

Taipower's White Paper on the Environment

Taipower Company

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Foreword

With local and international communities adopting greater expectations for environmental sustainability, both the public and private sectors must exercise greater prudence and take more active stances on facilitating environmental friendliness. While Taipower has historically spared no effort in its protection of Taiwan's water, air, land and biological resources, the general public has nevertheless sought improvements in environmental quality over recent years. Moreover, the issue of systemic global climate change has garnered much attention from the international community. These movements led to the Paris Agreement that was drafted in 2015 and has since set a course for all nations to pursue so that humanity can turn the tide against climate change. To achieve the goals of the agreement, all countries and businesses will have to stand shoulder to shoulder in taking responsibility for facilitating environmental sustainability by setting and attaining clearly defined goals and objectives. To this end, the Taiwan Power Company (hereinafter referred to as Taipower) has diligently endorsed environmental promotion while ensuring a stable domestic power supply. Internationally, Taipower has striven to promote carbon reduction and the development of renewable energy sources so that through its expertise and experience applying technology, the company will incrementally move towards becoming a world-class power utility group.

Over the past 70 years, Taipower has committed itself to various power transmission and delivery services and, in consequence, has become a bulwark that supports the commercial and economic growth as well as the prosperity that the citizens of Taiwan enjoy. More recently, Taipower has also been recognized for its quality performance by various authoritative international reporting agencies and bodies. For instance, the company has received awards from Doing Business (in the category for Getting Electricity) and The Asia Power Awards. Domestically, the company has been acknowledged with various distinctions including the TCSA (Taiwan Corporate Sustainability Awards), an Excellence Award for Corporate Social Responsibility and a Public Construction Award from the State-Owned Enterprise Commission. These awards reflect the tireless effort that the company has put forth in its core businesses and through its sustainable management.

Despite these successes, the changing local and international social expectations faced by the power industry mean that Taipower is now

additionally charged with a mission of demonstrating greater wisdom and introducing new technologies that will allow for the creation and maintenance of a win-win situation in which a steady power supply and environmental protection are sustainably balanced to ensure an ideal living environment, not only for the current generation, but for all the generations to come.

In the face of the resulting developments and the uncertainty they create in the external environment, the company will “be cognizant of changes and prepare for challenges” by remaining actively aware of relevant issues and adjusting pace accordingly. This will allow the company to take the initiative in responding to and addressing the environmental protection expectations of the general public and other relevant parties. Taipower took a major step towards addressing public concerns by initiating the systematic management and planning of its sustainable development through the establishment of a Sustainable Development Committee in 2009. The Committee consists of three specific teams: a Management Development Promotion Team, a Sustainable Environment Team and a Social Responsibility Team. The teams implement policies and take corresponding actions to achieve desired objectives.

Taipower’s Environmental Policies and this White Paper represent essential components of the company’s endeavors to promoting sustainable development. The company does not see itself as an outsider in the cause of promoting sustainable development on a global scale. Rather, Taipower has incorporated environmental issues into its broader management processes as a means of demonstrating its resolve to mitigate global warming and maintain the quality of the air, water and living environments.

This is reflected in the revision of the company’s corporate mission statement in 2016 to include “...supply stable power for the needs of socially diverse developments with an eco-friendly approach and at a reasonable cost.” This revision effectively incorporated environmental friendliness into the company’s most fundamental and crucial mission statement and declared the resolve of the company, its employees and stakeholders to protect the environment while beginning a new page in the history of green sustainability.

Taipower’s development has closely mirrored the development of Taiwan’s economy and commerce. As such, Taipower’s promotion of environmental protection can also be seen as a condensed version of the path toward environmental protection that Taiwan has taken. More than 30 years ago, Taipower became the first of Taiwan’s state-owned enterprises to establish a

dedicated department for environmental protection. The timing of this coincided with a period in which an awareness of the need for environmental protection had just started to take root in Taiwan.

In retrospect, Taipower has come a long way since the era in which it passively responded to specific environmental issues. Through various measures, such as the reduction of pollutant discharge at power plants, the implementation of environmental impact assessments, investments into pollution prevention facilities and improvements, Taipower has come to embrace active involvement in the promotion of environmental friendliness and the gradual fulfillment of its green vision. This can be seen in the company's formulation of comprehensive plans in their deployment to address specific vulnerabilities.

Taipower's vision has led in our strides and its Environmental Policy has served as the ladder for us to fulfill our eco-friendly visions. We shall climb this ladder with due diligence and tap into the company's momentum in promoting environmental protection to shape Taipower's corporate image as a green enterprise.

This White Paper on the Environment marks a turning point in Taipower's efforts in promoting environmental friendliness and represents an important transition and new phase for the company. By reviewing and reflecting on the actions and results that the company has taken and achieved thus far while summarizing relevant domestic and international issues of environmental sustainability, Taipower will be able to create an outline of appropriate aspects and objectives for action in the short, medium and long-term. In addition, by assessing the current status and future planning of various units and divisions and engaging them in bottom-up brainstorming and the collection of ideas and proposals, Taipower will lay down strategic goals and action plans for each of its business units, departments and offices.

Through this White Paper on the Environment, Taipower will present the goals it will be working towards in order to help the general public better understand the company and establish a partnership that facilitates supervision and collaboration. Internally, the White Paper will foster consensus within the organization by creating a framework of common language and targets for all members of the company. Through this joint effort, the company will set the groundwork for environmental protection and cooperation to create a better environment for Taiwan and international society.

Abstract

The contents of Taipower’s White Paper on the Environment can be separated into five main components which together offer a comprehensive blueprint for Taipower’s environmental sustainability to 2030. The paper offers a narrative and description of the company’s environmental commitments at the management level along with other details such as an outline of the planning undertaken to help the company achieve its goals.

The first chapter, “Sustainability Consensus,” presents a concise overview of the facts associated with the sophisticated and rapidly-changing trends (*i.e.* international energy issues and challenges of climate change) in environmental sustainability that Taipower faces, the status of Taiwan’s energy transition and Taipower’s own environmental vision that highlights material environmental sustainability issues for the company as it aspires to become a sustainable power utility group.

