrial to knowledge city. In: Isaksen A, Martin R, Trippel M (eds) *New Avenues for Regional Innovation Systems – Theoretical Advances, Empirical Cases and Policy Lessons*. Cham: Springer, pp. 85–104.

⁷ Garud, R. and Karnøe, P. (2001). ‘Path creation as a process of mindful deviation’. In Garud, R. and Karnøe, P. (Eds), *Path Dependence and Path Creation*. Mahwah, NJ: Lawrence Earlbaum, 1–38.

⁸ The same as the footnote 5

⁹ Gillian Bristow & Adrian Healy (2014) *Regional Resilience: An Agency Perspective*, *Regional Studies*, 48:5, 923-935, DOI: 10.1080/00343404.2013.854879

beyond merely firms and business actors. Recent studies have also explored how various agents, including state and non-firm entities, deliberately create regional conditions conducive to the emergence of new paths¹⁰. The link to institutional entrepreneurship clarifies how processes of institutional change¹¹, often essential for new path development, occur through the mobilization of resources, competencies, and power by institutional entrepreneurs to establish and transform institutions¹².

The role of institutional entrepreneurs involves embedding new beliefs, practices, and activities within innovation systems as new paths unfold¹³. Along with Schumpeterian innovative entrepreneurship and place leadership, institutional entrepreneurship is considered a key form of agency in facilitating new path development¹⁴. Adopting a technological innovation system perspective, Musiolik et al underline the importance of system builders who intentionally create, maintain, and alter system resources to aid in the establishment, diffusion, and further development of new technologies.¹⁵

The urgent need for green restructuring, given the pressing global challenges such as climate change and resource depletion, highlights the absence of a cohesive conceptual framework that amalgamates various research perspectives on new path development. The proposed SI approach calls for the reconfiguration of innovation systems to support green restructuring, underscoring the need to modify existing assets and implement systemic changes driven by a broad array of actors.

The crucial roles of both firm-level and system-level agency in advancing green restructuring are underscored, highlighting the initiatives of entrepreneurs in bringing forth green innovations and policymakers in adapting innovation systems for sustainable development. The paper recognizes the

¹⁰ Dawley, S. 2014. Creating new paths? Offshore wind, policy activism, and peripheral region development. *Economic Geography* 90 (1): 91–112.

¹¹ Julie Battilana, Bernard Leca and Eva Boxenbaum, 2009. How Actors Change Institutions: Towards a Theory of Institutional Entrepreneurship, *Academy of Management Annals* Vol. 3, No. 1. <https://doi.org/10.5465/19416520903053598>

¹² Ron Boschma, 2017. Relatedness as driver of regional diversification: a research agenda, vol. 51, issue 3, 351-364. DOI: 10.1080/00343404.2016.1254767

¹³ Sotarauta M, Mustikkamäki N (2015) Institutional entrepreneurship, power, and knowledge in innovation systems: Institutionalization of regenerative medicine in Tampere, Finland. *Environment and Planning C: Government and Policy* 33(2): 342–357.

¹⁴ Grillitsch M (2018) Following or breaking regional development paths: On the role and capability of the innovative entrepreneur. *Regional Studies* 53(5): 681–691.

¹⁵ Grzegorz Musiolik, Maximilian Kruss, Tunahan Demirci, Björn Schrinski, Jens Teiser, Frank Daerden, Michael D. Smith, Lori Neary, Gerhard Wurm 2018. Saltation under Martian gravity and its influence on the global dust distribution, *Icarus*, Volume 306, Pages 25-31, <https://doi.org/10.1016/j.icarus.2018.01.007>.

potential challenges and conflicts that may emerge during asset modification, including competition over scarce resources and the extensive economic and environmental impacts of green restructuring initiatives.

Further empirical research is needed to test the SI framework across diverse regional and industrial contexts, examining the variations in regions' capacities to adapt assets through agency and the dynamics of asset modification relative to specific industries. An in-depth examination of conflicts between different paths and the wider implications of green restructuring for economic and environmental sustainability is necessary.

Green Path Development and Asset Modification and Agency makes a significant contribution to economic geography by providing a comprehensive framework for analyzing green path development and restructuring. It illuminates the complex nature of green restructuring processes, the intricate interplay between green path development and innovation system configurations, and the pivotal role of agency in influencing the outcomes of asset modification efforts. This method stresses the need for policy interventions that proactively reconfigure innovation systems, facilitate asset modification, and engage in the constructive dismantling of obsolete assets to enable the emergence of new, sustainable industrial paths.

3. Green and Just Path Development

Industrial path development explores how economies evolve over time, either maintaining their existing industrial trajectories or evolving into new ones. This field, rooted in regional studies and economic geography, has begun to grapple with the implications of these evolutionary paths for the distribution of economic outcomes. A key concern is that without deliberate intervention, existing patterns of uneven development and exclusion may persist, even as economies undergo restructuring.

The urgency of decarbonization adds a critical layer to this discussion. The transition towards less carbon-intensive industries, while necessary, raises questions about the fairness of economic development. Although the concept of 'green' path development has gained traction, there is a noticeable gap in the literature concerning the socio-economic and environmental outcomes of such transitions. Furthermore, the integration of justice and equity considerations into the discourse on industrial change remains limited.

So Green and Just Path Development (GJPD) is a novel concept. less attention has been paid to questions of justice¹⁶. This concept aims to merge the insights of green path development with the principles of just transition, emphasizing the need for economic restructuring to be both environmentally sustainable and socially equitable. We argue for a broader analytical perspective that

¹⁶ Coenen, L., Hansen, T., Glasmeier, A., & Hassink, R. (2021). Regional foundations of energy transitions. *Cambridge Journal of Regions, Economy and Society*, 14(2), 219–233. <https://doi.org/10.1093/cjres/rsab010>

considers a wider array of influences and stakeholders in the path development process, highlighting the importance of including considerations of negotiation, inclusion, and exclusion.

3.1 Path Development: A Critical Overview

Path development is a fundamental concept in understanding how regions adapt and evolve economically. It encompasses the dynamics of innovation, industrial change, and sustainability transitions. Recent debates have focused on how new industrial paths are created, the role of institutions, and the importance of individual and collective agency in shaping these paths. There has been emerging concern for green path development.¹⁷

However, the literature often overlooks critical questions such as the ultimate purpose of regional path development and whom it serves. Implicitly, the goal seems to be to foster regional economic growth, but the broader impacts on societal well-being and environmental sustainability are less frequently addressed. This gap is especially pronounced in discussions around 'green' industrial pathways, where the environmental benefits are assumed rather than critically examined.

The concept of GJPD arises from the intersection of green path development and just transition literature. It seeks to ensure that the shift towards environmentally sustainable economies does not exacerbate existing inequalities or create new forms of injustice. This involves a comprehensive understanding of how industrial changes can contribute to more equitable and sustainable economic structures.

GJPD requires an expanded view of economic development, labor, and place, emphasizing the political nature of path development as a process of negotiation and struggle. It challenges us to rethink economic development in terms of its broader impacts on human and ecological well-being, advocating for an economy that supports livelihoods, fosters participation, and respects diverse needs and identities.

3.2 Implications for Theory and Practice

Adopting a GJPD perspective necessitates a reevaluation of the underlying logics of path development, expanding the range of actors considered and acknowledging the complex negotiations between different interests. This approach also calls for a deeper investigation of the outcomes of economic development, urging us to consider the well-being of both people and the planet.

The development of GJPD as a theory of change involves building new typologies of path development that can accommodate diverse logics, processes, and outcomes. This requires a close integration of theoretical insights with empirical research, highlighting the need for a more nuanced

¹⁷ Franz Tödting, Michaela Trippel, Alexandra Frangenheim 2020. Policy options for green regional development: Adopting a production and application perspective, *Science and Public Policy*, Volume 47, Issue 6, December 2020, Pages 865–875, <https://doi.org/10.1093/scipol/scaa051>

understanding of how different economic models, participation mechanisms, and decision-making processes influence the trajectory of industrial change.

GJPD advocates for a holistic approach to understanding industrial path development, one that integrates the principles of environmental sustainability and social justice. By expanding the analytical framework to include a broader set of considerations and stakeholders, we can develop a more comprehensive theory of change that addresses the critical challenges of our time. The concept of GJPD represents a step forward in this direction, offering a framework for analyzing and guiding the transformative processes that shape our economic landscapes.

Exploring regional development through the lens of degrowth, GJPD offers a fresh perspective on achieving equitable and sustainable outcomes. This approach advocates for a shift in focus from the pursuit of high-growth industries to embracing diverse economic practices that nurture well-being and ecological health, akin to "purpose-driven economic strategies that prioritize public services and redistribute incomes"¹⁸. It suggests transitioning towards economies centered on human and environmental welfare, emphasizing the need for economic strategies that serve societal needs and promote equitable distribution of wealth. This broader view encourages examining the interconnectedness of various industries, or 'interpatch dynamics'¹⁹, to foster a holistic approach to regional development. Particularly, GJPD underscores the importance of circular economic principles, advocating for a systemic collaboration across sectors to achieve sustainability goals, where the development of industrial symbiosis becomes critical²⁰. Such a collaborative approach is essential for cultivating industrial ecosystems that are both resilient and sustainable.

4. Green Path Development and Green Regional Restructuring

The concept of sustainable development, introduced in 1980, aimed to balance economic and social growth with environmental conservation. It suggests optimizing economic benefits while preserving natural resources over time. Sustainable development requires a shift from exploitation to conservation, emphasizing wealth redistribution and ceasing practices harmful to future generations.

Green development, as part of this broader concept, focuses on resource-efficient, low-carbon growth that promotes social equity. It's seen as a pathway to generate new growth and employment, transforming conventional "black development" models into greener, more inclusive alternatives. This

¹⁸ Wahlund M, Hansen T (2022) Exploring alternative economic pathways: a comparison of foundational economy and doughnut economics. *Sustain. Sci. Pract. Policy* 18(1):171–186

¹⁹ Fraggenheim, A., Trippel, M., & Chlebna, C. (2020). Beyond the single path view: Interpatch dynamics in regional contexts. *Economic Geography*, 96(1), 31–51. <https://doi.org/10.1080/00130095.2019.1685378>

²⁰ Henrysson, Maryna & Nuur, Cali. (2021). The Role of Institutions in Creating Circular Economy Pathways for Regional Development. *The Journal of Environment & Development*. 30. 107049652199187. [10.1177/1070496521991876](https://doi.org/10.1177/1070496521991876).

transformation is essential at the regional level to ensure ecological security and sustainable development across the economy, environment, and society.



4.1 Green Development Defined

Green development emerged in 1989, emphasizing economics as a tool to address environmental degradation and resource depletion. It's associated with green political philosophy, prioritizing environmental goals through broad social action. Despite the lack of a universally agreed definition, green development is recognized in various forms, all aiming to integrate economic growth with environmental and social sustainability. Green development is defined as the pursuit of economic growth that is both resource-efficient and low in carbon emissions, promoting social equity through jobs and income. This growth is driven by investments from both public and private sectors aimed at reducing emissions, enhancing resource quality, and safeguarding biodiversity and ecosystem services (UNEP 2011). In seeking mutually beneficial solutions and sustainable prosperity, green development integrates environmental concerns with economic and industrial strategies ²¹. Rather than replacing the concept of sustainable development, green development is increasingly recognized as a means to stimulate economic growth and job creation, laying the groundwork for global capital formation. On a regional scale, green development involves a shift from traditional "black development" practices to a more sustainable model characterized by lower carbon footprints, reduced resource use, and community inclusivity. This shift enhances regional ecological stability and promotes the restoration of natural environments, contributing to sustainable outcomes for the economy, the natural world, and society. ²²

4.2 Regional Restructuring for Sustainability

Sustainable development challenges the notion of limitless growth, advocating for a recognition of natural resource limits. This has led to calls for green regional restructuring, where regions adapt their development strategies to focus on green industries and sustainable practices. Regions play a crucial role in implementing sustainable development principles, balancing economic growth with environmental and social needs.

4.3 Green Industrial Path Development

Green path development in regions typically emphasizes establishing green industries. However, distinguishing between "green" and "nongreen" industries can be complex, as innovations can make traditionally dirty industries cleaner, and green industries can still have environmental impacts. Green

²¹ Bina O, 2013, "The green economy and sustainable development: an uneasy balance?" *Environment and Planning C-Government and Policy* 31 1023–1047.

²² Bonsinetto, F., & Falco, E. (2013). Analysing Italian regional patterns in green economy and climate change: can Italy leverage on Europe 2020 strategy to face sustainable growth challenges? *Journal of Urban and Regional Analysis*, 5(2), 123-142. <https://doi.org/10.37043/JURA.2013.5.2.2>

path development strategies include path renewal, diversification, importation, and creation, each with unique challenges and opportunities based on regional characteristics.



4.4 Challenges to Green Regional Restructuring

Green regional restructuring faces several challenges:

- (1) **Directionality:** Policies must clearly support green development, prioritizing pro-green businesses and discouraging unsustainable practices.
- (2) **One-Dimensional Approach:** There's a risk of focusing solely on environmental aspects, neglecting economic and social dimensions.
- (3) **Trade Protection:** Environmental policies should not be used to justify protectionist trade measures that disadvantage developing countries.
- (4) **Experimentation:** Regions must test and learn from new technologies and practices to overcome barriers to green development.
- (5) **Government Coordination:** Effective green development requires aligned policies across all government levels, ensuring a coherent approach to climate change and sustainable growth.

