



Case report

Green finance for mitigating greenhouse gases and promoting renewable energy development: Case study in Taiwan

Wen-Tien Tsai*

Graduate Institute of Bioresources, National Pingtung University of Science and Technology, Pingtung, Taiwan

* **Correspondence:** Email: wtttsai@mail.npu.edu.tw.

Abstract: In recent years, the tools of green finance have evolved to foster green economic growth like renewable energy and climate change mitigation. Taking a case study of Taiwan not yet reviewed in the literature, the present study aimed to conduct a preliminary analysis for exploring the amazing growth in renewable energy over the past fifteen years (2010–2023) in connection with the achievements of green finance promotion over the past five years (2018–2022). The updated database was accessed on the websites of Taiwan's competent authorities. This work was divided into the following main parts: Taiwan's carbon neutrality policy and sustainable development goals (SDGs) relevant to green finance, the regulatory promotion for green finance action plans in Taiwan, and the status of green finance measures and achievements in Taiwan. The findings supported the idea that the implications of green policies for unlocking green finance and green investment significantly enhanced a positive influence on green energy industry development in Taiwan. In this regard, it showed the amazing growth of renewable energy generation, particularly in solar photovoltaics (PV) power and offshore wind power, since 2010. These findings were similar to those in Asian countries like China and Japan. Responding to Taiwan's SDGs policy by 2030 and the net-zero emissions in 2050, aspects relevant to climate change mitigation and adaptation were investigated in order to focus on the use of green finance tools.

Keywords: green finance; sustainable development goals; carbon neutrality policy; renewable energy development; regulatory promotion

JEL Codes: E52, G38, Q28, Q48, Q54

1. Introduction

The goal of the Paris Agreement, entered into force on November 4, 2016, was to hold “the increase in the global average temperature to well below 2°C above pre-industrial levels” and pursue efforts “to limit the temperature increase to 1.5°C above pre-industrial levels” (UNCC, 2024a). To limit global warming to 1.5°C through the significant reduction in greenhouse gas (GHG) emissions by 2030, the Agreement provided a framework for financial, technical, and capacity building supports to those countries or regions. Today, the financial sector has played an important role in the fight against climate change by supporting reduction in climate-related risks and mitigating the impact of adverse climate events due to GHG emissions (Monasterolo, 2020; Zhou et al., 2023). Several studies have explored green finance (or sustainable finance) and its environmental benefits (Bhatnagar and Sharma, 2022a; Ozili, 2022). Several studies have explored green finance (or sustainable finance) and its environmental benefits (Bhatnagar and Sharma, 2022a; Ozili, 2022), and recently reviewed on green finance (Akomea-Frimpong et al., 2022; Bhatnagar and Sharma, 2022a; Rahman et al., 2022; Ozili, 2022; Debrah et al., 2023; Dhayal et al., 2023; Kumar et al., 2023; Ahmed et al., 2024; Khan et al., 2024). The research findings concluded that carbon taxes (or carbon pricing) as well as green innovation (research and development) budgets and strict environmental policies can be useful tools for achieving sustainable development goals (SDGs) in the GHG mitigation and climate change adaptation (Khurshid and Deng, 2021; Wang et al., 2022; Khurshid et al., 2022; Khurshid et al., 2023; Li et al., 2023). In this regard, green finance provides a powerful tool to increase levels of financial flow to invest sustainable development and climate change priorities (Berrou et al., 2019; Gilchrist et al., 2021; Bhattacharyya, 2022). These money flows are from public/private financial institutions through banking, micro-credit, insurance, and loans. The literature review was surveyed by the Web of Science (<https://www.webofscience.com/wos/woscc/basic-search>) keying titles like “green finance”, “green financing”, and “review”, which focused on the trends, research (innovation) directions, benefit analysis, and gaps of green finance. The findings further supported the implications that green policies for unlocking green finance and green investment significantly enhanced the progressive development of green energy establishment, GHG mitigation, and ambient air quality improvement.