The second chapter, “Green Commitment,” covers the Environmental Policy that Taipower has formulated and adopted after reaching an internal consensus on the course of sustainability that should be pursued. The policy covers six major environmental aspects that Taipower will focus on as the guiding principles in its endeavor to achieve environmental sustainability. The six aspects include: response to climate change, safeguarding environmental quality, focus on circular innovation, improving management systems, fostering ecological harmony and expanding engagement

The third chapter, “Promotion and Implementation,” features a discourse on Taipower’s planning of promotions that will further its vision for environmental protection. This includes both the strategic components of the aforementioned six aspects and the specific contents of the 12 environmental strategies the aspects are composed of. All of the strategic aspects incorporate short, medium and long-term environmental goals at the corporate level up to the year 2030. Specific objectives and action plans for responsible business units are laid out for implementation. Additionally, specific objectives, actions and measures have been established for all of Taipower’s business units/systems, including the Power Generation, Nuclear Power, Transmission System, Distribution and Service Divisions along with relevant offices in the company’s construction system.

Taipower's six major environmental strategic aspects are as follows:

1. Response to climate change: Taipower will face the impact of climate change by continuing to develop its response plans in order to improve mitigation and adaptation in its management of greenhouse gases, development of renewable energies, investment in low-carbon technologies, planning of adaptive measures, integration of carbon rights management, establishment of low-carbon business models and so forth.
2. Safeguarding environmental quality: Taipower will continue to mitigate and reduce the negative impacts of its operations on the environment and the health of the general public in terms of air and water quality and through the appropriate handling and disposal of nuclear wastes and so forth.
3. Focus on circular innovation: Taipower will take inspiration from the concepts of the circular economy and strive to improve resource utilization efficacy and the circular use of resource in order to develop circular business models.
4. Improving management systems: Taipower will improve and integrate its existing systems for environmental management and develop its system for intelligent power management, thereby strengthening the company's overall capacity for environmental management.
5. Fostering ecological harmony: Taipower will carry out a comprehensive assessment of its existing properties to ensure that power facilities foster ecological harmony and protect the biodiversity of living organisms.
6. Expanding engagement: Taipower will continue communicating with its external stakeholders in order to establish the company's image as a green enterprise while promoting science education and environmental protection in the domestic power industry, thereby facilitating the process of energy transformation in Taiwan.

Taipower will adopt and use these six strategic aspects as a compass in its promotion of environmental sustainability. Through the planning and gradual implementation of various specific objectives and action plans, Taipower will achieve its vision of attaining harmony with the environment. By establishing

comprehensive management and evaluation mechanisms, the company will be able to achieve its vision of reaching environmental sustainability.

The fourth chapter, “Green Reality,” features a comprehensive record of the concrete results and outcomes that Taipower has achieved in the areas of renewable energy development, green facility promotion, harmonious coexistence with local ecologies and air pollution prevention.

The final chapter, “Co-creating New Opportunities,” illustrates Taipower’s prospects and outlook for sustainability.

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I. Sustainability Consensus

More than 30 years have gone by since Taipower established its Department of Environmental Protection in 1986. The company remains as vigilant as ever in its adherence to the latest domestic trends in environmental protection and its inclusion of relevant eco-friendly measures as it incorporates environmental protection as an integral part of its day-to-day operations. In light of the rapid changes in the global environment and the ongoing pursuit of sustainable development, the issues of environmental protection have become more complicated and diverse. Given Taipower's position as a power utility group, with operations covering power generation, transmission distribution and service and its intricate relationship with Taiwan's economic and social development, the company is obliged to commit to both thorough deliberation on the scope of its operations and consideration of the potential impacts that could be inflicted upon the environment.

Taipower has now reached a crucial point in which it is facing both a transition in Taiwan's power industry and a corporate transformation. These changes have made the adoption of forward-thinking and systematic planning necessary to adequately respond to key environmental impacts and to embrace specific eco-friendly measures that create positive environmental value. In light of these considerations, Taipower has examined relevant perspectives and issues of concern from the World Energy Council (WEC), environment and energy related organizations and international power industries¹ in order to identify the changes and environmental concerns that are paramount for the global power industry. This examination provides the company with a reliable reference for environmental policy and allows it to establish sound guidelines for environmental protection in the decades to come.

1.1 Current challenges for the power industry

1.1.1 International energy issues

I. Staying up to date with international energy issues

The material issues for the global energy industry, as ranked by the WEC according to relative uncertainty and impact are shown in Figure 1.²

¹ GEO-6 Regional Assessment for Asia and Pacific, UNEP, 2016.

² World Energy Issues Monitor 2018, World Energy Council, 2018.

While emerging issues such as Blockchain and digitization have brought about high degrees of uncertainty and impact, more direct environmental issues such as energy efficiency, despite their relatively limited uncertainty, are believed to have the potential to result in substantial impact. In the last decade, for instance, the consequences of climate change have affected the world in such a way that energy conservation and carbon reduction have come to be accepted and embraced as universally important issues. In consequence, the climate framework for enterprises has been classified as an issue with a relatively greater impact and a higher degree of uncertainty. A range of derivative issues such as sustainable cities, electricity storage, decentralized systems, Carbon Capture and Storage(CCS) and so forth are also designated as having relatively higher uncertainty. These issues will no doubt pose significant challenges to the management and decision-making processes for leaders in the energy industry.



Figure 1. Analysis of world energy issues

(Source: World Energy Issues Monitor 2018)

By analyzing the world energy issues monitor for the past five years (2013-2018), Taipower has identified three key trends:

- Carbon reduction: In the report by the World Energy Issues Monitor, issues such as electricity storage, digitization, decentralized systems, market design and so forth have been steadily moving to the upper right region of the matrix. This reflects an increase in both their uncertainties and impacts. In contrast, the issue of renewable energies has been moving to the lower right region in the matrix,

meaning that while its impact continues to grow, its relative uncertainty has been steadily falling. As far as the energy industry is concerned, the growing focus and attention on climate issues within the general public means that the introduction of carbon-reduction technologies will certainly become a key component of development in the future.