Achieving sustainable development through green regional restructuring requires a comprehensive approach, integrating economic, social, and environmental considerations. Policymakers and academics must address the challenges of green development, ensuring flexible policies that support innovation and sustainable practices. A holistic, coherent, and sustainable approach to regional restructuring is essential, grounded in universal values and tailored to regional specifics, to achieve true sustainable development.

5. Summary: The Importance of Green Path Development and Its Relation to Other Concepts

Green path development is a critical concept that emphasizes sustainable economic growth by integrating environmental and social considerations. The importance of green path development lies in its potential to transform traditional industrial models into more sustainable and inclusive ones, addressing the urgent need for ecological security and sustainable development. The Key Aspects of Green Path Development are as follows:

5.1 Sustainable Development:

Introduced in 1980, sustainable development aims to balance economic growth with environmental conservation and social equity. It emphasizes the redistribution of wealth and the preservation of natural resources for future generations. Green path development is a component of sustainable development, focusing specifically on resource-efficient, low-carbon growth that promotes social equity.

5.2 Green and Just Path Development (GJPD):

GJPD merges green path development with the principles of just transition, ensuring that economic restructuring is both environmentally sustainable and socially equitable. This concept highlights the need for inclusive and fair economic growth, addressing the socio-economic impacts of transitioning to green industries.

5.3 Green Regional Restructuring:

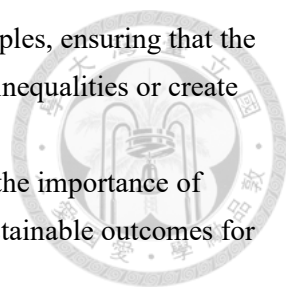
Regional restructuring for sustainability challenges the notion of limitless growth by advocating for the recognition of natural resource limits. Green regional restructuring involves adapting development strategies to focus on green industries and sustainable practices, balancing economic growth with environmental and social needs.

5.4 Challenges and Strategies:

Green path development faces several challenges, including policy directionality, the risk of one-dimensional approaches, trade protection issues, the need for experimentation, and government coordination. Effective green development requires policies that prioritize green businesses, discourage unsustainable practices, and ensure a holistic approach integrating economic, social, and environmental considerations.

5.5 Relation to Other Concepts:

- (1) Sustainable Development: Green path development is a subset of sustainable development, emphasizing low-carbon and resource-efficient growth while promoting social equity.

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- (2) Just Transition: The GJPD concept integrates just transition principles, ensuring that the shift towards sustainable economies does not exacerbate existing inequalities or create new forms of injustice.
 - (3) Regional Development: Green regional restructuring emphasizes the importance of adapting development strategies at the regional level to ensure sustainable outcomes for the economy, environment, and society.
 - (4) Innovation and Industrial Change: Green path development involves the renewal, diversification, importation, and creation of green industries, highlighting the role of innovation and industrial change in achieving sustainable growth.

Green path development is essential for achieving a sustainable future, addressing both environmental and social challenges. By integrating green path development with concepts like sustainable development, just transition, and regional restructuring, we can create a comprehensive framework for sustainable and inclusive economic growth. This holistic approach ensures that the benefits of green development are widely shared, promoting ecological stability and social well-being.

Chapter Three Green Path in the world



1. Green Path in the U.S: U.S. National Innovation Pathway

On April 20, 2023, a collaborative effort between the White House Office of Science and Technology Policy, the Department of Energy, and the State Department led to the release of the "U.S. National Innovation Pathway." This initiative is dedicated to expediting innovation within crucial clean energy technologies. According to the report, the Biden administration is implementing a strategic approach centered around three core aspects: innovation, demonstration, and deployment. This approach is designed to enhance the development and research of essential technologies, facilitating the United States' transition towards a zero-carbon power sector by 2035. It also aims to achieve 50% zero-emission vehicle sales by 2030 and realize a net-zero emission economy by 2050.²³

1.1 U.S. Clean Energy Innovation Strategy

The United States is committed to reducing its greenhouse gas emissions by 50-52% from 2005 levels by 2030, aligning with its Nationally Determined Contribution (NDC). This ambitious goal sets the stage for achieving net-zero emissions by 2050. The strategy outlines various paths to reach these objectives, including:

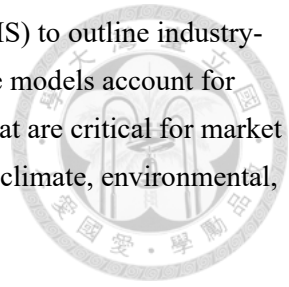
- (1) Establishing a carbon-free power grid by 2035.
- (2) Ensuring zero-emission vehicles constitute 50% of all new vehicle sales by 2030.
- (3) Enhancing energy efficiency across all sectors and promoting the electrification of end-use sectors (such as transportation, construction, and industry) where possible.
- (4) Transitioning energy-intensive industries and modes of transportation to zero-emission or carbon-neutral fuels.
- (5) Adopting carbon capture and storage techniques for high-emission industries and reducing methane and other greenhouse gas emissions.
- (6) Encouraging sustainable practices in agriculture, forestry, and land use.²⁴

To support these goals, the U.S. has initiated a comprehensive net-zero technology action plan, comprising innovation, demonstration, and deployment phases. This plan includes significant investments in research and development (R&D) for breakthrough innovations, demonstration projects to boost market confidence, and regulatory and financial incentives to accelerate the adoption of existing technologies.

²³ White House Office of Science and Technology Policy United States Department of Energy United States Department of State 2023. Mission Innovation NATIONAL INNOVATION PATHWAY OF THE UNITED STATES. <https://www.whitehouse.gov/wp-content/uploads/2023/04/US-National-Innovation-Pathway.pdf>

²⁴ Webpage : Clean Energy Innovation Office of Energy Efficiency & Renewable Energy: Clean Energy Innovation , <https://www.energy.gov/eere/clean-energy-innovation>

The strategy employs economic energy models (GCAM and OP-NEMS) to outline industry-specific pathways for achieving short-term and long-term climate goals. These models account for both current and future technologies, identifying "innovation opportunities" that are critical for market success. The strategy emphasizes the importance of aligning innovations with climate, environmental, economic, and security objectives.



1.2 Participation of Non-Federal Government and Private Sector

The success of America's clean energy innovation hinges on collaboration with the private sector, encompassing research, development, and commercial deployment. Partnerships with industry, academia, and other stakeholders are crucial for advancing scientific research and technological breakthroughs. Financial and technical support mechanisms, such as the Department of Energy's Loan Program Office, play a pivotal role in bridging the gap between laboratory research and market readiness.

1.3 International Cooperation

The U.S. actively engages in international cooperation to bolster its innovation leadership globally. This includes strategic energy dialogues, research collaborations, and leadership roles in international forums like the Mission Innovation (MI) and the Clean Energy Ministerial (CEM). Initiatives such as the First Mover Coalition (A global coalition of companies leveraging their purchasing power to decarbonize the world's heavy-emitting sectors) and the Clean Energy Technology Demonstration Challenge demonstrate²⁵ the U.S.'s commitment to international collaboration in achieving net-zero emissions.

1.4 National Energy Innovation Ecosystem

The national energy innovation ecosystem is a collaborative network that includes public and private sectors, federal agencies, research institutions, and the private industry. This ecosystem is essential for advancing basic research, fostering new discoveries, and facilitating the commercial application of emerging technologies. Key institutions like the Department of Energy and its national laboratories play a vital role in this ecosystem, driving innovation from research and development to practical application.

The "U.S. National Innovation Pathway" is a comprehensive framework designed to propel the United States toward its ambitious climate goals. Through a combination of domestic strategies, international cooperation, and a robust innovation ecosystem, the U.S. aims to lead the way in clean energy innovation and sustainable development.

²⁵ Webpage : U.S. EMBASSY & CONSULATES IN CHINA: FACT SHEET: President Biden to Galvanize Global Action to Strengthen Energy-Security and Tackle the Climate Crisis through the Major Economies Forum on Energy and Climate, <https://china.usembassy-china.org.cn/fact-sheet-president-biden-to-galvanize-global-action-to-strengthen-energy-security-and-tackle-the-climate-crisis/> (last visited June 19, 2024)

1.5 California's Groundbreaking Climate Disclosure Bill SB 253

In September 2023, California's legislature passed a pioneering climate disclosure bill, Senate Bill 253 (SB 253), which mandates large corporations to disclose their greenhouse gas emissions. This legislation, supported by major corporations such as Apple and Google, represents a significant step towards greater corporate transparency and accountability in environmental impacts. The bill stipulates that companies with annual revenues exceeding \$1 billion must publicly disclose their direct (Scope 1) and indirect (Scope 2) greenhouse gas emissions starting in 2026, and their supply chain emissions (Scope 3) beginning in 2027. This paper provides an academic analysis of SB 253, its requirements, and its implications for corporate environmental responsibility.²⁶

SB 253, also known as the Climate Corporate Leadership and Accountability Act, was introduced by California Senators Scott Wiener, Lena Gonzalez, and Henry Stern on January 30, 2023. The bill initially passed the state Senate but fell short by a single vote in the state Assembly. However, the increased support from influential companies in 2023 led to its eventual passage. The legislation now awaits the signature of Governor Gavin Newsom, who has yet to publicly declare his position on the bill. SB 253 targets large corporations operating in California with annual revenues of at least \$1 billion. The legislation will impact approximately 5,400 companies, including well-known entities such as Walmart and Apple.²⁷ The bill requires these companies to disclose:

- (1) Scope 1 Emissions: Direct emissions from owned or controlled sources, such as emissions from manufacturing facilities.
- (2) Scope 2 Emissions: Indirect emissions from the consumption of purchased electricity, steam, heating, and cooling.
- (3) Scope 3 Emissions: All other indirect emissions that occur in a company's value chain, including both upstream and downstream activities.

The disclosure standards align with the Greenhouse Gas Protocol's Corporate Accounting and Reporting Standard and the Corporate Value Chain (Scope 3) Accounting and Reporting Standard. The California Air Resources Board (CARB) is tasked with developing the regulatory framework for these disclosures by January 1, 2025.

Beginning in 2026, affected corporations must annually report their Scope 1 and Scope 2 emissions. From 2027 onward, Scope 3 emissions will also need to be disclosed. To ensure the accuracy and credibility of the reported data, companies are required to undergo verification by an

²⁶ Webpage: CLA Business Law Section Agribusiness Standing Committee By Brent W. Thompson <https://calawyers.org/business-law/californias-climate-disclosure-requirements-an-overview-of-senate-bills-253-and-261/>

²⁷ Webpage: California Legislative Information: SB-253 Climate Corporate Data Accountability Act. (2023-2024) , https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202320240SB253, (last visited June 19, 2024)

independent third party. The disclosure reports will be publicly accessible through a digital reporting system established by CARB, thereby enhancing transparency for investors, stakeholders, and the general public.

SB 253 outlines a penalty framework to enforce compliance. Companies failing to disclose their emissions data could face fines of up to \$500,000 per year. However, the bill provides a grace period until 2030, during which penalties will primarily target non-disclosure of Scope 3 emissions rather than inaccuracies in the reported data, provided they are made in good faith.

The enforcement of Scope 3 emissions disclosure is particularly significant, as it encompasses the entire lifecycle of products and services, from raw material extraction to end-of-life disposal. This requirement poses substantial challenges for various industries:

- (1) Food and Beverage: Companies must disclose emissions from agricultural production, processing, packaging, and distribution.
- (2) Electronics: Emissions from the entire lifecycle of electronic products, including raw material extraction, manufacturing, usage, and disposal, must be reported.
- (3) Fashion: Brands must account for emissions from fabric production, garment manufacturing, transportation, consumer use, and disposal.
- (4) Automotive: Manufacturers need to report emissions from vehicle production, fuel consumption, and the entire supply chain.

Environmental advocacy groups, such as the Sierra Club, have endorsed SB 253, emphasizing its potential to enhance public awareness and drive corporate accountability. Conversely, the California Chamber of Commerce and other industry representatives have expressed concerns about the feasibility and economic impact of the new regulations.

SB 253 marks a transformative development in corporate environmental governance, setting a new standard for climate disclosure in the United States. By mandating comprehensive reporting of greenhouse gas emissions, including the often-overlooked Scope 3 emissions, California is leading the way in fostering greater corporate responsibility and transparency. As the state awaits Governor Newsom's decision, the successful implementation of SB 253 will hinge on the establishment of clear regulatory guidelines and effective enforcement mechanisms by CARB. This legislation not only aligns with global sustainability efforts but also sets a precedent for other states and countries to follow in the pursuit of a more sustainable future.

2. Green Path in Japan: Zero Carbon Cities by 2050 (2050 ゼロカーボンシティ宣言)

The Japanese government has declared its ambition to achieve a carbon-neutral society by 2050, setting intermediate targets for carbon neutrality by 2030 and publishing a revised 'Green Growth Strategy' that underscores the crucial role of decarbonizing the electricity sector. To facilitate municipal-level carbon neutrality, the Ministry of the Environment has identified 'Zero Carbon Cities by 2050,' while businesses have aligned their visions with carbon neutrality policies.

Aligning with global net-zero initiatives, then-Prime Minister Yoshihide Suga announced on October 26, 2020, Japan's commitment to achieving carbon neutrality by 2050, aiming to eliminate greenhouse gas emissions and realize a carbon-free society.