Although Taiwan is not a member state of the United Nations (UN), the government has taken actions to prepare the national GHG inventory report based on the 2006 Intergovernmental Panel on Climate Change Guidelines (IPCC, 2006). It showed that Taiwan’s total GHG emissions (excluding carbon sinks by forestry, land use, and land use change), in 2021, had slightly increased by $297,007 \times 10^3$ metric tons of carbon dioxide equivalent (CO₂eq) from $286,962 \times 10^3$ metric tons of CO₂eq in 2010 (MOE, 2023), accounting for about 0.8% of global GHG emissions (GCDL, 2024). In addition, the energy sector is usually the most important sector in GHG emission inventories, typically contributing to over 90% of the CO₂ emissions and 75% of the total GHG emissions in developed countries (Liu et al., 2019; Erdogan et al., 2020; GCDL, 2024). For example, Taiwan’s statistics on various GHG emissions in 2021 showed that CO₂ accounted for 95.32%, followed by methane (1.82%), nitrous oxide (1.50%), and fluorinated

greenhouse gas (1.36%) (MOE, 2023). Meanwhile, the GHG emissions from the energy sector were responsible for approximately 90.55% of the total emissions, while the industrial process and product use (IPPU) sector, agricultural sector, and waste sector contributed to 7.46%, 1.09%, and 0.90%, respectively (MOE, 2023). In response to the UN sustainable development goals (SDGs) and net-zero emissions (carbon neutrality) in recent years (UN, 2024), the Taiwan government began to take actions under the authorizations of the Greenhouse Gas Reduction and Management Act of 2015 and the Climate Change Response Act of 2023 (MOJ, 2024). Taiwan's sustainable development goals were initiated and further revised by the National Council for Sustainable Development (NCSD) (NCSD, 2022). The National Development Council announced the net-zero policy by 2022 in Taiwan (NDC, 2022), which focused on the four major transition strategies (i.e., energy, industry, lifestyle, and society), as well as 12 key strategies (including green finance).

Concerning the implementation of green finance by countries and/or regions, Tolliver et al. (2021) examined the green finance policies implemented by Japan, South Korea, and China. Bhatnagar and Sharma (2022b) reviewed the potential of green finance in India by conducting strengths-weaknesses-opportunities-threats (SWOT) analysis. Meo and Karim (2022) examined the relationship between green finance and CO₂ emissions in the top ten economy bodies (i.e., Canada, Denmark, Hong Kong, Japan, New Zealand, Norway, Sweden, Switzerland, the United Kingdom, and the United States). Zakari et al. (2023) investigated the role of green finance and energy in the environmental performance of Asia (China and Japan) between 2010 and 2020, showing that green finance promoted environmental sustainability and also reduced environmental pollution. In addition, green finance played a vital role in renewable energy investment and renewable energy electricity output (Li et al., 2021; Rasoulinezhad and Taghizadeh-Hesary, 2022), especially in wind power energy generation (Sun et al., 2023). Chiu et al. (2021) adopted a document analysis method to seek more diversified financing channels for the development of the community renewable energy projects (e.g., small-scale hydropower) in Taiwan. It was found that the combination of financial technology (FinTech) and the power of the masses (e.g., crowdfunding) has become one of the emerging financial instruments for the development of Taiwan's green energy industry. Kung et al. (2022) investigated the influence of green-bond rates on bioenergy production in Taiwan. The results showed that the implementations of green bonds are costly and less competitive in the short run.

As mentioned above, green finance in Taiwan has not been looked at as a regional case study in connection with the amazing renewable energy development over the past fifteen years (2010–2023). In this regard, the novelty of this work may be based on the interactive analysis of green finance for promoting renewable energy establishments in Taiwan. The present study is, thus, aimed at conducting a preliminary analysis for exploring the amazing growth in renewable energy over the past fifteen years (2010–2023) in connection with the achievements of green finance promotion over the past five years (2018–2022). This paper is divided into three main parts: Taiwan's carbon neutrality policy and sustainable development goals (SDGs) relevant to green finance, the regulatory promotion for green finance action plans in Taiwan, and the status of green finance measures and achievements in Taiwan. In addition, some aspects for promoting the adoption of green finance in the energy, residential, and industrial sectors were also addressed to keep in step with the sustainable development goals (SDGs) in 2030, especially in the mitigation of GHG emissions by renewable power generation and energy efficiency improvements in the building and industrial sectors.