- **Increased digitization:** While the issue of digitization has been identified as growing in both impact and uncertainty, a number of related emerging issues have also been acknowledged, such as IoT, Blockchain, Platform and Mobile Cloud technologies, and so forth. Incidentally, all of these new issues have been associated with high levels of uncertainty and thus will require further development and observation.
- **Greater decentralization:** Decentralized systems first appeared in this report as an emerging issue in 2014. At that time, they were placed in the lower left-hand corner of the matrix, meaning that decentralization received very limited attention. However, the issue has subsequently shown dramatic increases in both its uncertainty and impact. With the challenges of climate change and improvements in power availability and accessibility in remote areas, decentralized power generation and distribution systems have received more attention. This has been closely tied to the move by utilities to accelerate the development of renewable energy and fortify power grid resilience in order to benefit the masses. Conversely, issues related to traditional centralized power generation systems such as nuclear and coal have witnessed decreasing uncertainty and impact. This is reflected in the fact that the influence of centralized power generation solutions is expected to wane throughout the energy sector in the foreseeable future.

II. United Nations' Sustainable Development Goals

Among all the current issues in international environment management, the United Nations' Sustainable Development Goals (SDGs) stand out as a feature that cannot be overlooked. In 2015, countries around the world adopted the 2030 Agenda for Sustainable Development and its 17 SDGs in hopes that the world could work as one to pool resources from both public and private sectors to achieve all the goals by 2030.

In the SDG Industry Matrix, jointly published by the UN and KPMG to showcase industry-specific examples and ideas for corporate action related to the

SDGs,³ a number of SDGs have been identified as both eco-friendly and suitable for energy industry participation. The identified SDGs are as follows: SDG6 Clean water and sanitation, SDG7 Affordable and clean energy, SDG11 Sustainable cities and communities, SDG12 Responsible consumption and production, SDG13 Climate action, SDG14 Life below water, SDG 15 Life on land and SDG 17 Partnerships for the goals.

The identified SDGs and Taipower’s corresponding actions are presented in Table 1. The table also includes existing and potential dimensions in which the company may improve environmental protection.

Table 1. United Nations SDGs and Corresponding Opportunities for Power Industry Action

SDG	Corresponding eco-friendly actions
SDG6 Clean water and sanitation	<ul style="list-style-type: none"> ● Reduce water consumption ● Continue monitoring effluent quality ● Water resource management and circular use
SDG7 Affordable and clean energy	<ul style="list-style-type: none"> ● Transition to clean, alternative energies (<i>i.e.</i> Liquefied Natural Gas) ● Accelerate the transition to renewable energies ● Develop energy storage technologies ● Connect more renewable energy grids ● Develop affordable low-carbon decentralized power grids
SDG11 Sustainable cities and communities	<ul style="list-style-type: none"> ● Ensure grid resilience ● Assist in the improvement of residential/commercial energy efficiency ● Strive for better use of urban resources and energy circulation
SDG12 Responsible consumption and production	<ul style="list-style-type: none"> ● Set science-based objectives for carbon-reduction ● Reduce the consumption of raw materials ● Actively manage chemical substances and wastes ● Assist in the development of sustainable consumption
SDG13 Climate action	<ul style="list-style-type: none"> ● Set internal carbon pricing ● Develop and apply CCS technologies ● Assess climate risks ● Mitigate the risks of hazards and disasters
SDG14 Life below water	<ul style="list-style-type: none"> ● Study and promote marine protection ● Strengthen wastewater treatment ● Set shipping environmental management

³ SDG Industry Matrix, United Nations Global Compact & KPMG, 2015.

SDG	Corresponding eco-friendly actions
	standards
SDG 15 Life on land	<ul style="list-style-type: none"> ● Promote studies on ecological values ● Protect biodiversity ● Comply with pertinent international conventions
SDG 17 Partnerships for the goals	<ul style="list-style-type: none"> ● Share relevant environmental information ● Become a member in various environmental advocacy organizations

1.1.2 Climate change challenges for the energy industry

In the aforementioned reports from key international organizations, one common factor stood out for its significant impact on the energy industry – climate change. With threats from climate change ever looming, continuing to provide safe, reliable, competitive and environmentally friendly power remains the most important task for the energy industry. As such, the energy industry needs to involve itself actively in both the mitigation and adaptation work by incorporating both into its environmental planning. Many energy departments and governing bodies around the world have already adopted a clearly defined objective: to create an energy system that is cleaner and more resilient.

I. Energy and emissions

In the Fifth Assessment Report (AR5) drafted by the Intergovernmental Panel on Climate Change (IPCC), the chapter on the energy sector can be summarized with the following points: (1) The growth in global energy demand could potentially lead to increased carbon emission, thereby further exacerbating climate change; (2) Climate change will pose a greater challenge and result in a great impact upon power generation and transmission; (3) The energy sector needs to achieve effective reduction of its carbon emissions in all aspects of operation; (4) In order for governments to achieve the target of limiting global warming to 2°C, the climate-related policies implemented will invariably lead to significant impacts on energy departments, thus making the planning for de-carbonization a vital task and (5) Although it is a great challenge, the stimulation of low-carbon technology development through policy implementation could bring about benefits such as promotion of better health and creation of more employment opportunities.

In 2015, the Paris Agreement was signed by various state representatives at the 21st Conference of the Parties of the UNFCCC. The parties committed to the goal of keeping the increase in average global temperatures to less than 2°C above pre-

industrial levels and to strive to limit the increase to 1.5°C. Each participating nation has proposed Nationally Determined Contributions (NDCs) that cover relevant climate policy objectives such as carbon reduction and renewable energy development. After the Paris Agreement was signed, the IPCC took a step further to determine the potential outcome of continued warming increases (at the current rate) and published a Global Warming Special Report: Global Warming of 1.5°C⁴. The report states that if the world really wants to keep increases in global warming to under 1.5°C, global carbon emission levels will have to be reduced before 2030 to 40-60% of 2010 levels. Moreover, carbon neutrality must be reached no later than 2050. Even if warming is kept to less than 1.5°C, the resulting impact will still lead to substantial changes to human societies. As such, governments and corporations have been strongly advised to evaluate climate risks and take an aggressive stance on relevant adaptive measures. At the 24th Conference of the Parties (COP24) held in Poland at the end of 2018, the parties acknowledged the key findings that were presented in the IPCC 1.5°C special report and finished working on mechanism rules for carbon inventory, control and reporting. In 2019, mechanisms and regulations for international carbon trading will be completed and introduced so that the Paris Agreement can be officially initiated in 2020 as scheduled.