According to data from Japan's Ministry of Economy, Trade, and Industry, Japan is earnestly working towards the initial milestone of a carbon-neutral society, having reduced greenhouse gas emissions by 2.7% compared to the fiscal year 2019, thanks to the widespread adoption of renewable energy and advancements in related technologies. This marks six consecutive years of decreasing emissions, with significant reductions among the G7, the world's seven most advanced economies.²⁸

2.1 Public Awareness of Decarbonization Goals in Japan

Following the government's net-zero policy announcement, a public opinion survey conducted by the Cabinet Office after the Prime Minister's declaration of carbon neutrality revealed that 33.2% of the population is aware of the concept of a decarbonized society, while an additional 35.1% have heard of decarbonization but lack detailed understanding. In total, nearly 70% of the population is familiar with the term "decarbonized society," indicating significant public awareness of the need for societal decarbonization.²⁹

In December of the same year, the National Forum on Carbon Neutrality by 2050 was held, with Prime Minister Yoshihide Suga affirming Japan's commitment to the carbon neutrality challenge by 2050. The forum emphasized ongoing dialogue among stakeholders, increased participation, and the government's multifaceted efforts to enhance stakeholders' understanding and recognition of carbon neutrality by 2050.

But what exactly are Japan's carbon neutrality goals, and what are the specific strategies? Initially, the Japanese government formally set and legislated the intermediate carbon neutrality targets for 2030.

At the Global Warming Countermeasures Promotion Headquarters meeting on April 22, 2021, Japan set forth an ambitious goal to achieve a 46% reduction in emissions by 2030, aiming to further reach a 50% reduction. This pledge was proclaimed to the international community at the Global Leaders' Climate Summit the following day. In May of the same year, the goal of achieving carbon neutrality by 2050 was officially codified in the Japanese Diet, followed by the publication of a

²⁸ Webpage : Ministry of the Environment Government of Japan: Japan's National Greenhouse Gas Emissions in Fiscal Year 2019 (Preliminary Figures) , <https://www.env.go.jp/en/headline/2483.html>, (last visited June 19, 2024)

²⁹ Webpage : Risk Society and Policy Research Center, National Taiwan University : Is it possible to achieve carbon neutrality by 2050? Japan's road map to achieve carbon neutrality ,<https://rsprc.ntu.edu.tw/zh-tw/m01-3/climate-change/1763-0216-jp-carbon-neutral.html>, (last visited June 19, 2024)

revised "Green Growth Strategy" in June, outlining Japan's industrial development trajectory towards carbon neutrality.³⁰

The Green Growth Strategy identifies 14 key growth industries, categorized into "energy, transportation, manufacturing, and home offices." Special emphasis is placed on decarbonization within the electricity sector, including the promotion of renewable energy, hydrogen power generation, the development of carbon recycling technology in thermal power generation, and enhancing nuclear power safety and restart initiatives.

Furthermore, beyond the electricity sector, the shift towards "electrification" is a primary focus in industries, transportation, business, and household sectors. Due to the rising demand for electricity and in response to decarbonization policies, energy-saving industries, new energy sources, and new technologies (such as the hydrogen industry, automotive/battery industry, transportation-related industry, and residential/construction-related industry) are identified as growth areas, paving the way for an electrified society in the future.

2.2 Achieving Carbon Neutrality: Local Adaptation

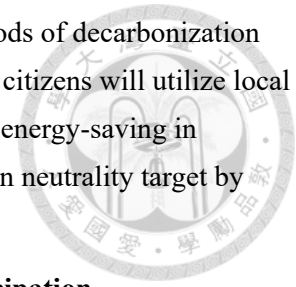
Local governments play an indispensable role in Japan's path to carbon neutrality. To achieve this goal, the Ministry of the Environment has designated "local governments that publicly commit to reducing carbon dioxide emissions to nearly zero by 2050" as Zero Carbon Cities by 2050. Before the government's announcement of carbon neutrality by 2050, only 166 municipalities had set the goal of becoming zero-carbon cities. However, following the announcement, the number of cities committed to zero carbon by 2050 rapidly increased. By the end of July 2022, a total of 758 municipalities, including Tokyo, Kyoto, and Yokohama, had joined. This includes 42 prefectures, 445 cities, 20 special wards, 213 towns, and 38 villages declaring their intention to "reduce carbon dioxide emissions to virtually zero by 2050." These local governments represent a population of approximately 118.52 million people, exceeding 90% of the population and accounting for 93.9% of Japan's total population.³¹

On June 9, 2021, Prime Minister Suga attended a local decarbonization meeting and proposed a roadmap for local decarbonization, starting with the creation of decarbonization demonstration areas. By 2030, it is expected that there will be 100 such demonstration areas, actively promoted by local governments, local businesses, and financial institutions, with support from the central government.

³⁰ Webpage : Taiwan Green Productivity Foundation : Japan - New carbon reduction target for 2030: 46% reduction compared to 2013 · <https://www.ccct.org.tw/news/show?id=c47cfaf7fd374efc8888c0d624e07361>, (last visited June 19, 2024)

³¹ The same as 29

Due to the unique development characteristics of each area, the methods of decarbonization will differ between cities and rural areas. Local governments, businesses, and citizens will utilize local features and development, such as using personal solar power generation and energy-saving in buildings and homes, to achieve the intermediate goals by 2030 and the carbon neutrality target by 2050.



2.3 Responding to Climate Action: The Japanese Industry's Active Participation

To address carbon neutrality policies, Japan's largest economic organization, Keidanren (Japan Business Federation), released a carbon neutrality action plan on November 8, 2021, outlining the vision and basic policies for various industries towards carbon neutrality by 2050, mobilizing the business community. To address climate change, there are four main pillars.

First, from the fiscal year 2013 to 2020, there was an approximate 22.3% reduction in carbon dioxide emissions in the industrial, energy transformation, commercial, and transportation sectors. Following that, there's an active effort to increase overall societal awareness of products and services that contribute to emission reduction.

The third pillar emphasizes international cooperation, particularly the overseas transfer of Japanese industry technology, to help reduce global greenhouse gases. Lastly, innovation in technology is key; since traditional technologies may not achieve carbon neutrality, new technologies will be crucial for reaching carbon neutrality by 2050. Industries will collaborate with the government to complete technology research and development.³²

3. Green Path in Europe

Climate change has prompted a global push towards "Net-Zero Emissions by 2050," with Taiwan officially announcing its "Taiwan 2050 Net-Zero Emissions Pathway and Strategy" on March 30, 2022, aspiring to join the worldwide transition to net-zero by 2050. The European Union (EU) positions itself as a leader in net-zero emissions and sustainable development. This context sets the stage for analyzing the EU's 2050 net-zero emissions new thinking through The European Green Deal, serving as a reference for Taiwanese society and beyond.

3.1 European Green Deal

The European Commission unveiled The European Green Deal on December 11, 2019, aiming to transform the EU into a fair, inclusive, low-carbon, sustainable, and competitive economy, with 2030 climate goals set to reduce emissions by at least 50-55% compared to 1990 levels and achieving climate neutrality by 2050.³³

³² The same as 29

³³ Website European Commission https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

The EU has implemented several policy tools, including the Carbon Border Adjustment Mechanism, the Energy Taxation Directive (ETD), Renewable Energy Directive (RED), Energy Efficiency Directive (EED), sustainable maritime and aviation fuel policies, and an expanded Emissions Trading System, among others, to drive global climate action and transform economic investment and societal norms.



The European Green Deal covers extensive domains such as energy, economy, construction, transportation, agriculture, ecology, and the environment. It emphasizes full societal participation, accelerates green transformation, promotes economic growth, breaks the link between resource consumption and growth, and insists on balancing economic and social development with ecological sustainability.

The Green Deal's comprehensive approach includes dimensions such as ambitious climate goals for 2030 and 2050, providing pollution-free, affordable, and secure energy, promoting industries free from pollution and embracing the circular economy, enhancing energy efficiency in buildings and renovations, accelerating the transition to sustainable and smart transport, designing a fair, healthy, and environmentally friendly food system "from farm to table," preserving and restoring ecosystems and biodiversity, and targeting a zero-pollution ambition for a toxic-free environment.

The European Green Deal, initiated under the leadership of European Commission President Ursula von der Leyen, symbolizes a new commitment to addressing climate and environmental challenges. It requires mobilizing legal, fiscal, policy, and market strategies to achieve a comprehensive policy transformation and lead the global community towards sustainable development, reflecting Europe's strategic long-term planning in combating climate change and moving closer to its ambitious climate goals.

The Green Deal, with its goal-oriented approach supplemented by policies and actions across energy, industry, construction, transportation, food, ecology, and environmental governance, incorporates sustainability into green finance, environmental budgets, technological innovation, and education, offering support for Europe's green transition. This new thinking towards net-zero emissions provides valuable insights and reference points for Taiwan and other regions looking to embark on a similar journey towards sustainability.

3.2 Small and Medium-sized Enterprises (SMEs) to Achieve Net-Zero Emissions by 2050

In recent years, governments worldwide have set ambitious targets to achieve net-zero emissions by 2050. Various policy tools have been introduced to help SMEs transition to low-carbon and sustainable business models. These tools are essential for enabling SMEs to capitalize on green business opportunities and contribute to climate goals.³⁴

³⁴ Website Small and Medium Enterprises are Critical to Net-Zero Goals by Vishnu Nair, <https://perspectives.se.com/blog-stream/small-and-medium-enterprises-are-critical-to-net-zero-goals>

The policy tools designed to support SMEs in their green transition can be categorized into four main areas:



- (1) Regulatory Measures
- (2) Green Certifications and Awards
- (3) Financial Incentives
- (4) Technical Assistance

Regulatory measures simplify administrative processes for SMEs to adopt sustainable practices, offer tax reductions, standardize applications for sustainability-related intellectual property, and encourage environmental management certifications to enhance competitiveness in public tenders.

Establishing green certification standards and awarding green prizes help SMEs demonstrate their commitment to sustainability. These measures can enhance SMEs' competitiveness in green trade by recognizing their efforts towards sustainable development.

Financial incentives encompass a variety of tools such as direct subsidies, private equity investments, and preferential loans. For startups that find it challenging to access market funding, direct subsidies are crucial for entering the net-zero pathway. For growing SMEs, private equity funds and low-carbon project investments can provide a conducive environment for development while enhancing competitiveness.

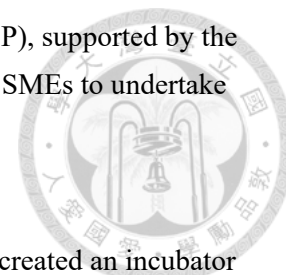
Technical assistance involves training and mentoring to equip SMEs with the necessary skills and knowledge for sustainable transformation. Creating platforms for technology exchange and collaboration accelerates the diffusion of green innovations and strengthens sustainable development capabilities. Several EU member states have implemented successful financial and technical support programs for SMEs:

3.3 Financial Incentives

- (1) Greece: The Greek Green Fund, established through the European Union Recovery Plan, supports SMEs in green and circular economy sectors. Managed by the Hellenic Development Bank of Investment (HDBI), the fund provides venture capital and private equity investments with HDBI setting investment standards.³⁵
- (2) Ireland: The Green Enterprise: Innovation for a Circular Economy program involves a two-stage review process by government-appointed experts. After approval, funds are disbursed based on progress reviews.

³⁵ Webpage : Balkan Green Energy News: Greek Green Funds target over EUR 3 billion in investments ,<https://balkangreenenergynews.com/greek-green-funds-target-over-eur-3-billion-in-investments/>, (last visited June 19, 2024)

- (3) Italy: The Guarantee Programme of Cassa Depositi e Prestiti (CDP), supported by the European Investment Bank (EIB), provides preferential loans for SMEs to undertake sustainable transitions.



3.4 Technical Assistance

- (1) Belgium: The Brussels Institute for Research and Innovation has created an incubator encouraging school participation and offering Science Vouchers for activities like science competitions. The government provides a comprehensive administrative platform linking various public departments related to sustainable transformation.
- (2) Denmark: The Danish Business Authority funds the Dansk Iværksætter Forening, a non-profit organization that invites successful green entrepreneurs to share their experiences and provide solutions to common challenges. This organization also participates in policy-making to enhance public-private communication.
- (3) EU-wide: The Technical Support Instrument (TSI) under the Multiannual Financial Framework helps member states and organizations achieve green and digital transitions through customized institutional reform services.

The EU's approach to supporting SMEs in their green transition is multi-faceted, incorporating financial incentives, technical assistance, regulatory measures, and green certifications. These tools are designed to address the diverse needs of SMEs at different stages of growth, from startups requiring direct subsidies to established enterprises benefiting from private equity investments. Technical assistance through training and collaboration platforms further enhances the capacity of SMEs to innovate and adopt sustainable practices. By drawing on the EU's experience, countries can develop effective strategies to support their SMEs in contributing to global climate goals.

4. Green Path in China

In recent years, the world has experienced frequent extreme weather events, including record-breaking heatwaves, droughts, heavy rainfall, floods, and blizzards. These extreme weather events have significantly impacted people's lives and economic activities, leading to reduced agricultural production, transportation disruptions, energy shortages, and even casualties. Human activities, particularly the emission of large amounts of greenhouse gases such as carbon dioxide and methane, have contributed to these phenomena by creating a greenhouse effect in the atmosphere, leading to a rise in Earth's surface temperature.³⁶

³⁶ EDMUND DOWNIE (2021), GETTING TO 30-60: HOW CHINA'S BIGGEST COAL POWER, CEMENT, AND STEEL CORPORATIONS ARE RESPONDING TO NATIONAL DECARBONIZATION PLEDGES, in https://www.energypolicy.columbia.edu/wp-content/uploads/2021/08/ChinaBusiness30-60_CGEP_Report_111122.pdf

4.1 China 30-60 Target & 1+N Policy (中国 3060 路径—双碳“1+N”政策体系)

Since the Industrial Revolution, rapid and large-scale carbon emissions have accelerated global warming beyond natural climate cycles. The World Meteorological Organization (WMO) reported in the "State of the Global Climate 2022" that the global average temperature in 2022 was 1.15°C higher than the average level between 1850 and 1900. Concentrations of carbon dioxide, methane, and nitrous oxide reached record highs in 2021 and continued to rise in 2022.³⁷

These extreme climates not only disrupt ecological balance and threaten species but also pose risks and instabilities for human sustainable development. Balancing economic growth with environmental protection has become a significant challenge for all countries. China has taken substantial responsibility and commitments in addressing climate change. In September 2020, President Xi Jinping announced at the 75th United Nations General Assembly that China aims to peak carbon emissions before 2030 and achieve carbon neutrality before 2060, known as the "30-60" target. This commitment is a significant contribution to global climate governance and represents China's critical choice for high-quality development. To achieve these goals, China has established a "1+N" policy framework to promote a comprehensive green transformation of the economy and society, aiming to develop a clean, low-carbon, safe, and efficient energy system and promote sustainable economic and social development.