2. Data mining and methodology

In this work, a systematic methodology was based on the main objectives of this study. Therefore, the Web of Science was first used to survey the evolution, trends, and gaps of green finance by the title keywords like “green finance”, “green financing”, and “review”. This approach was taken on the implications of green finance tools (e.g., carbon taxes, carbon pricing) for achieving SDGs in GHG mitigation. Concerning the carbon neutrality policy and SDGs in Taiwan, the official reports were accessed on the websites of the central competent authorities (NCSD, 2022; NDC, 2022), including the National Council for Sustainable Development (NCSD) and National Development Council (NDC). In addition, the regulatory promotion for green finance action plans in Taiwan were compiled from the official website of the Ministry of Justice (MOJ, 2024). The most relevant act for this financial innovation is the Climate Change Response Act passed on February 15, 2023. Based on the authorization of the Act (formerly called the Greenhouse Gas Reduction and Management Act on July 1, 2015), the Green Finance Action Plan was planned and performed in stages by the Financial Supervisory Commission (FSC, 2018, 2020, 2022a). A further search was conducted on the achievements of the Green Finance Action Plan (FSC, 2022b), which was used to connect with the amazing progress in renewable energy since 2010.

3. Related literature reviews on the carbon neutrality policy and sustainable development goals (SDGs) in Taiwan

3.1. Carbon neutrality policy in Taiwan

The carbon neutrality (or net-zero emissions) policy by the mid-21st century was triggered by the Paris Agreement in 2015 (UNCC, 2024a). It is an international treaty on climate change to limit global warming to 1.5°C, signed by 196 parties at the United Nations (UN) Climate Change Conference (COP21) on December 12, 2015, and entered into force on November 4, 2016. In addition, the Agreement required the parties to submit their national climate action plans (known as nationally determined contributions, NDCs) on a five-year cycle (every 5 years), and introduced a policy for climate finance. Thereafter, the COP26 (Glasgow Climate Pact) in 2021 pledged the goals to accelerate climate actions on limiting global warming to 1.5°C (UNCC, 2024b). The targets are to reduce global net human-caused emissions of CO₂ by 2030 (especially focused on limiting unabated coal use in power plants), and to further reach net-zero emissions around 2050. Additionally, the international carbon trading mechanisms were adopted at COP26 to support climate adaptation funding and green finance.

In response to the international carbon neutrality trends by 2050, the Taiwan government declared the “2050 Net-Zero Transition” on Earth Day on April 22, 2021. Subsequently, the central competent authority announced “Taiwan’s Pathway to Net-Zero Emissions in 2050” on March 30, 2022 (NDC, 2022), which provided the action pathways for achieving the “2050 Net-Zero Emissions” goal. This Pathway is based on the four major transition strategies of “energy transition”, “industrial transition”, “lifestyle transition”, and “social transition”, as well as the two governance foundations of “technology research and development” and “climate legislation”, and is supplemented by “twelve key strategies”.

It should be noted that green finance has been listed as one of these key strategies. In the green finance strategy, the green finance action plan and the sustainable development guide map for the companies listed in the Taiwan Stock Exchange (TWSE) and Taipei Exchange (TPEx) were included. These green finance strategies will be described in the subsequent section.

3.2. Sustainable development goals (SDGs) in Taiwan

In 2015, the United Nations (UN) announced the 17 SDGs of the 2030 Agenda, which offered the most practical and effective pathways to tackle urgent events like poverty, hunger, energy, climate change, and environmental degradation (UN, 2024). The Taiwan government promptly decided to take actions on the establishment of Taiwan's SDGs by the National Council for Sustainable Development (NCSD) under Executive Yuan in 2016. This document, including a total of 18 goals (SDGs), 143 targets, and 336 indicators, was officially announced in 2019. To meet the national policy of net-zero emissions by 2050, it was further revised and reformed on Dec 29, 2022 (NCSD, 2022).

In connection with green finance issues, the most relevant SDGs are: “Goal 8: Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all” and “Goal 12: Ensure sustainable consumption and production patterns”, which involved the following targets.

Target 8.3: Provide credit guarantees or financial assistance and encourage engagement in the green economy, innovation, and development of micro-, small-, and medium-sized enterprises (SMEs).

Target 12.4: Encourage companies to adopt sustainable practices and disclose sustainable development information, while ensuring information accuracy and quality.

In addition, the related indicators and their goals by 2025 and 2030 in Taiwan were summarized as follows:

1. Indicator 8.3.1: Enhancing SMEs in the green industry access to finance through the credit guarantee schemes.

- Goals by 2025

Accumulative loans of approvals of SMEs during the period from Nov 2016 to Dec 2025, achieved to NT\$ 799.6 billion (US\$ 26.6 billion).