According to the policy goals published by governments around the world and the New Policy Scenarios (NPS) analysis performed by the International Energy Agency (IEA)⁵, the proportion of global renewable energy generation could reach as high as 40% by 2040 (see Figure 2). As such, energy departments are expected to actively involve themselves in this area in order to help realize the green future that all members of the international community are looking forward to.

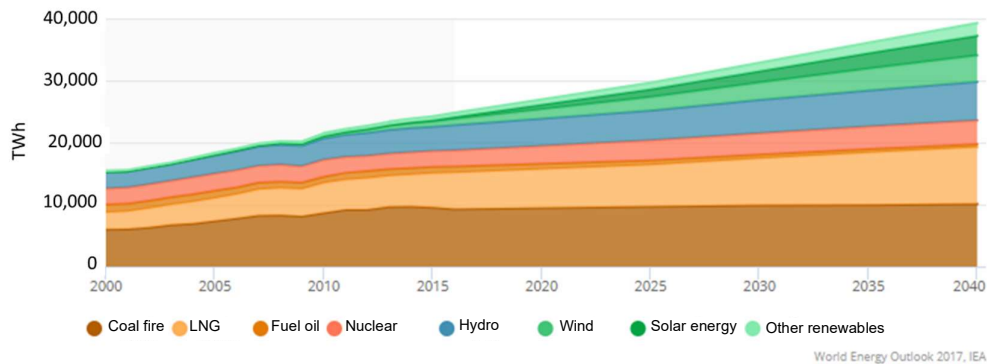


Figure 2. Forecast for international energy development

⁴ Special Report: Global Warming of 1.5°C, 2018, IPCC

⁵ World Energy Outlook 2017, IEA, 2017.

(Source: IEA, World Energy Outlook 2017)

Following in the footsteps of other nations, Taiwan has defined an estimated contribution, which involves a pledge to reduce Green House Gas(GHG) emissions by 50% by 2030 compared to the Business As Usual(BAU) estimates derived based on that of 2013 (equivalent to 214 million metric tons of carbon dioxide). Taiwan’s NDC also includes raising the power sector’s renewable generation capacity to 30,161MW by 2025, increasing the proportion of LNG generation, replacing dated power generation equipment with the best available technology, planning smart grid infrastructure and continuing to promote and implement energy integration and management to boost energy efficiency.

According to the “2017 Republic of the China National Greenhouse Gas Inventory Report” published by the Executive Yuan’s Environmental Protection Agency (EPA), Taiwan’s energy sector was the nation’s primary source of emissions and had discharged a total of 256 million metric tons of carbon dioxide equivalent (Figure 3). The figure translated to a growth of 131.82% over 1990 levels with an average annual growth rate of 3.42%.

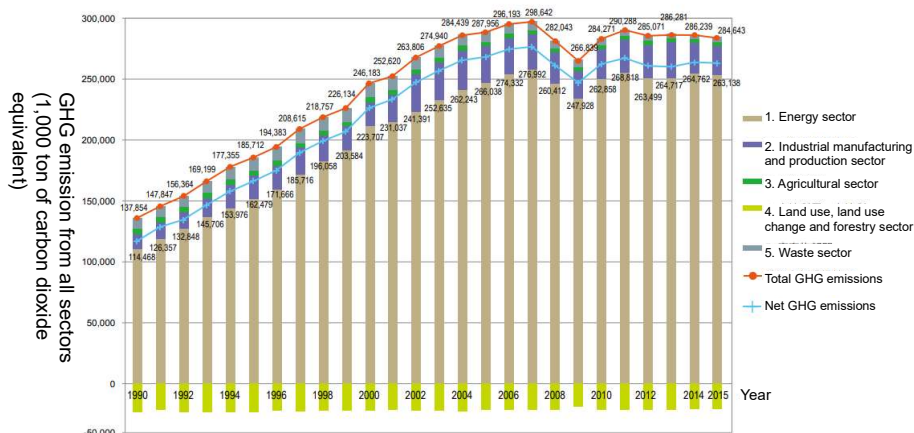


Figure 3. Trends in Green House Gas Emissions by Different Sectors in Taiwan from 1990 to 2015

(Source: 2017 Republic of China National Greenhouse Gas Inventory Report)

II. Impact of climate change

Two reports, Global Environment Outlook 5 (GEO-5), published by the UNEP⁶, and Climate Change: Implications for the Energy Sector, an analysis jointly published by the World Energy Council and the Cambridge Institute for

⁶ GEO-5 for Business: Impact of a Changing Environment on the Corporate Sector, UNEP, 2013.

Sustainability Leadership based on IPCC’s AR5, have identified the impacts of climate change on the energy sector. Their findings are summarized in Table 2⁷. In the table, it is evident that various factors such as the acquisition of fuel, power plants, power grids and the continuous development of renewable energy are all crucial items that Taipower must over-compensate for in ensuring adequate preparations are made for a rapidly changing environment.

Table 2. Impacts from climate change on the energy sector

Category	Description of primary impact
Power plants	Traditional thermal power plants could suffer from reduced energy conversion efficiency when environmental temperatures are increased; other factors such as extreme weather, shortages of water, unstable water supplies and higher average water temperatures can also affect power plant operations, with a high likelihood of power plants needing to seek alternative means of cooling and effluent treatment. For example, the heat wave that struck Europe in 2003 caused the EDF to temporarily halt the operations of a few nuclear power plants and suffer huge losses as a result. For hydro generation, power companies must also evaluate the potential effects of changes in rainfall on dam operation to prevent turbine damage and reduced dam capacities.
Petroleum/gas pipelines	Infrastructure for coal, natural gas and petroleum will become exposed to significant risks. For example, petroleum/gas pipelines in coastal areas will become even more susceptible to the effects of extreme weather, rising sea levels and coastal erosion and will therefore require the taking of comprehensive and immediate measures for enhanced protection.
Power grids	Extreme weather and frequently occurring, intense floods will expose power grid systems to more risks. As such, power companies will need to strengthen, optimize or relocate their existing power grid infrastructure while expanding transmission capacities and preparing to respond to potential power outages. The increasing connection of grids to renewable energy will also pose new challenges to existing power grids.
Renewables	Climate changes will invariably affect the existing models of hydro generation and an increased frequency of rainy days could also impact the availability of solar power.
Power markets	According to the IEA estimates, the power demand for all developing nations around the world in 2035 will exceed that of 2009 by as much as 70%. As for developed nations, existing solutions developed to mitigate climate change, such as electric vehicles, will also lead to dramatically increased demands for power.