The "30-60" dual-carbon goal includes peaking carbon emissions and achieving carbon neutrality. Peaking carbon emissions means that carbon dioxide emissions will reach their maximum in a certain year and then start to decline, while carbon neutrality means balancing carbon dioxide emissions with absorption, achieving net-zero emissions.

In September 2020, President Xi Jinping proposed at the United Nations Assembly that China's carbon dioxide emissions strive to peak by 2030 and achieve carbon neutrality by 2060. The "30-60" target was subsequently included in the 14th Five-Year Plan and the 2035 Long-Range Objectives, elevating "carbon peaking" and "carbon neutrality" to the national strategic level. The establishment of China's carbon neutrality goal coincides with the layout year of the "14th Five-Year Plan," meaning future carbon emission intensity will be included in binding indicators, clarifying the distribution and coordination of carbon emission control tasks for different regions and industries.

China's double-carbon policy system, known as the "1+N" policy, is designed to integrate actions across various industries and dimensions to reduce carbon emissions. The "1" refers to the guiding opinion issued by the Central Committee of the Communist Party of China and the State Council, which serves as the top-level design and overall framework for the double-carbon policy. It clarifies the content, basic paths, and key tasks of the double-carbon goals, covering both carbon

³⁷ Kowtham Raj, Aayog Pranav Lakhina, Clay Stranger (2022 Harnessing GREEN HYDROGEN OPPORTUNITIES FOR DEEP DECARBONISATION IN INDIA, 55-56; https://www.niti.gov.in/sites/default/files/2022-06/Harnessing-Green-Hydrogen_V21_DIGITAL_29_06.pdf

peaking and carbon neutrality phases. The "N" refers to specific policies and plans developed by various departments and local governments according to the guiding opinion, covering key areas such as energy, industry, urban-rural construction, transportation, agriculture, and rural areas, as well as support in technology, finance, statistical accounting, and talent cultivation.³⁸

The "1+N" policy system's overall approach is to use the guiding opinion as the lead, with all departments and local governments contributing to achieve the double-carbon goals. This approach demonstrates both unity and coordination as well as diversity and flexibility. Unity and coordination ensure that all actions are consistent with the overall goals and coordinated among different parties, while diversity and flexibility allow for tailored policies and plans according to each department's and local government's specific conditions and characteristics.

The "1+N" policy system features clear goals and pathways, emphasizing systemic and coordinated efforts. Various departments and local governments complement each other, forming a comprehensive policy system to support the achievement of the double-carbon goals. The system also encourages innovation and flexibility, allowing for diverse approaches to carbon reduction and sustainable development.

4.2 China's Industrial Green Pathways

In the context of global climate change, industrial development must evolve towards sustainability. China, as the world's largest manufacturing nation, faces significant challenges and opportunities in transitioning to green and low-carbon industrial practices. This academic analysis explores the comprehensive strategies and pathways China is employing to achieve industrial decarbonization and sustainable development.

China has established a robust legislative and policy framework to guide its industrial green transformation. Key legislation includes the Energy Conservation Law and the Environmental Protection Law, which provide the foundational legal basis for promoting energy efficiency and reducing emissions across industries. Recent strategic plans, such as the "14th Five-Year Plan for National Economic and Social Development" and the "The Action Plan for Carbon Dioxide Peak Before 2030 (2030 年前碳达峰行动方案)" outline detailed roadmaps for integrating green development principles into industrial policies. These documents emphasize the importance of coordinated policies and cross-sectoral efforts to achieve the dual goals of carbon peak and carbon neutrality.³⁹

³⁸ Webpage : ESG30: China 30-60 Target & 1+N Policy ,<https://index.caixin.com/2024-03-01/102170557.html>, (last visited June 19, 2024)

³⁹ Webpage: China Government: The State Council issued the "Action Plan for Carbon Dioxide Peak Before 2030", https://www.gov.cn/xinwen/2021-10/26/content_5645001.htm, (last visited June 19, 2024)

China's approach to industrial green transformation is informed by the experiences of other major economies, including the United States, the European Union, and Japan. These regions have implemented comprehensive legislative frameworks, advanced technological innovations, and financial incentives to promote low-carbon development. For instance, the United States emphasizes strategic planning and technological R&D, while the European Union focuses on integrating digital and green transitions, supported by a well-established carbon trading system. Japan's emphasis on circular economy principles and advanced energy technologies also provides valuable lessons for China's green pathway. The Pathways for Key Industries are as follows.

4.3 Steel Industry

The steel industry is a significant contributor to China's carbon emissions, primarily due to its reliance on coal-based processes. Key strategies for reducing emissions in this sector include:

- (1) Promoting Electric Arc Furnace (EAF) Steelmaking: EAF steelmaking, which uses recycled scrap metal, has significantly lower carbon emissions compared to traditional blast furnace methods.
- (2) Hydrogen-Based Steelmaking: Developing and deploying hydrogen metallurgy technologies can substantially reduce carbon emissions by using hydrogen instead of carbon as a reducing agent.
- (3) Carbon Capture, Utilization, and Storage (CCUS): Implementing CCUS technologies in steel production can capture and store emissions, preventing them from entering the atmosphere.

4.4 Petrochemical Industry

The petrochemical industry faces unique challenges due to its high energy consumption and the increasing demand for petrochemical products. Key strategies for this sector include:

- (1) Improving Energy Efficiency: Enhancing the energy efficiency of production processes through technological upgrades and better management practices.
- (2) Electrification of Processes: Increasing the use of electricity, particularly from renewable sources, in place of fossil fuels for various production processes.
- (3) Development of Green Hydrogen: Utilizing green hydrogen, produced from renewable energy, as a feedstock for chemical production can significantly reduce emissions.

4.5 Building Materials Industry

The building materials sector, especially cement production, is another major source of emissions. Strategies for reducing emissions in this sector include:

- (1) Alternative Raw Materials: Using alternative raw materials that require less energy to process and result in lower emissions.

- (2) Alternative Fuels: Substituting traditional fossil fuels with alternative fuels, such as biomass and waste-derived fuels, in production processes.
- (3) Energy Efficiency Improvements: Implementing advanced technologies to enhance energy efficiency in the production of building materials.



4.6 Technological Innovation and Implementation

Technological innovation is critical to achieving low-carbon goals across all industrial sectors. Key areas of focus include:

- Digitalization: Leveraging digital technologies, such as big data, artificial intelligence, and the Internet of Things (IoT), to optimize industrial processes and reduce emissions.
- Smart Manufacturing: Integrating smart manufacturing systems to enhance efficiency and reduce waste through real-time monitoring and adaptive control.
- Renewable Energy Integration: Increasing the use of renewable energy sources, such as solar and wind power, in industrial operations to reduce dependency on fossil fuels.

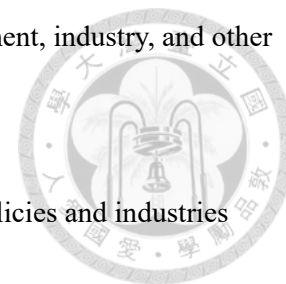
4.7 Policy Recommendations

Achieving China's green industrial transformation requires comprehensive and coordinated policy measures. Key recommendations include:

- (1) Strengthening Carbon Reduction Responsibilities: Enhancing regulatory frameworks to ensure that all stakeholders are accountable for meeting carbon reduction targets.
- (2) Policy Integration and Coordination: Ensuring that green development principles are integrated into all aspects of industrial policy and that there is coordination across different sectors and levels of government.
- (3) Investment in R&D: Promoting research and development of new technologies that can support low-carbon industrial processes, including funding for pilot projects and support for the commercialization of innovative solutions.
- (4) Market Mechanisms and Incentives: Creating market demand for green products and services through incentives, subsidies, and public awareness campaigns. This includes expanding green procurement programs and promoting green certifications.
- (5) International Collaboration: Engaging in global initiatives and partnerships to share knowledge, resources, and best practices for industrial green transformation. Participation in international climate agreements and collaborative research projects can also enhance China's efforts.

China's pathway towards green and low-carbon industrial development is a vital component of its broader strategy for sustainable development and climate change mitigation. By implementing robust policies, fostering technological innovation, and leveraging international experiences, China aims to lead the global transition towards a sustainable industrial economy. The successful realization

of these goals will require sustained efforts and collaboration among government, industry, and other stakeholders to build a sustainable and prosperous future.



5. Green Path in India

There are also some green path policies in India including the government policies and industries activities. In this section, will show the main green path policies in India.

5.1 National Action Plan for Climate Change

The National Action Plan for Climate Change (NAPCC) is a comprehensive program launched by the Government of India in 2008, aiming to mitigate and adapt to the adverse impacts of climate change. The plan is supervised by the Prime Minister's Council on Climate Change (PMCCC) and involves eight sub-missions focused on fulfilling India's developmental objectives while reducing the emission intensity of its economy. The plan underscores the need for support from developed countries, emphasizing the goal of keeping India's carbon emissions below those of developed economies.

The eight missions under NAPCC are designed to address various aspects of climate change and sustainability:

- (1) National Solar Mission
- (2) National Mission for Enhanced Energy Efficiency
- (3) National Mission on Sustainable Habitat
- (4) National Water Mission
- (5) National Mission for Sustaining Himalayan Ecosystem
- (6) Green India Mission
- (7) National Mission for Sustainable Agriculture
- (8) National Mission on Strategic Knowledge for Climate Change

The National Solar Mission, launched in 2010 as the Jawaharlal Nehru National Solar Mission, aims to produce 20,000 Megawatts of solar power in three phases (2010-2013, 2013-2017, and 2017-2022). The target was revised in 2015 to 100,000 Megawatts by 2022, with a goal of generating 40 Gigawatts from rooftop solar projects and 60 Gigawatts from large and medium-scale grid-connected projects. The Ministry of New and Renewable Energy provides capital subsidies and seeks funding from bilateral donors and the Green Climate Fund under the UNFCCC.⁴⁰

Several schemes, such as the Kisan Urja Suraksha Evam Uthhan Mahabhiyan (KUSUM), were introduced to promote solar power and reduce dependency on traditional energy sources.

⁴⁰ Webpage: International Energy Agency: Jawaharlal Nehru National Solar Mission (Phase I, II and III), <https://www.iea.org/policies/4916-jawaharlal-nehru-national-solar-mission-phase-i-ii-and-iii>, (last visited June 19, 2024)

However, issues such as the Domestic Content Requirement provision have posed challenges for foreign manufacturers.⁴¹

Derived from the Energy Conservation Act of 2001, the NMEEE aims to enhance India's energy efficiency. Approved in 2010, the mission targets a total avoided capacity addition of 19,598 MW, fuel savings of 23 million tonnes per year, and greenhouse gas emissions reductions of 98.55 million tonnes annually. The mission includes four key components:⁴²

- (1) Perform, Achieve, Trade (PAT)
- (2) Energy Efficiency Financing Platform
- (3) Market Transformation for Energy Efficiency (MTEE)
- (4) Framework for Energy Efficiency Economic Development

The PAT scheme allocates energy-saving targets to industries and issues tradable energy saving certificates. The Energy Efficiency Financing Platform supports financial institutions in funding energy efficiency projects, while the Framework for Energy Efficiency Economic Development mitigates investment risks. The MTEE component promotes energy-efficient equipment, exemplified by the "Bachat Lamp Yojna" and "UJALA" schemes for distributing energy-efficient bulbs.

National Mission on Sustainable Habitat focuses on reducing energy consumption in urban sectors such as transportation and building. It promotes the Energy Conservation Building Code (ECBC), solid and liquid waste management, and public transport. Research and development efforts under this mission aim to improve waste and water management practices.

The National Water Mission aims to ensure equitable water distribution and enhance management of overexploited water resources. It targets a 20% increase in water use efficiency and promotes traditional and multipurpose water conservation projects. The mission emphasizes decentralized water resource management and public participation.⁴³

The National Mission for Sustaining Himalayan Ecosystem addresses the climate change impacts on the Himalayan ecosystem, crucial for millions of people. The mission involves the Ministry of Science and Technology and other relevant ministries, focusing on assessing and preserving the health of the Himalayan ecosystem.

⁴¹ Webpage: Ministry of Electronics & Information Technology: PM-KUSUM (Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan) Scheme. <https://www.india.gov.in/spotlight/pm-kusum-pradhan-mantri-kisan-urja-suraksha-evam-utthaan-mahabhiyan-scheme>, (last visited June 19, 2024)

⁴² Webpage: International Energy Agency: National Mission for Enhanced Energy Efficiency, <https://www.iea.org/policies/7449-national-mission-for-enhanced-energy-efficiency>, (last visited June 19, 2024)

⁴³ The same as 42

The Green India Mission aims to increase forest and tree cover, targeting an additional 5 million hectares of forest area and improving forest quality on another 5 million hectares. It seeks to enhance carbon sequestration, biodiversity, and livelihoods for 3 million people through forest-based activities. However, funding constraints have delayed its implementation.