- Goals by 2030

Accumulative loans of approvals of SMEs by 2030, achieved to NT\$ 1249.7 billion (US\$ 41.6 billion).

2. Indicator 8.3.3: Number of approvals of micro start-up loan applications.

- Goals by 2025

Accumulative number of approvals of micro start-up loan applications during the period of 2021–2025, increased to 2100.

- Goals by 2030

Accumulative number of approvals of micro start-up loan applications during the period of 2021–2030, increased to 4200.

3. Indicator 12.6.2: Balance of loans by domestic banks to the “green electricity and renewable energy industries”.

- Goals by 2025

Total loans by domestic banks, achieved to NT\$ 1274.4 billion (US\$ 42.5 billion).

- Goals by 2030

Total loans by domestic banks, achieved to NT\$ 1455.6 billion (US\$ 48.5 billion).

4. Indicator 12.6.3: Number of listed companies required to prepare and file sustainability reports.

- Goals by 2025

Number of listed companies for preparing and filing sustainability reports compulsorily, increased to 580.

- Goals by 2030

(1) Number of large-sized listed companies for preparing sustainability reports compulsorily and disclosing them regularly, increased to 600.

(2) Disclosing the information about the important corporate responsibility report (CSR) issues (inclusive of finance) in the annual report of the shareholder meeting by all listed companies.

4. Regulatory promotion for green finance action plans in Taiwan

In Taiwan, the beginning of green finance came from the regulatory establishment of the Greenhouse Gas Reduction and Management Act on July 1, 2015, which has been renamed as the Climate Change Response Act on February 15, 2023, in response to the “net-zero emissions (or carbon neutrality) by 2050” policy in recent years (NDC, 2022). According to the Act, there are two policies relevant to green finance.

1. Article 6 (Climate change response plans or programs shall comply with the following principles):

In Provision 5, it noted to establish a green finance mechanism and promotion measures, in order to bring about a healthy cycle of investment and pursuit of sustainable industrial development.

2. Article 8 (Relevant central government agencies shall promote greenhouse gas reduction and climate change adaptation through the following actions)

In Provision 11, it noted to promote the green finance and greenhouse gas (GHG) reduction incentive mechanisms, led by the Financial Supervisory Commission (FSC) and the Environmental Protection Administration (restructured into the Ministry of Environment on August 22, 2023), and co-led by the Ministry of Economic Affairs and the Ministry of Finance.

In this regard, Executive Yuan approved the Green Finance Action Plan 1.0 on November 6, 2017 (FSC, 2018), which was planned and performed by the central competent authority (FSC), and was being jointly promoted by the FSC, Ministry of Economic Affairs (MOEA), Ministry of Finance (MOF), National Development Council (NDC), Ministry of Environment (MOE), and National Development Fund. The plan focused on “encouraging financial institutions to invest and finance the green energy industry and use capital to support the development of the green energy industry”. In August 2020, the FSC further announced the Green Finance Action Plan 2.0 (FSC, 2020), which aimed at covering “environmental, social, and governance (ESG) issues to encourage financial institutions to expand their investment and financing in green and sustainable industries, innovate and develop financial products and services, nurture sustainable finance talents, promote ESG information disclosure, and encourage financial institutions to manage climate-related risks and continue to adopt international standards”.

To further promote climate change issues and also support the national policy of carbon neutrality by 2050, the FSC announced the Green Finance Action Plan 3.0 in August 2022. The Plan

3.0 was to integrate resources to support net-zero transition by the three core strategies: collaboration to promote sustainable development, GHG emission disclosure and financing carbon reduction, and data integration to strengthen resilience and risk management. The implementation aspects included deployment, funding, data, empowerment, and the ecosystem (FSC, 2022a), which are briefly summarized below to highlight their important guidelines.

(1) Deployment

- Set the time schedule for the disclosure and inventory of Scope 1 and Scope 2 GHG emissions by financial institutions. (Note: Scope 1 GHG emissions are “direct emissions” from sources that are owned or controlled by the company. Scope 2 GHG emissions are the emissions released into the atmosphere from the use of purchased energy.)