⁷ Climate Change: Implications for the Energy Sector, Cambridge Institute for Sustainability Leadership and World Energy Council, taken from: www.cisl.cam.ac.uk/ipcc

Category	Description of primary impact
Policy effects	Many countries have instructed relevant sectors to reduce GHG emissions through legislation and have planned for an increased proportion of renewable energy sources. Some European countries (<i>i.e.</i> U.K., France, Netherlands, Portugal and Italy) have already announced estimated coal exit schedules. Under government regulation, the power industry will be subjected to control of total GHG emissions and other policies such as carbon trading, carbon taxes and reduced subsidies for petrochemical energies. Apart from having to face more sophisticated legal regulations, power companies will have to deal with the impacts of increased costs.
Effects of reputation	Extreme weather could lead to a composite impact on natural and social systems. If the power industry is ill-prepared, potential service disruption and reduced reliability could result in dissent from the media, consumers and investors. In addition, power plant operators that overly rely on petrochemical fuels will be perceived as the main culprits of exacerbated climate changes and subsequently become the subject of public pressure and criticism.

1.1.3 Energy transition planning in Taiwan

In April 2017, the Executive Yuan officially approved the revision of Taiwan’s Guidelines for Energy Development to focus on four major aspects of “Energy Security,” “Green Economy,” “Environmental Sustainability” and “Social Equity.” The introduction of these guidelines constituted an energy transition. Correspondingly, a white paper on the energy transition plan will be compiled and be subject to review every five years in order to accelerate the promotion and implementation of the shift.

The aspect of a “Green Economy” is intricately tied to environmental sustainability. The aspect will be the focus of three specific guidelines for the construction of ecological systems, the promotion of local applications and the use of innovative technologies for green energy and carbon reduction to integrate economic sectors and to cultivate green energy expertise and technologies thereby creating a foundation for a green energy sector with the capacity to compete on a global level. As far as Taipower is concerned, promotion of this aspect will involve the active capitalization of new business opportunities in the company’s main line of businesses while helping Taiwan to create various benefits through its green transition.

With regards to the aspect of “Environmental Sustainability,” Taipower will introduce new strategies that involve “maintaining air quality” and “planning for appropriate areas” as ways to address the issues of air pollution and environmental impacts caused by the construction of power facilities that

have received significant public attention in recent years. In the meantime, Taipower will also maintain its existing strategies for GHG emission reductions and continue the construction of low carbon environments. Taipower carries a great deal of responsibility for the transition process and will incorporate the key aspects of Taiwan's energy transition plan into its own environmental policies as it works towards a green energy transition.

The revision of the Electricity Act in 2017 was an essential turning point in Taiwan's promotion of green energy as the resulting change in regulations opened the doors for green energy suppliers to directly sell the power they have generated. Not only that, consumers also became entitled to freely choose their preferred distributor of green energy. These changes have essentially made the market more competitive. In the future, Taipower will continue to operate in conjunction with pertinent regulations and government policies in the continuous promotion of green energy while adjusting its energy transition strategies and planning for a power source profile. At the same time, the company will stay abreast of the latest international trends as it endeavors to promote green energy transition in Taiwan.

1.1.4 Response to air pollution

The issue of air pollution has continued to receive significant attention both domestically and in the international community. According to estimates from the World Health Organization⁸, outdoor air pollution caused by exhaust fumes from motor vehicles, oil fumes from restaurants and open exposure to surface dust and factory discharges results in the deaths of approximately 4.2 million people around the world each year. Not only that, approximately 91% of the world's population is dwelling in regions with an air quality that is worse than the recommended World Health Organization(WHO) quality levels. Indeed, eighty percent of all urban areas can be categorized as having severe air pollution. Among the aforementioned deaths, lung cancer stood out as the key factor (at 29%), along with other lethal factors such as lung function deterioration, respiratory tract infections, asthma and so forth. On the official website of the WHO, it is also clearly stated that the impact of air pollution on the health of humanity has surpassed that of cigarette smoking. As such, air pollution has become an issue that all governments around the world have to aggressively address. Presently, the key substances responsible for air pollution include particulate matter (PM), ozone (O₃), nitrogen oxide (NO_x) and sulfur

⁸ World Health Organization, taken from: <https://www.who.int/airpollution/en/>

oxide (SO_x). These are pollutants that require active monitoring and immediate control within our societies.

Findings in 2018's State of Global Air report published by the Health Effects Institute⁹ reaffirmed the statements made by the WHO. The grim facts illustrate the severity of air pollution as a critical environmental and health issue in most urban areas. This is especially true when it comes to the problem of PM_{2.5}, which has been identified as the primary air pollutant that leads to significant health impacts. The aforementioned report also pointed out that the development and growth of community and social media has become a source of pressure driving governments around the world to act and respond to the impacts of air pollution. When members of the general public become cognizant of changes in air quality, they express their opinions through various social medias and generate strong sentiments within public opinion. These trends have motivated governments to come up with better policies and more stringent regulations in order to effectively reduce and contain the discharge of exhausts from motor vehicles, fumes from restaurants, dust particles from open areas and factory discharges in order to combat air pollution.

1.2 Taipower's environmental vision

With the wave of eco-consciousness around the world growing into an unstoppable force, power industries now must place equal emphasis on energy quality, energy security and environmental sustainability. As a state-owned enterprise, Taipower is obliged to take responsibility for its role in all the aforementioned issues. Taipower has faithfully adhered to its corporate mission of "supplying stable power for the needs of diverse social development with an eco-friendly approach at a reasonable cost" and a corporate vision to "be deemed as a prominent, trustworthy world-class power utility group." In consideration of the aforementioned environmental issues, development trends, and key objectives of the international community, such as achieving the UN's SDGs by 2030 and reaching carbon neutrality by 2050, Taipower has formulated a roadmap for its long-term environmental development as shown in Figure 4.