National Mission for Sustainable Agriculture (NMSA) promotes sustainable agricultural practices through various programs such as the Soil Health Card Scheme, Paramparagat Krishi Vikas Yojana, and National Bamboo Mission. It focuses on efficient water use, soil health management, and climate-resilient agricultural practices.

National Mission on Strategic Knowledge for Climate Change aims to create knowledge networks among research institutions to facilitate data sharing and climate science research. It supports policy frameworks and institutional mechanisms for strategic knowledge dissemination.

The implementation of NAPCC faces several challenges, including inadequate coordination among ministries, insufficient funding, and slow progress in meeting targets. The PMCCC has faced criticism for its lack of accountability and infrequent meetings. Budget allocations have often fallen short of the promises made, and local governments struggle with limited financial resources to implement proposed programs.

Tracking the status of different missions is difficult due to bureaucratic hurdles and constant changes in budget heads and schemes. The slow progress has also impacted farmers, who face frequent climate impacts without adequate infrastructure and support, leading to increased debts and deteriorating living standards.

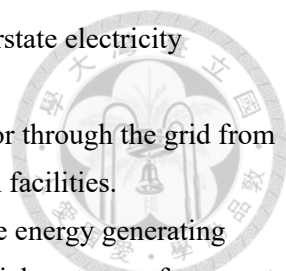
The National Action Plan for Climate Change represents India's comprehensive strategy to address climate change through a series of targeted missions. While the plan lays out ambitious goals and a structured approach, its success depends on improved coordination, increased funding, and effective implementation. Addressing these challenges is crucial for India to achieve its climate goals and contribute to global sustainability efforts.

5.2 Green Hydrogen Policy

India's "Green Hydrogen Policy," announced by the Ministry of Power on February 17, 2022, marks a significant step toward establishing a green hydrogen industry chain through fiscal and regulatory incentives. The policy aims to achieve India's carbon reduction targets pledged at the COP26 summit by fostering the production of green hydrogen, which has lower carbon emissions than its grey and blue counterparts due to its renewable energy-based production process.

The policy outlines key regulatory adjustments to promote green hydrogen production, including:

- (1) Green hydrogen, defined as hydrogen produced through electrolysis powered by renewable energy, including biomass, will be encouraged.

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- (2) Producers operational by June 30, 2025, will be exempt from interstate electricity transmission charges for 25 years.
 - (3) Electricity for green hydrogen production can be sourced on-site or through the grid from renewable facilities, regardless of the producers' operation of such facilities.
 - (4) Green hydrogen production facilities will be considered renewable energy generating facilities and allowed on corresponding lands, including commercial port areas for export facilitation.
 - (5) Renewable energy used for hydrogen production can count towards Renewable Purchase Obligation (RPO) requirements.
 - (6) Green hydrogen producers will be allowed to participate in the electricity trading market and the surplus electricity (banking) market, with regulated banking fees.

Despite these initiatives, green hydrogen is in its infancy in India, with prices between \$3 to \$6.5 per kilogram. The government's goal is to reduce this to \$1 per kilogram by 2030, highlighting the importance of green hydrogen for India's energy independence given the country's heavy reliance on energy imports.⁴⁴

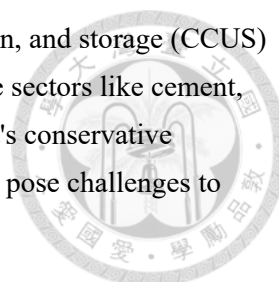
A report by energy consultancy Wood Mackenzie emphasizes India's unique opportunity to transition into a low-carbon economy powerhouse by 2050, leveraging rapid growth in renewable energy. India, already ranking fourth globally in renewable energy installations, aims to double its non-fossil fuel production in six years through the Pancharit initiative introduced at COP26. This ambitious renewable energy development could cumulatively reduce India's carbon emissions by 1 billion tonnes by 2030 and decrease carbon intensity by over 45% by 2070, aiding in achieving net-zero emissions.

However, to realize these goals, strengthening the domestic renewable supply chain is crucial. India's manufacturing ambitions and net-zero targets are hindered by its reliance on imports for solar cell manufacturing and other components. Further, the development of battery storage capacity is essential for supporting renewable energy growth, with the government incentivizing investments in projects requiring battery storage installation.

India's potential for biomass utilization and hydrogen production presents unique decarbonization opportunities. With approximately 750 million tonnes of agricultural residues annually, shifting biomass use from residential to industrial and transport sectors could significantly impact oil imports and reduce air pollution. India's advancements in compressed biogas, biomass pelletization, and bioenergy use, along with its rich bio-feedstocks, demonstrate its potential in Sustainable Aviation Fuel (SAF) production.

⁴⁴ Webpage: ETEnergyWorld: India aims to slash green hydrogen cost to \$1 per kg by 2030, <https://energy.economictimes.indiatimes.com/news/renewable/india-aims-to-slash-green-hydrogen-cost-to-1-per-kg-by-2030-amitabh-kant/106746346h>, (last visited June 19, 2024)

This report also highlights the importance of carbon capture, utilization, and storage (CCUS) for India's decarbonization efforts, especially in energy and emission-intensive sectors like cement, steel, and petrochemicals. Despite recognizing the importance of CCUS, India's conservative approach and lack of clear plans and financial support for CCUS development pose challenges to achieving net-zero emissions.



Decarbonizing manufacturing is crucial for India's 2050 net-zero vision, with the cement, steel, and petrochemical industries being significant contributors to industrial emissions. Innovative technologies, investments in low-carbon value chains, and a focus on energy-saving processes and cleaner manufacturing techniques are essential for reducing emissions in these sectors.

Building an Indian model for improved energy efficiency involves national policies with local impact, such as the UJALA initiative, which has significantly reduced energy consumption and sparked investments in LED bulb manufacturing. Additionally, schemes like Perform, Achieve and Trade in the industrial sector and initiatives addressing energy efficiency in the building sector, particularly cooling, play key roles in India's path to net-zero emissions by 2050.

In summary, India's Green Hydrogen Policy, combined with rapid renewable energy growth and strategic initiatives across various sectors, lays the foundation for the country's transition to a low-carbon economy. Strengthening the domestic renewable supply chain, increasing investments in battery storage, utilizing biomass, developing CCUS, and decarbonizing manufacturing are critical components of India's ambitious 2050 net-zero vision.

5.3 Industrial Policy, Sustainable Finance, and Carbon Markets

With an ambitious target to achieve net-zero emissions by 2070, India's green transition is crucial not only for its own climate resilience but also for the global effort to meet the Paris Agreement targets. This analysis examines India's industrial policies, sustainable finance mechanisms, and emerging carbon markets as integral components of its green transition strategy.

India's industrial policy aims to enhance local manufacturing capacity while expanding renewable energy installations. However, despite policy support, the progress in local manufacturing for renewable energy technologies remains modest compared to global leaders like China and the European Union. India's renewable energy policies focus on leveraging declining costs of new energy technologies to significantly increase installed capacity while also attempting to boost domestic manufacturing.

India's solar energy sector has seen a boost in installed capacity due to supportive policies like the Jawaharlal Nehru National Solar Mission. The country's solar capacity has increased, with significant policy incentives aimed at expanding local manufacturing. However, India's reliance on imports, particularly from China, poses a challenge. Although the country is gradually reducing its dependence on Chinese imports, the shift to more expensive domestic manufacturing could increase solar energy costs.

India's wind energy sector, despite policy support, lags behind in terms of installed capacity and market share compared to China and the EU. Policies supporting wind energy include accelerated depreciation and generation-based incentives, which provide financial support for wind power projects. However, challenges such as land acquisition and infrastructure limitations hinder rapid expansion.

India's sustainable finance market, though still developing, is crucial for funding the green transition. The Reserve Bank of India estimates that achieving low-carbon transition goals will require annual funding equivalent to 2.5% of India's GDP.⁴⁵

India is the second-largest issuer of green bonds among emerging markets, with significant funds directed towards renewable energy projects. Additionally, Indian banks have extended considerable green credit, supporting sectors like renewable energy. The government has also issued sovereign green bonds, backed by national credit, to fund public sector green projects at interest rates lower than traditional government bonds.

India has implemented ESG frameworks to enhance investment market certainty and attract international funding and technology. The country participates in numerous multilateral and bilateral initiatives to secure advanced low-carbon technologies and international capital. This approach not only helps mitigate domestic climate risks but also integrates India into the global green finance ecosystem.

India's nascent carbon market is a pivotal element of its strategy to meet climate targets and navigate international carbon regulations. The Energy Conservation Amendment Bill 2022 provides the legislative basis for establishing a nationwide carbon market. This market will consolidate various existing trading mechanisms into a unified framework.

India has experience with several trading schemes, such as the Perform, Achieve, and Trade (PAT) mechanism and the Renewable Purchase Obligation (RPO). These schemes have laid the groundwork for a more comprehensive carbon market. The PAT mechanism targets industrial energy efficiency, while the RPO mandates a certain percentage of energy from renewable sources. Both schemes have facilitated energy savings and renewable energy adoption, forming the basis for carbon market operations.

The transition to a unified carbon market involves integrating existing mechanisms into a cohesive system. Initially, the focus will be on voluntary carbon markets to address surplus certificates. By 2026, the market aims to transition to a compliance-based system, mandating carbon

⁴⁵ Webpage: Economist Impact: Scaling clean energy: financing and transition strategies for India's sustainable future, <https://impact.economist.com/sustainability/net-zero-and-energy/scaling-clean-energy-financing-and-transition-strategies-for-indias>, (last visited June 19, 2024)

credit certificates for major energy consumers. This phased approach seeks to balance market stability with the ambitious goals of reducing emissions and fostering green growth.

Despite significant strides, India faces challenges in fully realizing its green transition. Key issues include the over-reliance on coal, infrastructural deficiencies in renewable energy, and the financial instability of power distribution companies. Addressing these challenges requires enhanced policy coordination, robust infrastructure development, and financial mechanisms that lower the cost of green projects.

Moreover, the effective implementation of carbon markets necessitates clear guidelines for certificate conversions and robust enforcement mechanisms to prevent market distortions. The success of these initiatives depends on the seamless integration of national and state-level policies, ensuring that the green transition benefits are equitably distributed across the country.

India's journey towards a sustainable future involves complex but critical steps in industrial policy reform, financial innovation, and market mechanisms. By leveraging international collaborations, enhancing local manufacturing, and developing robust carbon markets, India can position itself as a leader in the global green transition. The success of these efforts will not only mitigate climate risks domestically but also contribute significantly to global climate goals.

6. Taiwan's Pathway to Net-Zero Emissions in 2050 (臺灣 2050 淨零排放路徑)

Taiwan's '2050 Net-Zero Emissions Plan' outlines an ambitious and comprehensive strategy to transition towards a sustainable, carbon-neutral future. This plan aligns with global efforts to combat climate change and mitigate its impacts. The plan is a multi-faceted approach that incorporates significant changes across various sectors, including energy production, industrial practices, transportation, building standards, and societal behaviors.

6.1 Global Context and Urgency

This plan emphasizes the critical global challenge of climate change, projecting a potential 1.5-degree Celsius rise in global temperatures within the next two decades. It highlights the international trend towards net-zero emissions, with 136 countries having declared targets to achieve this goal. Taiwan, being an export-oriented country with a significant portion of its GDP derived from exports, recognizes the imperative to adapt to green supply chain demands and carbon tariffs to maintain its economic competitiveness.

6.2 Decoupling Economic Growth from “Climate Change Response Act (氣候變遷因應法)”

The Ministry of Environment, following the "Climate Change Response Act," has compiled the "National Greenhouse Gas Inventory (國家溫室氣體排放清冊報告)" across various departments. The latest 2024 edition shows that Taiwan's total greenhouse gas emissions in 2022 amounted to 285.97 million tonnes of CO₂ equivalent (MtCO₂e). After deducting carbon sinks of 21.83 MtCO₂e, the net greenhouse gas emissions stood at 264.13 MtCO₂e, representing a 4.07% decrease compared

to 2021 and a 1.77% decrease compared to the baseline year of 2005. Taiwan's total greenhouse gas emissions have been declining annually since reaching a peak in 2007 until 2020. However, in 2021, due to the easing of the pandemic and the subsequent economic recovery, electricity consumption increased, leading to a rise in greenhouse gas emissions for that year. The 2022 emissions, however, reversed this trend and decreased again. Additionally, the carbon intensity in 2022 was 0.01191 kgCO₂ per NT dollar, approximately a 5.62% decrease compared to 2021.⁴⁶

6.3 Energy and Electricity Demand

The plan projects a slowing in energy demand growth due to increased electrification and efficiency measures, while electricity demand is expected to rise, particularly due to growth in information and communication technology (ICT) and lifestyle products. Major investments in projects and sectoral electrification are anticipated to drive these changes.