- Set the time schedule for the disclosure and inventory of GHG emissions from investment and financing positions (Scope 3) by financial institutions. (Note: Scope 3 GHG emissions include all other indirect emissions that occur across the value chain and are outside of the organization’s direct control.)

- Propose a time schedule for the development of Scope 1, 2, and 3 carbon reduction targets and strategies by financial institutions in the medium- and long-term with reference to the science-based approach and Taiwan’s Pathway to Net-Zero Emissions in 2050.

- Promote individual financial institutions to conduct stress tests on climate change and continue to enhance the stress test modules.

- Develop monitoring mechanisms for climate risks and file analysis reports for overall climate-related risk management.

(2) Funding

- Publish the Taiwan Sustainable Taxonomy, encourage companies to voluntarily disclose the applicability and compliance of their main economic activities to the Taxonomy, and formulate and implement strategies and plans with reference to the Taxonomy for carbon reduction and sustainable transition.

- Formulate in related self-governing regulations that for investments and financing of financial institutions or financial products, which use concepts such as “green”, “ESG”, or “sustainability”, financial institutions are encouraged to use the Taxonomy for investment and financing assessments, decision-making, product design, and engagement with companies.

- Develop the phase 2 Taiwan Sustainable Taxonomy (adding more industries and technical screening criteria to other environmental objectives).

- Actively promote the “Program to Encourage Lending by Domestic Banks to Enterprises in Six Core Strategic Industries” (i.e., information and digital technology, cybersecurity, medical technology and precision health, green and renewable energy, national defense and strategic industries, and strategic stockpile industries) to help green industries obtain financing. (Continued from Action Plan 2.0.)

- Encourage financial institutions to invest in and finance the sustainable development fields. (Continued from Action Plan 2.0.)

- Encourage financial institutions to invest in the green energy industry and green finance products such as green bonds. (Continued from Action Plan 2.0.)

- Continue to review and develop the green bond market and encourage the issuance and investment of green bonds. (Continued from Action Plan 2.0.)

(3) Data

- Promote the Joint Credit Information Center (JCIC) to build up a corporate ESG data platform.
- Promote the Taiwan Stock Exchange to expand the ESG data platform of listed companies.
- Promote the Taiwan Insurance Institute to compile statistics on insurance underwriting in response to climate change and that of sustainable insurance products.
- Work with government agencies to optimize the climate-related database for use by financial institutions to evaluate climate-related risks.
- Build up the Sustainable Finance website to compile sustainable finance statistics, related regulations, exchange information, and evaluation information.
- Plan to expand the Corporate Governance Evaluation to the ESG Evaluation.

(4) Empowerment

- Enhance sustainable finance training for directors, senior executives, and regular employees of financial institutions.
- Introduce sustainable finance certificates.
- Incorporate the knowledge and ideals of green and sustainable finance into financial education and advocacy to enhance social engagement regarding green and sustainability issues.

(5) Ecosystem

- Form the Coalition of Movers and Shakers for sustainable finance.
- Establish the Financial Industry Net Zero Working Group.
- Organize the Sustainable Finance Evaluation.
- Study the supervisory mechanisms of sustainability rating institutions in foreign countries as a reference for the adoption of similar supervisory mechanisms by the FSC.
- Organize “Green Financial Technology (FinTech)” promotion activities.

5. Status of green finance measures and achievements in Taiwan

As mentioned above, the FSC began to promote green finance in 2017 according to the Green Finance Action Plan 1.0. Thereafter, the Green Finance Action Plan 2.0 was announced in August 2020 to guide financial institutions and companies to attach importance to climate change issues and sustainable development. Concerning the achievements of the Green Finance Action Plan 2.0 under the promotion measures, their achievements were summarized as follows (FSC, 2022b):

- As of the end of July 2022, the total balance of loans of domestic banks to green electricity and renewable energy was approximately NT\$ 2.23 trillion (US\$ 740.3 billion), which was an increase of NT\$ 1.25 trillion (US\$ 416.6 billion) compared to that (NT\$ 0.98 trillion) of the period before the implementation of the incentives since September 2016.
- As of the end of June 2022, banks have signed contracts for financing offshore wind power with a credit limit of approximately NT\$ 348.1 billion (US\$ 13.9 billion) in local financing. As of the end of July 2022, the FSC has approved insurance companies' participation in syndicated loans in the green energy industry totaling approximately NT\$ 23.3 billion (US\$ 0.78 billion).
- As of the end of July 2022, the total authorized investments of insurance companies in green energy power plants amounted to approximately NT\$ 14.8 billion (US\$ 0.49 billion) and two life insurance companies have invested NT\$ 4.2 billion (US\$ 0.14 billion) in offshore wind farms.