⁹ State of Global Air, Health Effects Institute, 2018.

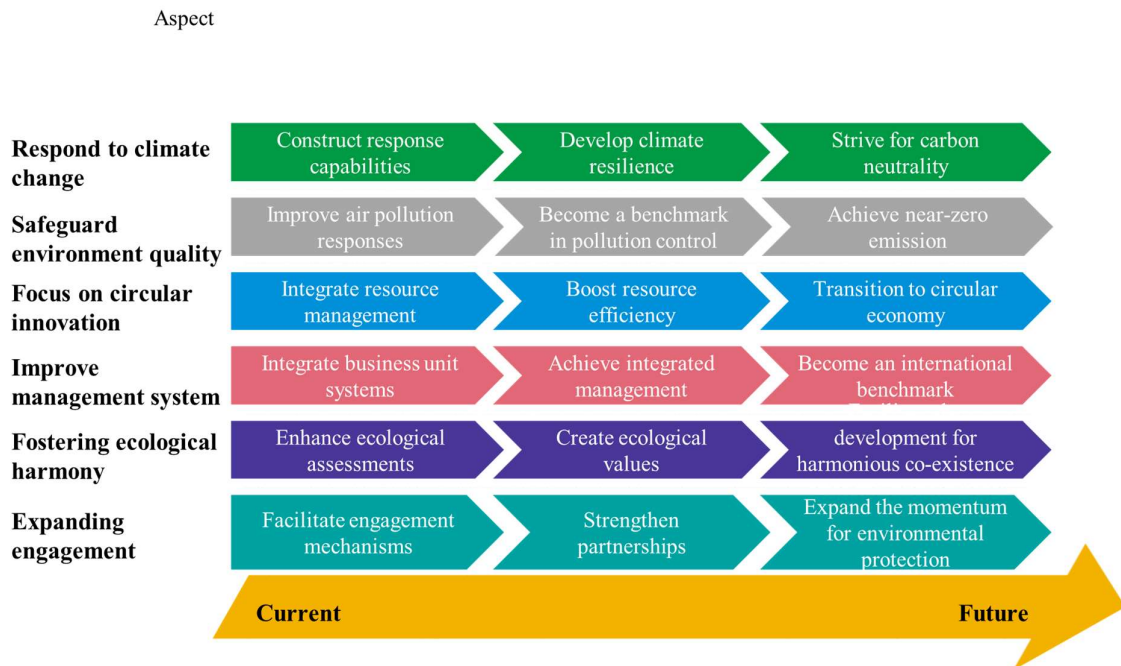


Figure 4. Taipower’s roadmap for environmentally friendly development

The company will continue to contribute to and facilitate environmental sustainability through actions that include assessment, the best available action plans, monitoring and prevention, informational transparency and communication with local residents. With regards to Taipower’s vision of becoming a world-class power utility group that advocates environmental sustainability and eco-friendliness, Taipower’s relevant long-term goals are:

- **Striving for carbon neutrality:** Climate change has become a serious issue that requires immediate and aggressive action to address. In order to alleviate humanity’s impact on the global environment, the energy sector (which has been responsible for high carbon emissions) has an even greater obligation to reduce carbon emissions. Perceiving itself as an international leader, Taipower aspires to engage in an innovative transition to a low-carbon model and to pursue value creation by working towards the goals of reaching both carbon neutrality by 2050 and becoming highly resilient in the face of climate changes. The achievement of these goals will enable Taiwan to benefit from a low-carbon environment and a stable power supply.
- **Aiming for zero discharge of pollutants:** Taipower will actively minimize the impact of its operations on the environment by adopting “high efficiency and the low discharge of pollutants” as a rule-of-thumb in its

replacement of equipment, construction of new facilities and in all of its day-to-day operations. This will allow the company to continue reducing various environmental impacts on air, water bodies, soil and in waste generation and to ultimately attain its goal of zero discharge of pollutants.

- Transition to a circular economy: Taipower will assess its existing operating models to identify the company's circular potential and construct a circular model for its energy resources. Through viable commercial models for key materials that are required for Taipower's circular economy, the company will leverage this approach to fortify its operating efficiency while establishing external partnerships in the circular economy so that it may become an innovative circular power company. This will in turn allow Taipower to become a driving force for circular transition in Taiwan.
- Set an international benchmark: in light of the trends of domestic power industry liberalization, reform, global energy transition and intelligent management, Taipower strives to become an international enterprise of excellence and thus, the company shall stay ahead of the competition in terms of its environmental efforts by continuing to utilize the best available technologies. In so doing, the company intends to set the international benchmark for power industries across the globe.
- Develop a harmonious relationship with the environment: Taipower will endeavor to strengthen its relationship with the natural environment by conducting comprehensive assessments on factors that could potentially affect the environment in order to minimize ecological impact. The company will also create power facilities that can co-exist harmoniously with their local environments so that its sites of operation can become ecological nodes with unique features that facilitate a sustainable and harmonious co-existence with the environment.
- Amplify the momentum of environmental protection: Taipower will integrate various actions and measures for environmental protection to amplify its external influence. This will allow the company to achieve greater synergy and results in environmental protection. The company will continue to heed the voices and wishes of its external stakeholders and take a pro-active green stance by means of environmental education, participation in environmental advocacy and engagements in order to

demonstrate its performance and influence in the domains of environmental sustainability and low-carbon energy transition.

II. Green Commitment

Taipower's Environmental Policy

As a power utility group with operations covering power generation, transmission, distribution and service, and a mission to achieve environmental friendliness while becoming a world-class power company, Taipower has established this environmental policy, which was approved by the Chairman before its publication, as the highest guiding principle for the company's efforts in environmental sustainability.

This environmental policy is applicable to the whole of the Taiwan Power Company, including its headquarters, various business units and secondary units along with all activities, products and services that can be influenced or controlled by the company and its suppliers, contractors and other partners in its value chain.