6.4 Taiwan's Pathway to Net-Zero Emissions and Strategies in 2050 (臺灣 2050 淨零排放路徑及策略)

Taiwan's strategy to achieve net-zero emissions by 2050 encompasses a broad spectrum of initiatives across different sectors:

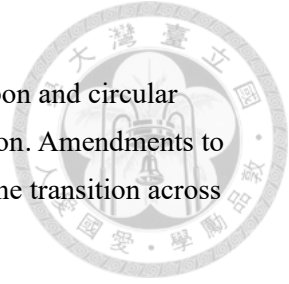
- (1) Energy: Transition to renewable energy sources, with an emphasis on solar and wind power, alongside exploring geothermal and ocean energy. The plan also includes decarbonizing thermal power development and gradually phasing out coal use.
- (2) Industry: Focus on process improvement, fuel switching, and embracing a circular economy. The manufacturing sector will see the replacement of old appliances and the adoption of hydrogen technology, among other measures.
- (3) Transportation: Electrification of vehicles is a key strategy, with goals for all urban public buses and a significant portion of personal vehicles to be electric by specified milestones.
- (4) Buildings: Enhancing energy efficiency in both new and existing buildings and appliances is outlined, with ambitious targets set for nearly zero carbon buildings by 2050.
- (5) Social Transition: Emphasizes a just transition and civic engagement, aiming to mediate conflicts arising from the transition and enhance the resilience of society.⁴⁷

⁴⁶ Webpage: RECESSARY: Ministry of Environment releases National Greenhouse Gas Inventory for 2022: global emissions hit new highs, Taiwan bucks the trend and decline, <https://www.recessary.com/zh-tw/news/world-regulation/environmental-ministry-2022-greenhouse-gas-emissions-down-despite-economic-growth>, (last visited June 19, 2024)

⁴⁷ Webpage: National Development Council: Taiwan Net-Zero Emissions, https://www.ndc.gov.tw/Content_List.aspx?n=FD76ECBAE77D9811, (last visited June 19, 2024)

6.5 Technology and Legislation

The plan underscores the importance of research and development in low-carbon and circular technologies, and the need for robust climate legislation to support the transition. Amendments to existing acts and the introduction of new regulations are proposed to support the transition across energy, buildings, transportation, and green finance sectors.



6.6 Investment and Economic Implications

Nearly NT\$900 billion is allocated for major plans related to the 2050 net-zero transition by 2030. This budget covers renewables, energy storage, low and negative carbon technologies, electrification of transport, and resource circulation, among other initiatives. The transition is expected to promote economic growth, stimulate private investment, and create green jobs, thereby making Taiwan's economy more secure, competitive, sustainable, and resilient.

In conclusion, Taiwan's "2050 Net-Zero Emissions Plan" presents a detailed and proactive approach to aligning with global climate goals, ensuring energy security, fostering economic growth, and enhancing societal well-being. The comprehensive strategy involves significant shifts in energy production, industrial practices, transportation, building standards, and public behavior, supported by technological innovation, legislative frameworks, and substantial investment.

Chapter Four From the critical perspectives of Taiwanese civil society and Taiwanese scholars.

1. From the critical perspectives of Taiwanese civil society and Researcher in the University.

Taiwanese scholars have provided some insights into the country's Taiwan's Pathway to Net-Zero Emissions and Strategies in 2050, highlighting several key aspects and potential challenges:

Comprehensive Transition Plan: Taiwan's net-zero emission plan, officially published in 2022, encompasses a comprehensive transition across energy, industrial, lifestyle, and social sectors. The plan emphasizes the transformation of infrastructure to incorporate renewable energy, electricity, and low-carbon fuels. However, scholars note that setting ambitious targets without fully understanding the implications of net-zero emissions and the means to achieve it can be risky. (Pin-Han Chen, Cheng-Han Lee 1, Jun-Yi Wu and Wei-Sheng Chen, 2023) ⁴⁸

Four Major Transition Strategies: Taiwan's Pathway to Net-Zero Emissions in 2050 includes four major transition strategies: Energy Transition, Industrial Transition, Lifestyle Transition, and Social Transition. It also relies on two governance foundations: Technology R&D and Climate Legislation. The plan aims to develop action plans for key areas, promoting economic growth, driving private investment, generating green employment, and enhancing social well-being. ⁴⁹

Dependence on Technological Advances: Scholars and government officials acknowledge that achieving the set goals relies heavily on technological advances in renewable energy, hydrogen power, carbon capture, utilization, and storage capabilities. The roadmap targets renewables to cover 60 to 70 percent of Taiwan's electricity needs by 2050, with additional contributions from hydrogen and fossil fuels equipped with carbon capture technologies. However, there's skepticism about Taiwan's ability to meet these goals, particularly due to geographical limitations and the current pace of deployment.

Funding and Implementation Challenges: The ambition to transition to net-zero emissions faces potential hurdles in funding and implementation. The government has committed significant investment towards renewables, hydrogen power, and the electricity grid, but there are concerns about underestimation of the costs involved and the financial capabilities of state-run enterprises contributing to the investment. Environmental groups have compared Taiwan's budget unfavorably with that of South Korea's, suggesting Taiwan may have seriously underestimated the necessary investment.

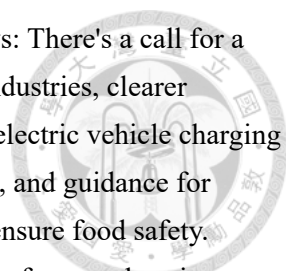
⁴⁸ Pin-Han Chen, Cheng-Han Lee 1, Jun-Yi Wu and Wei-Sheng Chen (2023). Perspectives on Taiwan's Pathway to Net-Zero Emissions. *Sustainability* 2023, 15(6), 5587; <https://doi.org/10.3390/su15065587>

⁴⁹ Website: Climate Change Laws of the World, https://climate-laws.org/document/pathway-to-net-zero-emissions-in-2050_1dd6?q=UAE (last visited June 19, 2024)

These perspectives underline the complexity of transitioning to net-zero emissions by 2050. While Taiwan's plan is robust in its strategies and goals, the successful implementation hinges on overcoming technological, financial, and infrastructural challenges.

The Researcher from the National Taiwan University has also highlighted several critical points of consideration regarding Taiwan's approach to net-zero emissions and the broader global context:

- (1) International Context: Fifty-one countries have submitted long-term emission reduction strategies to the United Nations, with twenty-nine countries and the European Union including comprehensive measures across all emission categories in their net-zero targets. Taiwan is among the 51 countries that have proposed a net-zero pathway but is not among the 17+1 (countries plus the EU) with concrete measures across all emission reduction categories.
- (2) Brown Economy Challenges: Taiwan, characterized by its "brown economy" developmental model—reliant on low costs of water, electricity, fuel, and labor—faces significant challenges in transitioning towards net-zero due to delayed energy transition and slow industrial transformation.
- (3) External and Internal Pressures: The competitive push for net-zero emissions internationally, particularly highlighted during the COP26 conference, places Taiwan under dual pressures from international carbon adjustment mechanisms and domestic challenges like air pollution.
- (4) Impacts of Pandemics and Wars: The COVID-19 pandemic and conflicts like the Russia-Ukraine war have exacerbated the challenges in energy transition by delaying renewable energy development and causing spikes in international energy prices.
- (5) Lack of Policy Integration: Inconsistencies in policies, such as vacillation in banning fuel cars, freezing electricity prices, and debates over subsidies for oil and electric vehicles, complicate the path to net-zero. There is an urgent need for a societal support system and a shared vision for sustainable green economic development.
- (6) Envisioning a Net-Zero Society by 2030 and 2050: There's a need to construct a clear vision and roadmap for a net-zero society that moves beyond economic-driven development to a low-carbon society that values social innovation, human-centered development, and environmental prosperity.
- (7) Strengthening Governance and Legal Frameworks: Recommendations include establishing central guidance mechanisms, such as a Net-Zero Emission Reform Committee, and new governance organizations like a Climate Change Council for dynamic policy planning. Additionally, integrating climate adaptation policies and enhancing climate resilience for industries, especially SMEs, through reforms in energy and carbon taxation, is crucial.

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- (8) Concrete Industry Transformation and Sectoral Net-Zero Pathways: There's a call for a more detailed examination of energy-intensive and high-carbon industries, clearer renewable energy base-load planning, regulatory frameworks for electric vehicle charging infrastructure, carbon regulation for maritime and aviation sectors, and guidance for environmentally responsible investment to mitigate disputes and ensure food safety.
- (9) Mobilizing Society for Net-Zero Transition: Highlighting the lack of comprehensive stakeholder engagement, the recommendation is to expand participatory governance, incorporating dialogue with academia, NGOs, and the wider society to foster broad-based support and mobilization for the net-zero transition.

These points reflect a deep understanding of the multifaceted challenges Taiwan faces in its journey towards net-zero emissions, emphasizing the need for integrated policies, societal engagement, and a clear vision that aligns with global standards and addresses local challenges.

2. Legal issue in Taiwan

In March 2022, Taiwan announced the Taiwan's Pathway to Net-Zero Emissions in 2050 in response to global trends. The strategy is based on four major transformations, underpinned by 'climate legislation' and 'technology research and development' as the two main governance foundations.

(1) Climate Legislation

The Taiwanese legislature began revising the Greenhouse Gas Reduction and Management Act in May 2022, including renaming it to the Climate Change Response Act. Key changes included setting the carbon reduction target to net-zero by 2050, establishing cross-ministerial coordination mechanisms, introducing a carbon fee system paid by polluters, and incorporating a "just transition" for those impacted by climate policies. Although Taiwan is not a party to international treaties, its national legislation acts as unilateral legal act compliance, linking to the Paris Agreement.

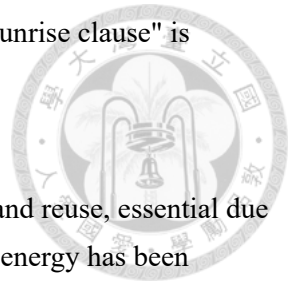
(2) Challenges and Adjustments

The draft Climate Change Response Act did not incorporate mid-term (2030) reduction targets into law, raising concerns about alignment with international standards. Taiwan's energy structure is inefficient with high carbon intensity, making short-term reduction of fossil fuel use challenging. The legislation has a provision for a review every five years, and some public group suggests using national climate programs and action plans to outline 2030 targets without overcommitting.

(3) Carbon Pricing and Economic Considerations

The legislation includes a new carbon pricing system, which is yet to be detailed in terms of rates. Carbon trading markets are considered essential for connecting to the Paris Agreement mechanisms and responding to the EU's Carbon Border Adjustment Mechanism (CBAM). The basis

for carbon pricing involves accumulating carbon emission data, for which a "sunrise clause" is proposed to integrate data for sustainable investments and international trade.



(4) Technological Development and Prospects

Taiwan has made significant progress in carbon capture technologies and reuse, essential due to the high carbon coefficient of industries like cement. Research in hydrogen energy has been promoted to address complex infrastructure and safety issues. Bioenergy technologies, such as biogas from pig farming, show potential for large-scale application.

Current Taiwanese climate laws compare well with the EU but lack comprehensive "climate finance" provisions. The future financial planning should integrate substantial public construction and transformation projects into a cohesive climate strategy. This also reflects Taiwan's ambitious legislative and technological efforts to meet its 2050 net-zero targets while facing inherent challenges in its current energy and economic structures.

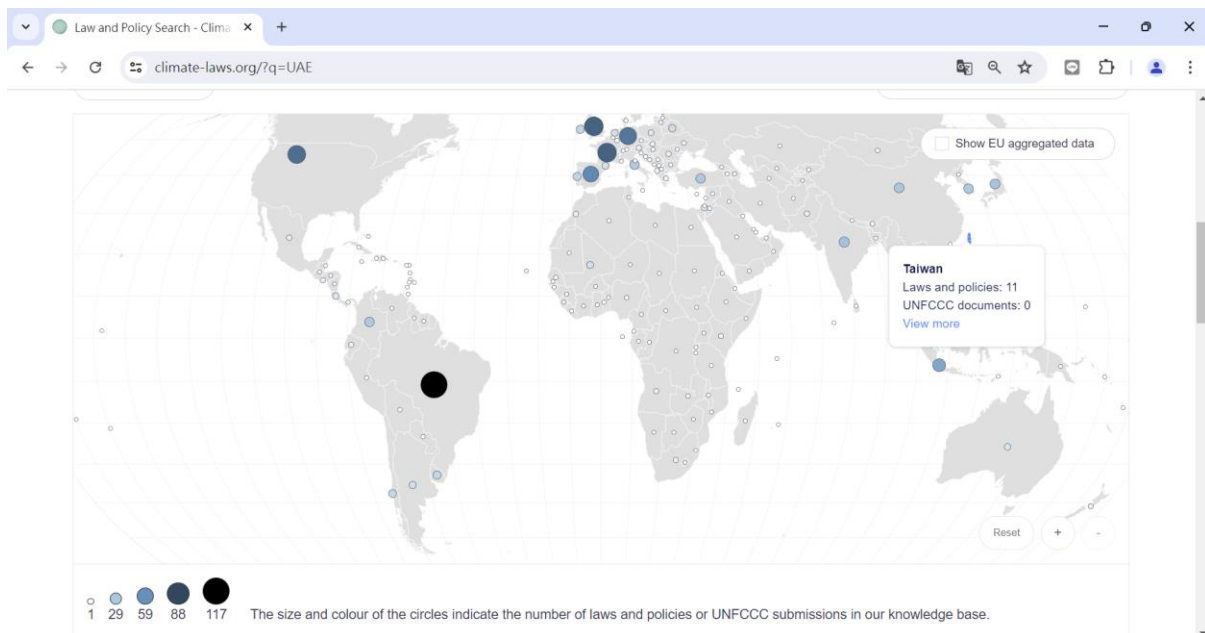


Figure 3. The Current Legislative Status of Green Law in Taiwan

3. Comparison of Green Paths and Climate Change Policies with the other countries

This comparative analysis examines Taiwan's climate change policies and green energy strategies alongside those of the United States, Japan, the European Union, China, and India. It explores these nations' objectives, implementation strategies, technological innovations, public participation, and international cooperation. This research will compare the plans of these countries and propose potential areas for improvement in Taiwan.