- As of the end of August 2022, 94 green bonds have been issued with an amount of approximately NT\$ 258.6 billion (US\$ 8.62 billion). Meanwhile, 20 sustainability bonds have been issued with an amount of approximately NT\$ 74.6 billion (US\$ 2.47 billion). In addition, 9 social responsibility bonds have been issued with an amount of approximately NT\$ 18.1 billion (US\$ 0.60 billion).
- As listed in Table 1 and shown in Figure 1 (TWSE, 2024), the disclosure number of CSR reports by TWSE listed companies increased from 171 in 2013 to 632 in 2022. In addition, the submission number of CSR reports by TPEx listed companies indicated an amazing increase from 41 in 2013 to 255 in 2022.

Table 1. Statistics on the number of TWSE listed companies and TPEx listed companies and their corresponding total number of companies that submitted CSRs in Taiwan.

Year	TWSE ¹			TPEx ¹		
	Total listed companies	Market capitalization	Total CSR-submitted companies	Total listed companies	Market capitalization	Total CSR-submitted companies
2010	758	23,811.42	- ²	564	1984.64	-
2011	790	19,216.18	-	607	1417.09	-
2012	809	21,352.16	-	638	1737.98	-
2013	838	24,519.56	171	658	2324.82	41
2014	854	26,891.50	267	685	2680.56	75
2015	874	24,503.63	276	712	2730.83	89
2016	892	27,247.91	342	732	2722.62	97
2017	907	31,831.94	352	744	3317.04	105
2018	928	29,318.45	367	766	2826.57	118
2019	942	36,413.52	407	775	3433.53	126
2020	948	44,903.83	430	782	4352.01	159
2021	959	56,282.02	492	788	5782.14	194
2022	971	44,266.03	632	808	4424.07	255

¹ Source (TWSE, 2024); Unit: NT \$ billion (US \$ ≈ 30 NT \$).

² Not counted.

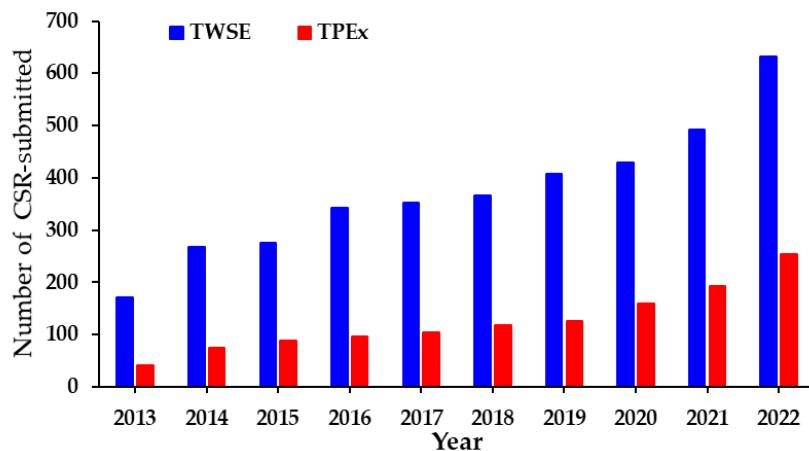


Figure 1. Number of CSR-submitted companies by TWSE/TPEX in Taiwan since 2013.

Based on the above-mentioned achievements, the credits, investments, and capital market fundraising in green finance focused on the green electricity and renewable energy industry, especially in offshore wind power. In connection with the Green Finance Action Plan 1.0, 2.0, and 3.0, Tables 2 and 3 summarize the data on Taiwan's geothermal, wind (onshore and offshore), and solar photovoltaic (PV) power during the period of 2010–2023 (up to November) in terms of installed accumulation capacity and electricity generation, respectively (MOEA, 2023, 2024). To highlight the significant progress in offshore wind power and solar PV power in recent years, Figures 2 and 3 further show the corresponding installed accumulation capacity and electricity generation during the period of 2017–2023. Based on the statistics in Tables 2 and 3, the trend analysis is briefly addressed as follows:

- The total installed capacity of solar PV power showed a roaring increase from 35 megawatts (MW) in 2010 to 12,418 MW in 2023 due to the promotion strategies under the promulgation of the Renewable Energy Development Act in August 2009. For example, the Taiwan government announced the promotion program, Green Energy Roofs Project, in December 2017 (Liu and Lin, 2021), which encouraged homeowners to install green energy roofs by adopting the “zero funding from the public, zero subsidy from the government” policy. With the constant increase in solar PV power installations, its electricity generation reached to 12,908.7 gigawatt-hours (GWh) in 2023, which indicates an amazing growth compared to 21.7 GWh in 2010.
- In Taiwan, it is more and more difficult to install onshore wind power establishments due to the available land, thus causing the slight increase in terms of installed accumulation capacity. Therefore, the Taiwan government announced the Wind Power Promotion Plan in May 2017, which focused on the demonstration development of offshore wind power farms. In this regard, the total installed capacity of offshore wind power significantly increased from 8 MW in 2017 to 1763 MW in 2023, thus generating power largely increased from 20.4 GWh in 2017 to 4497.3 GWh in 2023. It should be noted that the offshore wind power construction was retarded by the COVID-19 pandemic during the period of 2020–2022 (Tsai, 2021).

Connecting the data in Table 1 with the statistics in Tables 2 and 3, the implications of green policies for unlocking green finance and green investment significantly enhanced green energy industry

development in Taiwan, thus driving the significant growth of renewable energy generation, particularly in solar PV power and offshore wind power. These findings were similar to those in Asian countries like China (Liu et al., 2023) and Japan (Taghizadeh-Hesary et al., 2023). For example, Taghizadeh-Hesary et al. (2023) investigated the effects of green finance on the increasing consumption of renewable power (solar, wind, and hydro) in Japan during the period of 1990–2020, showing a considerable impact from the issued green bonds.

Table 2. Main renewable energy power in terms of installed accumulation capacity in Taiwan since 2010.¹

Year	Geothermal power	Wind power		Solar power by photovoltaics (PV)
		On-shore	Offshore	
2010	0 ²	476	0	35
2011	0	523	0	130
2012	0	571	0	231
2013	0	614	0	410
2014	0	637	0	636
2015	0	647	0	884
2016	0	682	0	1245
2017	0	684	8	1768
2018	0.0	705	8	2738
2019	0.3	717	128	4150
2020	0.3	809	128	5817
2021	4.5	825	269	7700
2022	5.4	836	745	9724
2023	7.0	911	1763	12,418

¹ Sources (MOEA, 2023; MOEA, 2024); Unit: megawatts (MW).

² Not yet installed.