Compliance with pertinent regulations shall be the minimum standard in Taipower's environmental sustainability development. Yet, guided by the relevant policies, Taipower shall endeavor to attain an outstanding performance in environmental protection that is befitting of its aspirations of becoming "a world-class power utility group." The company will work together with all collaborating partners to create a clean and sustainable environment where harmonious co-existence is possible as Taipower continues to generate, transmit, supply and distribute power.

In order to achieve a performance level that is befitting of a world-class power utility group, Taipower pledges to the following environmental commitments in six major principles, apart from basic pollution prevention measures, so that the company can continue to improve its environmental performance while continuing to communicate with its external stakeholders:

- Response to climate change: to implement and facilitate low-carbon transmission and strengthen the company's resilience against climate change as we strive to achieve carbon neutrality
- Safeguarding environmental quality: to eradicate, reduce and control the impact of pollutants on the environment and health of people while getting as close as possible to our objective of zero emission and discharge.
- Focus on circular innovation: to set the way to high-efficiency and sustainable energy material usage through circular thinking and put the theory of circular economy into practice.
- Improving management systems: to adopt principles of intelligent, high-efficiency and high response capabilities in the construction of a leading environmental management system.
- Fostering ecological harmony: to create ideal models for power generation, transmission, supply, distribution and sales that will facilitate harmonious co-existence with surrounding environments and ecologies so that Taipower may become a green enterprise.
- Expanding engagement: to continue communication with relevant internal and external stakeholders and to play an active role in the

delivery of information pertaining to environmental protection for the power industry while promoting energy transition.

Taipower shall refer to the aforementioned six principles in its construction of a focused environmental dimension while constantly supervising and adjusting the overall achievement rate of the company's environmental objectives. All business units and systems will establish specific goals and action plans for implementation based on their duties and obligations.

After its publication, this environmental policy may be reviewed and revised depending on factors such as international trends and changes in the internal or external environments. Such revisions shall be approved by the Chairman before relevant updates and public announcements are made.

Chairman _____

Date.....

III. Promotion and Implementation

3.1 Promotional Framework for Taipower's Environmental Policy

To ensure the concrete fulfillment of Taipower's mission and vision, the company has examined relevant international environmental issues and trends while adhering to its own developmental vision and overall management strategies to establish a long-term, conglomerate-level environmental policy. In order to ensure the policy's effective promotion and implementation, Taipower has planned the policy's strategic aspects by focusing on specific areas of environmental sustainability. Each strategic aspect can also be separated into multiple strategic dimensions to develop relevant goals and solutions for different business units and systems in accordance with their individual traits and responsibilities. Apart from objectives for business units and systems, Taipower has also established corresponding short-term (by 2021), medium-term (by 2025) and long-term (by 2030) goals for each strategic dimension. These employ either top-down or a bottom-up progressions so that the company can gradually fulfill the "green commitment" that Taipower has set for itself, for society and for Taiwan. For an illustration of the aforementioned environmental policy's promotional framework, refer to Figure 5. For the key items of the framework and their descriptions, refer to Table 3.



Figure 5. Promotional Framework for Taipower’s Environmental Policy

Table 3. Description of key items in Taipower’ s promotional framework for the Environmental Policy

Item	Description
Environmental policy	Formulated in accordance with Taipower’s mission and vision, the policy serves as a collection of the company’s highest guiding principles, commitments and objectives in its promotion of environment-related measures
Strategic aspects	Key domains in the environmental policy that require focus through the study and review of relevant international trends in environmental protection, actions adopted by benchmark corporations and issues of social concern
Strategic dimensions	By identifying the contents of each strategic aspect the focus can be extended downward into multiple environmental strategic dimensions of substantial importance
Strategic goals	Short, medium and long-term goals established by the headquarters, business units and systems based on relevant strategic dimensions
Action plans	Relevant measures and projects that have been planned to ensure that specific strategic goals can be accomplished

3.2 Strategic environmental aspects and dimensions

In consideration of factors such as external trends in environmental sustainability, material issues for stakeholders, Taipower’s mission, vision and environmental policy, the company has formulated six critical environmental aspects that it will focus on and involve itself in. These domains also represent Taipower’s six strategic aspects of environmental protection as shown in Table 4.

Table 4. Practical implications of the six strategic aspects

Strategic aspects	Practical implications
Response to climate change	As it faces the impacts of climate change, Taipower will continue to develop its response planning to mitigate and adapt for features such as the management of greenhouse gases, development of renewable energies, investment in low-carbon technologies, planning of adaptive measures, integration of carbon right management, establishment of low-carbon business models and so forth.
Safeguarding environmental quality	Taipower shall continue to mitigate and reduce the negative impacts of its operations on the environment and the health of the general public in areas such as air quality, water quality and the appropriate handling and disposal of radioactive wastes and so forth.
Focus on	The company will draw inspiration from the concepts of a

circular innovation	circular economy and strive to improve resource utilization efficacy and circular use of resources in order to develop circular business models.
Improving management systems	Through the improvement and integration of Taipower’s existing system for environmental management, the company will develop its system for intelligent power management and thereby strengthen its capacity for environmental management.
Fostering ecological harmony	The company will carry out a comprehensive assessment of its existing premises and facilities to ensure that power facilities will foster ecological harmony and protect biodiversity for all living organisms within the perimeters of Taipower’s properties.
Expanding engagement	To continue communication with relevant internal and external stakeholders and deliver information pertaining to environmental protection and relevant issues for the power industry while promoting energy transition in Taiwan.

From the six strategic aspects, 12 strategic dimensions have been derived to serve as the basis for Taipower’s environmental sustainability operations. These are shown in Figure 6.



Figure 6. Twelve strategic dimensions of Taipower’s six major strategic aspects

The practical implications of the 12 strategic dimensions are presented in Table 5 below.