Table 1. Comparison Table of Green Policies by Country

Country	Government Policies	Corporate Policies	Advantages	Disadvantages
U.S.	U.S. National Innovation Pathway, California Climate Disclosure Bill (SB 253)	Emphasis on innovation in clean energy technologies by corporations like Apple and Google	Comprehensive approach with federal and state initiatives, strong private sector involvement	High dependence on political will, which can change with administrations
Japan	Zero Carbon Cities by 2050, Green Growth Strategy	Strong corporate responsibility and technology adaptation in alignment with national goals	Advanced technology use, public awareness, and municipal level initiatives	High costs associated with technology and infrastructure changes
EU	European Green Deal, SME strategies for net-zero emissions	SME support through regulatory measures, green certifications, and financial incentives	Wide-ranging policies covering energy, economy, and more, with high public participation	Requires significant changes to lifestyle and existing systems, challenging to implement across diverse states
China	30-60 Target, 1+N Policy framework	Industrial Green Pathways, emphasis on renewable energy and sustainability in major industries	Ambitious targets, comprehensive policy coverage across multiple sectors	Enforcement variability, significant changes required in industrial practices
India	National Action Plan for Climate Change, Green Hydrogen Policy	Rapid expansion in renewable energy installations and development of green hydrogen	Focus on renewable energy, innovative policies like Green Hydrogen Policy	Challenges with infrastructure, coordination, and funding
Taiwan	Taiwan 2050 Net-Zero Emissions Plan	Alignment with global trends, emphasis on technology and legislative support	Strong government commitment, comprehensive strategy across various sectors	Challenges in technology advancement and public engagement, high initial costs

- (1) United States: The "U.S. National Innovation Pathway" focuses on the innovation, demonstration, and deployment of clean energy technologies, aiming to achieve a zero-carbon power sector by 2035 and 50% zero-emission vehicle sales by 2030. The U.S. policy emphasizes the importance of innovation and demonstration phases and utilizes economic energy models (such as GCAM and OP-NEMS) for specific industry pathway planning.
- (2) Japan: The Japanese government has set a goal to achieve carbon neutrality by 2050, emphasizing decarbonization of the power sector and planning to promote Zero Carbon

Cities nationwide. Japan's strategy covers multiple sectors including energy, transportation, and home offices, with a particular focus on decarbonizing the power sector and ensuring the safety and restart of nuclear power.

- (3) European Union: The EU's "European Green Deal" aims for climate neutrality by 2050, with an intermediate target of reducing greenhouse gas emissions by at least 50-55% by 2030. This policy spans a wide range of areas including energy, economy, construction, transportation, and agriculture, and promotes comprehensive societal participation in the green transition.
- (4) China: China's "30-60 target" aims to peak carbon emissions before 2030 and achieve carbon neutrality before 2060. The Chinese policy framework "1+N" covers multiple industries and aspects, aiming to promote a green transformation of the economy and society, and emphasizes the importance of technological innovation and international cooperation.
- (5) India: India's Green Hydrogen Policy aims to promote the production and application of green hydrogen through regulatory adjustments and financial incentives to achieve carbon reduction targets. India especially emphasizes the rapid development and expansion of renewable energy and non-fossil fuel production.

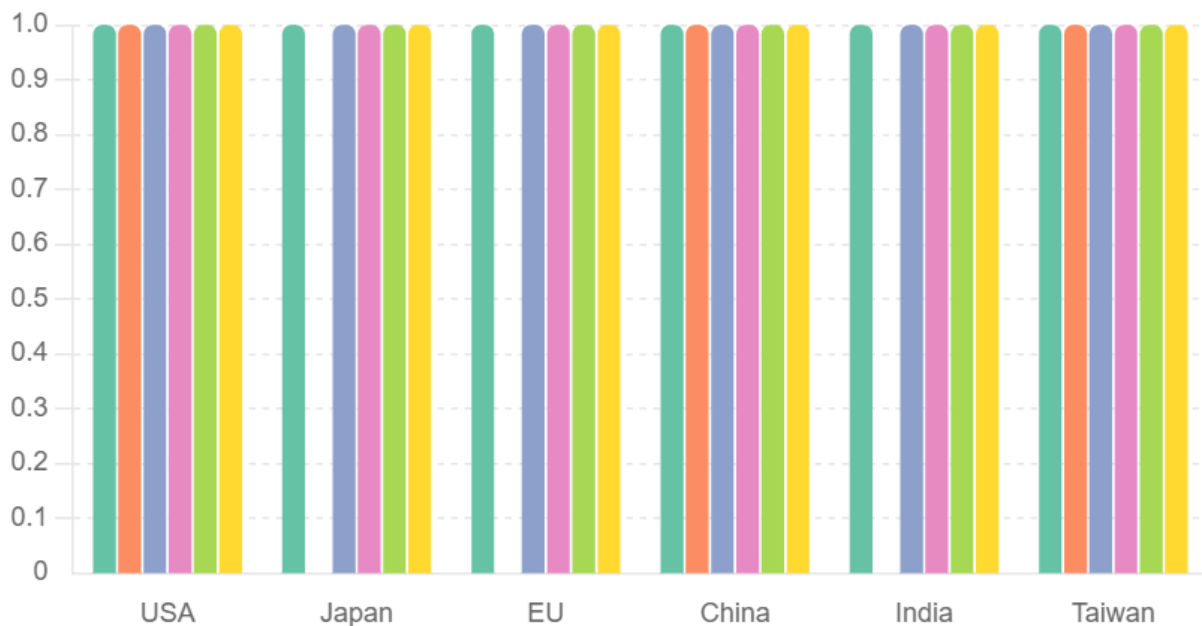


Figure 4. Stacked Bar Chart Of Green Policies Across Countries

Y Number of Policies X Country: Renewable Energy, Carbon Capture and Storage, Energy Efficiency, Electric Vehicle Technology, Green Hydrogen Technology, 以及 Green Technology Cooperation

Taiwan's Pathway to Net-Zero Emissions in 2050 includes significant changes across energy production, industrial practices, transportation, building standards, and societal behaviors. Although

Taiwan has successfully decoupled economic growth from greenhouse gas emissions, it still faces the following challenges and areas for improvement:

(1) Technological Innovation and Research & Development:

Taiwan needs to increase investment in low-carbon and circular technology R&D, emulating the approaches of the U.S. and EU to enhance domestic and international technology cooperation and innovation ecosystems.

(2) Public Participation and Education:

Following Japan's extensive public education and outreach on decarbonization goals, Taiwan could further enhance public awareness and participation in climate change issues.

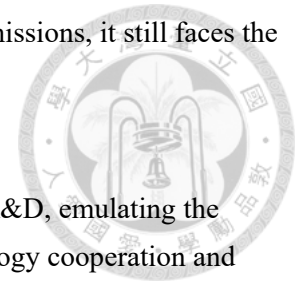
(3) International Cooperation:

Taiwan needs to strengthen cooperation with other countries in climate action, particularly in technology transfer and joint research, learning from China and India's experiences in international cooperation.

(4) Comprehensive Policy Framework:

Taking cues from the EU and China's comprehensive policy frameworks, Taiwan could consider establishing more thorough climate regulations and policies to coordinate and promote climate action across various sectors and local governments.

Through the above analysis, Taiwan can draw on successful green policies globally and tailor strategies to its unique characteristics, accelerating progress toward its 2050 net-zero emissions target.



Chapter Five Results and Suggestions.

1. Results

Taiwan's Pathway to Net-Zero Emissions in 2050 is a comprehensive strategy aimed at addressing climate change challenges and transforming Taiwan into a sustainable, carbon-neutral future. This plan encompasses significant changes across various domains, including energy production, industrial practices, transportation, building standards, and societal behaviors, all supported by technological innovation, legal frameworks, and substantial investments.

However, there are areas within this grand vision that may require further improvement and recommendations:

- (1) **Technological Innovation and Research and Development (R&D):** Technological innovation is key to achieving net-zero emissions targets. Taiwan needs to continue investing in research and development of low-carbon and circular technologies. Moreover, strengthening international cooperation in clean energy and climate technology fields could accelerate technology transfer and application.
- (2) **Public Participation and Awareness Raising:** Ensuring the fairness of the transition process and garnering broad support from all sectors of society is crucial. The government can enhance public awareness and participation through education, public outreach, and societal dialogues.
- (3) **Green Finance and Investment:** The net-zero transition requires significant financial support. Establishing a robust green finance system and attracting more private sector investment are key to achieving these goals. The government could incentivize more green investments by providing tax incentives, subsidies, and risk-sharing mechanisms.
- (4) **Regulatory and Policy Frameworks:** Strengthening and updating relevant laws and regulations is essential to support the achievement of net-zero targets. This may include stricter standards for the energy, buildings, transportation, and industrial sectors, as well as innovative policies like carbon pricing and trading mechanisms to internalize the environmental cost of carbon emissions.
- (5) **Local Government and Community Engagement:** Encouraging local governments and communities to develop and implement customized net-zero action plans based on local characteristics and needs is important. Local innovations and practices can provide valuable experiences and models for the national net-zero transition.
- (6) **Industry Transformation and Workforce Retraining:** Targeted industry transformation strategies and workforce retraining programs are needed to ensure that the shift from a high-carbon to a low-carbon economy does not result in job losses, especially for industries and workers most affected.

By implementing these improvements and recommendations, Taiwan's Pathway to Net-Zero Emissions in 2050 can be made more comprehensive and effective, contributing significantly to sustainable development and climate change mitigation.



1.1. Recommended Country for Taiwan's SMEs: European Union

Why Taiwan's SMEs Should Learn from the European Union

- (1) The European Union (EU) has developed a wide-ranging support framework for small and medium-sized enterprises (SMEs) to transition towards net-zero emissions. This framework includes regulatory measures, financial incentives, technical assistance, and green certifications, all of which are designed to help SMEs overcome the barriers to adopting sustainable practices.
- (2) The EU has streamlined administrative processes for SMEs to adopt sustainable practices. For instance, the EU provides tax reductions, standardizes applications for intellectual property related to sustainability, and encourages environmental management certifications. These measures enhance the competitiveness of SMEs in public tenders and green trade.
- (3) The EU offers a variety of financial tools to support SMEs in their green transition, including direct subsidies, private equity investments, and preferential loans. For example, Greece's Green Fund supports SMEs in green and circular economy sectors, and Italy's Guarantee Programme provides preferential loans for sustainable projects. These incentives are crucial for SMEs, especially startups, to enter and thrive in the green economy.
- (4) The EU emphasizes the importance of technical assistance to equip SMEs with the necessary skills and knowledge for sustainable transformation. Programs like Belgium's incubator initiatives and Denmark's mentoring from successful green entrepreneurs provide platforms for technology exchange and collaboration, accelerating the diffusion of green innovations.
- (5) Establishing green certification standards and awarding green prizes help SMEs demonstrate their commitment to sustainability. This not only enhances their market competitiveness but also encourages other businesses to adopt sustainable practices.

1.2. Reasons for Choosing the European Union

- (1) The EU's approach is holistic, addressing various aspects of the green transition simultaneously. This comprehensive strategy ensures that SMEs receive the necessary support to adopt sustainable practices without being overwhelmed by the complexity of the transition.
- (2) The EU's policies have been successful in various member states, showcasing the effectiveness of their strategies. Countries like Ireland, Italy, and Greece have

implemented these policies with positive outcomes, providing a reliable blueprint for Taiwan's SMEs.

- (3) The EU fosters a culture of innovation and collaboration, essential for the green transition. By promoting research and development, and facilitating partnerships between businesses, governments, and academia, the EU creates an environment conducive to sustainable growth.
- (4) The EU's policies are adaptable, allowing them to be tailored to the specific needs and contexts of different regions and industries. This flexibility is particularly beneficial for Taiwan, which can modify these policies to fit its unique economic and industrial landscape.

By learning from the EU's comprehensive and successful strategies, Taiwan's SMEs can effectively navigate the challenges of the green transition and contribute significantly to the country's 2050 net-zero emissions goal.

2. Conclusion

Taiwan's future challenges and difficulties in achieving its green path, along with suggested solutions is as below:

For challenges and difficulties

(1) Technological Advancements:

Challenge: Taiwan's reliance on technological advancements in renewable energy, hydrogen power, and carbon capture and storage (CCS) is critical for meeting its 2050 net-zero goals. However, Taiwan faces geographical limitations and the current pace of deployment is slow.

Difficulty: High costs associated with developing and deploying these technologies can be prohibitive. Additionally, there may be a shortage of skilled professionals and technological know-how to implement these solutions effectively.

(2) Funding and Financial Constraints:

Challenge: Achieving net-zero emissions requires significant investment in renewable energy, infrastructure, and technological innovation. The government has committed substantial funds, but there are concerns about underestimating the total costs involved.

Difficulty: The financial capabilities of state-run enterprises and the overall budget allocation might be insufficient to cover the extensive investments needed. Additionally, securing private investment may be challenging due to perceived risks and uncertainties.

(3) Public Engagement and Societal Transition:

Challenge: Effective transition to a green economy necessitates widespread public participation and behavioral changes. There is a need for societal engagement in adopting energy-efficient practices and supporting green policies.

Difficulty: Achieving broad-based public support and changing long-established habits and preferences can be difficult. Public resistance due to lack of awareness or perceived inconvenience may hinder the transition.

(4) Policy Coordination and Governance:

Challenge: The success of the net-zero pathway relies on coordinated efforts across various government departments and sectors. Consistent and coherent policies are essential for smooth implementation.

Difficulty: Inconsistencies in policy implementation, such as fluctuating support for electric vehicles or renewable energy projects, can create uncertainties and slow progress. Ensuring alignment among different government levels and agencies is challenging.