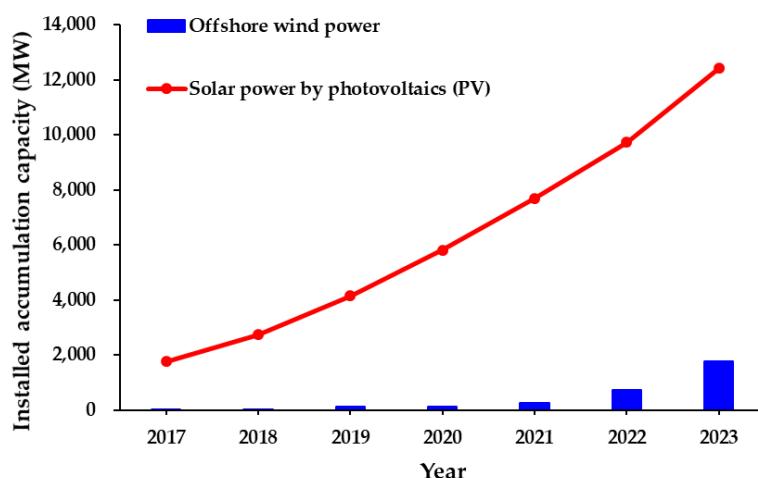


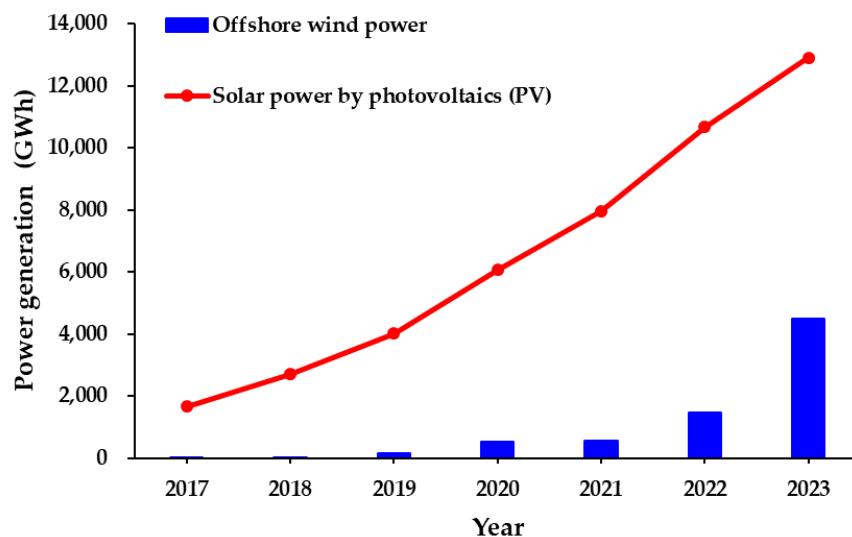
Figure 2. Offshore wind power and solar PV power in terms of installed accumulation capacity in Taiwan since 2017.

Table 3. Statistics on main renewable energy power generation in Taiwan since 2010¹.

Year	Geothermal power (MWh)	Wind power (GWh)		Solar power by photovoltaics (GWh)
		On-shore	Offshore	
2010	0 ²	1026.3	0	21.7
2011	0	1492.7	0	61.6
2012	0	1413.5	0	159.9
2013	0	1640.0	0	321.1
2014	0	1500.5	0	528.8
2015	0	1525.2	0	850.3
2016	0	1457.1	0	1109.0
2017	0	1702.1	20.4	1667.5
2018	1	1682.8	26.7	2703.7
2019	757	1715.9	176.4	4015.9
2020	1912	1792.5	516.1	6074.7
2021	9074	1701.5	556.0	7970.2
2022	25,008	2082.8	1460.3	10,677.0
2023	23,164	1704.1	4497.3	12,908.7

¹ Sources (MOEA, 2023; MOEA, 2024); Unit: Gigawatt-hour (GWh) or megawatt-hour (MWh).

² Not yet installed.

**Figure 3.** Electricity generation by offshore wind power and solar PV power in Taiwan since 2017.

5. Conclusions and future prospects

Since 2004, the Taiwan government achieved the decoupling of economic development from GHG emissions, which can be attributed to the progressive development of renewable energy and

energy efficiency under the regulatory measures and promotional actions (or programs). During this period, the financial sector in Taiwan has become an important role in supporting the investment in green energy establishments, especially in solar PV power and offshore wind power. Under the three-stage green finance action plans by the Financial Supervisory Commission (FSC), the disclosure number of sustainability reports by the listed companies has shown an upward trend, increasing from 212 in 2013 to 887 in 2022. Furthermore, the total corresponding installed capacities of solar PV power and offshore wind power showed a roaring increase from 35 megawatts (MW) and 0 MW in 2010 to 12,418 MW and 1763 MW in 2023, respectively.

In response to Taiwan's SDGs policy by 2030 and the net-zero emissions in 2050, green finance has been listed as one of the key strategies by the Taiwan government. On February 15, 2023, the Taiwan government further promulgated the Climate Change Response Act (CCRA) to require decarbonization measures and adaptation strategies, including a green finance mechanism. In this regard, Taiwan is moving toward a low-carbon society in the near future. However, the Taiwan government should pay more attention to the following phases by green finance promotion:

- The establishment of renewable energy, especially in solar PV power, geothermal power, and offshore wind power.
- The enhancement of energy efficiency, especially in green buildings (including green building materials) and low energy consumption machines (e.g., compressor, pump).
- The investment in innovative energy technologies, especially in hydrogen energy and carbon capture and utilization (CCU).
- The reformation of innovative lifestyle technologies, especially in crowdfunding, sustainability education, artificial intelligence (AI), big data, and E-health.

Use of AI tools declaration

The author declares that they have not used artificial intelligence (AI) tools in the creation of this article.

Conflict of interest

The author declares that there are no conflicts of interest in this paper.

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