(5) Industrial Transition:

Challenge: Taiwan's industrial sector, characterized by high energy consumption and carbon intensity, needs significant transformation to reduce emissions. This includes adopting new technologies and improving energy efficiency.

Difficulty: Transitioning established industries to greener practices involves high costs, potential disruptions, and resistance from stakeholders accustomed to traditional methods. The speed of technological adoption may vary across different sectors.

For the suggested solutions:

(1) Enhanced Technological Investment:

Solution: Increase government and private sector investment in research and development for renewable energy, hydrogen power, and CCS technologies. Establish partnerships with leading global technology firms and research institutions to accelerate innovation.

Implementation: Provide grants, tax incentives, and subsidies to encourage investment in green technologies. Support training programs to develop a skilled workforce capable of managing and implementing these technologies.

(2) Robust Financial Mechanisms:

Solution: Develop comprehensive financial strategies to support green projects, including green bonds, public-private partnerships, and international funding mechanisms. Ensure transparent and efficient allocation of funds to high-impact areas.

Implementation: Create a dedicated green finance task force to identify funding opportunities and streamline financial support processes. Engage with international financial institutions to attract foreign investments.

(3) Public Awareness and Education Campaigns:

Solution: Launch extensive public awareness campaigns to educate citizens about the benefits of the green transition and the importance of their participation. Promote energy-saving behaviors and the adoption of renewable energy solutions.

Implementation: Use multiple media platforms to disseminate information and success stories. Collaborate with educational institutions to integrate sustainability topics into curricula and organize community workshops and events.

(4) Integrated Policy Framework:

Solution: Develop an integrated and coherent policy framework that aligns national and local government efforts towards the net-zero target. Establish clear guidelines and performance indicators for policy implementation.

Implementation: Form a central coordination committee to oversee and ensure policy alignment across various sectors and government levels. Regularly review and update policies based on progress and emerging challenges.

(5) Support for Industrial Innovation:

Solution: Encourage industrial innovation through targeted support for green technology adoption and energy efficiency improvements. Provide incentives for industries to invest in sustainable practices and technologies.

Implementation: Establish industry-specific green innovation funds and provide technical assistance for implementing sustainable practices. Facilitate knowledge sharing and best practices through industry associations and networks.

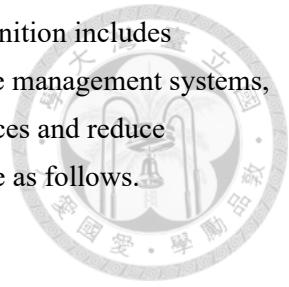
By addressing these challenges with comprehensive and coordinated solutions, Taiwan can enhance its chances of successfully achieving its 2050 net-zero emissions goal and setting a precedent for other nations.

3. Suggestion: Green technologies for Taiwan

Green technologies, commonly referred to as green tech, play an instrumental role in aiding nations and businesses in their journey towards sustainable practices, often dubbed the 'Green Path'. This journey encompasses a wide range of innovations designed to mitigate environmental impact, enhance resource efficiency, and foster economic activities that do not compromise the health of our planet.

Green technology encompasses the application of science and technology to create environmentally friendly products and services that not only aim to reduce ongoing harm to our

environment but also promote its restoration and regeneration. This broad definition includes renewable energy sources, sustainable transportation methods, advanced waste management systems, and innovations in agriculture and manufacturing that conserve natural resources and reduce pollution. The Role of Green Technologies in Green Paths to Sustainability are as follows.



(1) Renewable Energy:

Renewable energy technologies, such as solar, wind, and geothermal power, are fundamental to reducing dependence on fossil fuels, which are a major source of greenhouse gas emissions contributing to global warming. By transitioning to renewable energy, countries and companies can significantly cut emissions, reduce their carbon footprint, and stabilize their energy costs in the long run. For example, the installation of solar panels in corporate buildings or the adoption of wind farms at the national level can supply clean, sustainable energy that powers economies without degrading the environment.

(2) Sustainable Transportation:

Technologies that promote sustainable transportation, including electric vehicles (EVs) and hydrogen fuel cells, help reduce emissions from one of the most polluting sectors: transportation. By investing in EV infrastructure, such as charging stations, or transitioning public transport fleets to electric or hydrogen power, governments and businesses can contribute significantly to reducing urban air pollution and enhancing public health.

(3) Waste Management and Recycling:

Advanced waste management and recycling technologies enable more efficient use of materials and help reduce landfill use and methane emissions. Innovations like composting biodegradable waste or recycling plastics into new products can help create a circular economy where waste is minimized, and resources are reused, benefiting both the environment and the economy.

(4) Energy Efficiency Solutions:

Technologies that enhance energy efficiency in buildings, industrial processes, and consumer devices play a crucial role in reducing overall energy consumption. Smart grids, LED lighting, and high-efficiency heating and cooling systems can drastically lower energy use and costs, making operations more sustainable and less environmentally intrusive.

(5) Sustainable Agriculture:

Green technologies in agriculture, such as precision farming, hydroponics, and the use of biochar, help conserve water and soil, increase productivity, and reduce the carbon footprint of farming activities. These technologies allow for higher yields with lower impacts on natural ecosystems, promoting food security and sustainability.

Governments can accelerate the adoption of green technologies through policies such as subsidies, tax incentives, and grants for research and development. By creating favorable regulatory

environments and setting ambitious sustainability targets, governments can encourage private sector investment in green technologies.

Corporations play a crucial role by integrating green technologies into their operations and business models. Corporate investment in green tech not only helps mitigate environmental impact but also positions companies as leaders in sustainability, enhancing their brand reputation and long-term profitability.

The advancement and integration of green technologies are vital for achieving the environmental goals of both nations and businesses. From renewable energy to efficient waste management, these technologies provide the tools needed to embark on a green path, leading to a sustainable, prosperous, and environmentally responsible future. As we look ahead, the continued innovation and adoption of green technologies will be critical in addressing the complex challenges of climate change, resource depletion, and environmental degradation, ultimately steering global efforts towards a more sustainable and regenerative planet.

4. Challenges: Legal Challenges in Green Path

In Taiwan, there is an urgent need for collaboration between the central and local governments to achieve net-zero emissions. Legal frameworks and policy guidelines are crucial in facilitating this cooperation. However, the division of responsibilities and powers between the central and local authorities is currently ambiguous, hindering the effective implementation of net-zero policies.

The existing legal framework presents challenges. The prevalent administrative control methods—penalties and incentives—each face different challenges. Penalties require central approval, while incentives need funding support. The current legal structure often compresses local autonomy due to the unclear division of powers between the central and local governments. Constitutional interpretations affirm local autonomy, but there is a lack of clear legal distinctions between self-governing and delegated matters. Article 26 of the Local Government Act lacks clear review standards for local ordinances, allowing central authorities to reject them for being “inappropriate.”

As the central government has not provided a framework, local governments cannot make specific decisions. Currently, the central government expects local action but does not grant sufficient authority and funding, often rejecting net-zero ordinances through fiscal discipline laws. The central government's role should transform from control to coordination and empowerment, establishing broad principles and granting local governments enough authority to execute them effectively.

Regarding carbon fee distribution, local governments expect allocations from the central government. However, the specifics are still being planned.

Currently, the net-zero ordinances in Taipei, Kaohsiung, and Taichung have passed their third reading in local councils, with Taipei's ordinance already approved by the Executive Yuan in February. Tainan, New Taipei, Chiayi, and Yilan are still gathering public opinions. Regulations are feasible without penalties, feasible if there is no overlap with central inspections, but invalid if

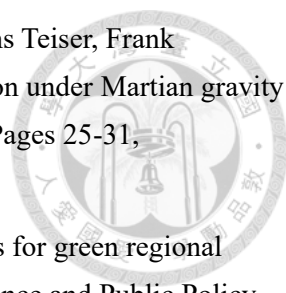
necessary for carbon trading. Therefore, local governments cannot conflict with other central supervisory laws, particularly the Securities Exchange Act and the Financial Discipline Act.

There is significant room for improvement in central-local strategies for net-zero emissions. Adjusting legal frameworks and policy guidelines and re-evaluating the empowerment of local governments are crucial steps towards achieving climate goals. The central government should set overarching principles and provide sufficient authority and resources to local governments, ensuring their actions align with national targets while allowing for localized decision-making. This collaborative approach will enhance the implementation of net-zero policies and drive the collective effort towards sustainability.

A clear legal framework, shared authority, and adequate resources are essential for effective cooperation. By transforming its role to one of coordination and empowerment, the central government can better support local efforts, fostering a collaborative path to achieving climate goals.

Reference

- Cathy Sandeen (2009), It's Not Easy Being Green: Green Marketing and Environmental Consumerism in Continuing Higher Education, *Continuing higher education review*, Vol. 73
- Martin, R. (2014). Path dependence and the spatial Economy: A key concept in retrospect and prospect. In M. M. Fischer, & P. Nijkamp (Eds.), *Handbook of regional science* (pp. 609–629). Berlin: Springer.
- Mustafa Emirbayer, Ann Mische. *American Journal of Sociology*, Vol. 103, No. 4 (January 1998), pp. 962-1023 <https://doi.org/10.1086/231294>
- Sotarauta M, Suvinen N (2018) Institutional agency and path creation: institutional path from industrial to knowledge city. In: Isaksen A, Martin R, Trippel M (eds) *New Avenues for Regional Innovation Systems – Theoretical Advances, Empirical Cases and Policy Lessons*. Cham: Springer, pp. 85–104.
- Garud, R. and Karnøe, P. (2001). 'Path creation as a process of mindful deviation'. In Garud, R. and Karnøe, P. (Eds), *Path Dependence and Path Creation*. Mahwah, NJ: Lawrence Earlbaum, 1–38.
- Gillian Bristow & Adrian Healy (2014) *Regional Resilience: An Agency Perspective*, *Regional Studies*, 48:5, 923-935, DOI: 10.1080/00343404.2013.854879
- Dawley, S. 2014. Creating new paths? Offshore wind, policy activism, and peripheral region development. *Economic Geography* 90 (1): 91–112.
- Kowtham Raj, Aayog Pranav Lakhina, Clay Stranger (2022) *Harnessing GREEN HYDROGEN OPPORTUNITIES FOR DEEP DECARBONISATION IN INDIA*, 55-56; https://www.niti.gov.in/sites/default/files/2022-06/Harnessing-Green-Hydrogen_V21_DIGITAL_29_06.pdf
- Julie Battilana, Bernard Leca and Eva Boxenbaum, 2009. How Actors Change Institutions: Towards a Theory of Institutional Entrepreneurship, *Academy of Management Annals* Vol. 3, No. 1. <https://doi.org/10.5465/19416520903053598>
- Ron Boschma, 2017. Relatedness as driver of regional diversification: a research agenda, vol. 51, issue 3, 351-364. DOI: 10.1080/00343404.2016.1254767
- Sotarauta M, Mustikkamäki N (2015) Institutional entrepreneurship, power, and knowledge in innovation systems: Institutionalization of regenerative medicine in Tampere, Finland. *Environment and Planning C: Government and Policy* 33(2): 342–357.
- Grillitsch M (2018) Following or breaking regional development paths: On the role and capability of the innovative entrepreneur. *Regional Studies* 53(5): 681–691.

- 
- Grzegorz Musiolik, Maximilian Kruss, Tunahan Demirci, Björn Schirnski, Jens Teiser, Frank Daerden, Michael D. Smith, Lori Neary, Gerhard Wurm 2018. Saltation under Martian gravity and its influence on the global dust distribution, *Icarus*, Volume 306, Pages 25-31, <https://doi.org/10.1016/j.icarus.2018.01.007>.
- Franz Tödting, Michaela Tripl, Alexandra Frangenheim 2020. Policy options for green regional development: Adopting a production and application perspective, *Science and Public Policy*, Volume 47, Issue 6, December 2020, Pages 865–875, <https://doi.org/10.1093/scipol/scaa051>
- Wahlund M, Hansen T (2022) Exploring alternative economic pathways: a comparison of foundational economy and doughnut economics. *Sustain. Sci. Pract. Policy* 18(1):171–186
- Fraggenheim, A., Tripl, M., & Chlebna, C. (2020). Beyond the single path view: Interpath dynamics in regional contexts. *Economic Geography*, 96(1), 31–51. <https://doi.org/10.1080/00130095.2019.1685378>
- Henrysson, Maryna & Nuur, Cali. (2021). The Role of Institutions in Creating Circular Economy Pathways for Regional Development. *The Journal of Environment & Development*. 30. 107049652199187. [10.1177/1070496521991876](https://doi.org/10.1177/1070496521991876).
- Bina O, 2013, "The green economy and sustainable development: an uneasy balance?" *Environment and Planning C-Government and Policy* 31 1023–1047.
- Bonsineto, F., & Falco, E. (2013). Analysing Italian regional patterns in green economy and climate change: can Italy leverage on Europe 2020 strategy to face sustainable growth challenges? *Journal of Urban and Regional Analysis*, 5(2), 123-142. <https://doi.org/10.37043/JURA.2013.5.2.2>
- White House Office of Science and Technology Policy United States Department of Energy United States Department of State 2023. Mission Innovation NATIONAL INNOVATION PATHWAY OF THE UNITED STATES. <https://www.whitehouse.gov/wp-content/uploads/2023/04/US-National-Innovation-Pathway.pdf>
- Pin-Han Chen, Cheng-Han Lee 1, Jun-Yi Wu and Wei-Sheng Chen (2023). Perspectives on Taiwan's Pathway to Net-Zero Emissions. *Sustainability* 2023, 15(6), 5587; <https://doi.org/10.3390/su15065587>