Table 5. Practical implications for the 12 strategic dimensions

Strategic aspects	Strategic dimensions	Practical implications
Response to climate change	Promote alleviating measures	Taipower will control and reduce GHG emissions from its operations. This will entail the development of renewable energy, investment in carbon-reduction technologies, the establishment of power service models that are lower in carbon generation and the adoption of other management approaches such as conducting inventories, assessing and setting science-based reduction objectives, improving building energy efficiency and so forth. Through a multi-pronged approach, Taipower will achieve its goal of reducing carbon emissions.
	Improve adaptive capacity	The company will strengthen the resilience of existing power facilities against extreme climates so as to reduce the impact of natural disasters and changes in energy demand.
Safeguard environment quality	Manage air pollutant discharge	Taipower will continue to reduce its discharge of air pollutants and establish composite management capabilities for assessment, prediction and dispatch.
	Improve water conservation and material control	Taipower will reduce its water use footprint for power generation and carry out assessments to plan for more efficient use of water and means of recycling to create a positive environmental influence while continuing to manage and reduce the environmental impact of backend radioactive wastes.
Focus on circular innovation	Establish circular business models	Taipower will assess and establish relevant planning for circular value creation and thereby make the circular economy a new direction for Taipower to engage in future business collaborations.
	Improve resource usage efficiency	By evaluating opportunities for re-using wastes generated by Taipower, the company strives to improve its recycling and reuse ratios, reduce resource requirements for operations and extend equipment/resource lifecycles in order to achieve the objective of improving resource usage efficiency.

Strategic aspects	Strategic dimensions	Practical implications
Improve management systems	Integrate environmental management systems	Taipower shall integrate the existing environmental management systems that are present at all power facilities in order to achieve systematic control over the company's overall environmental input and output.
	Develop intelligent management	Through digitization and smart technologies (including smart grids, smart meters, IoT and so forth), Taipower will boost its capacity for environmental management and monitoring and improve productivity to minimize the impact of its operations on the environment.
Foster ecological harmony	Manage biodiversity	Taipower will perform inventories on the ecologies in close proximity to its power facilities and invest in relevant ecological preservation projects.
	Plan for symbiosis between facilities and ecologies	Taipower will introduce specific design methodologies to facilitate symbiosis between facilities and ecologies in order to promote a harmonious co-existence between power facilities and the environment.
Expand engagement	Deliver environmental information from the perspective of the power industry	Taipower will continue to communicate with internal and external stakeholders (including the general public, students and suppliers) to deliver knowledge on relevant environmental issues that the power industry faces and improve the general public's awareness of Taipower's green actions.
	Lead in energy transition	Taipower will continue to lead, promote advocacy and action on the low-carbon transition to accelerate the development of low-carbon energy in Taiwan.

In order to achieve the tasks that have been laid out within the six strategic aspects, Taipower has taken into consideration the degree of relevance and materiality of specific strategic dimensions for its Power Generation, Nuclear Power, Transmission, Distribution and Service Divisions along with its Construction Systems. This allows specific strategic dimensions to be assigned to the relevant corresponding division or system. The divisions and systems will in turn develop their own short, medium and long-term goals and action plans in accordance with their duties and responsibilities.

3.3 Short, Medium and Long-term Strategic Goals

3.3.1 Key environmental goals

The key environmental goals that correspond to Taipower’s six major environmental strategic aspects are described in detail in the following table:

Table 6. Six major environmental strategic aspects and key environmental goals

Strategic aspect	Key Strategic dimension	Short-term goal (2021)	Mid-term goal (2025)	Long-term goal (2030)
Response to climate change	Promote alleviating measures	Reduce thermal unit GHG emission intensity by 7% compared to that of 2016	Reduce thermal unit GHG emission intensity by 15% compared to that of 2016	Reduce thermal unit GHG emission intensity by 20% compared to that of 2016
Safeguard environmental quality	Manage air pollutant discharge	Reduce air pollutant emission intensity by 30% compared to that of 2016	Reduce air pollutant emission intensity by 40% compared to that of 2016	Reduce air pollutant emission intensity by 50% compared to that of 2016
Focus on circular innovation	Establish circular business models	Inventory material with circular potential and develop pilot programs for viable commercial models	Create “circular resource supply model”	Complete the construction of a circular economy
Improve management systems	Develop intelligent management	Increase smart management and service coverage rate to 52% (including the installation of smart meters for up to 1.5 million households to achieve monitoring of 69% of the nation’s total power consumption)	Increase smart management and service coverage rate to 65% (including the installation of smart meters for up to 3 million households to achieve monitoring of 81% of the nation’s total power consumption)	Increase smart management and service coverage rate to 82% (including the installation of smart meters for up to 6 million households to achieve monitoring of 85% of the nation’s total power consumption)
Foster ecological harmony	Plan for symbiosis between facilities and ecologies	Formulate 1 or more plans for ecological symbiosis at one power facility	Formulate 3 or more plans for ecological symbiosis at one power facility	Formulate 5 or more plans for ecological symbiosis at one power facility
Expand	Deliver	Communicate	Communicate	Communicate

engagement	environmental information from the perspective of the power industry	environmental protection information for the power industry to up to 480,000 individuals on a yearly basis	environmental protection information for the power industry to up to 700,000 individuals on a yearly basis	environmental protection information for the power industry to up to 750,000 individuals on a yearly basis
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3.3.2 Direction of promotion

I. Response to climate change

(i) Promotion of alleviating measures

Through the renewal and modification of large thermal units, Taipower will focus on improving its generation efficiency, developing renewable energy (including hydro, wind power in inland and offshore areas, solar power generation, geothermal generation and the construction of related energy storage systems), investing in the study of carbon reduction technologies (such as carbon capture and storage technologies and construction of carbon-reduction technology parks featuring demonstrations of relevant experimental equipment), constructing power service models that generate even less carbon (*i.e.* by promoting demand-based response solutions for enterprises and users, developing ESCO energy service technical services and power-saving diagnostics and demonstration service centers) along with other management approaches such as making inventories, assessing and setting science-based reduction objectives, improving building energy efficiency and so forth. Through a multi-pronged approach, Taipower will achieve its goal of reducing carbon emissions.

(ii) Improving adaptive capacity

Taipower will perform comprehensive climate and potential disaster impact analysis for its power generation, transmission and supply, distribution and service systems. This will allow the individual systems to carry out their own inventories and assessments of climate change risks and determine if they could be subject to climate impacts that are beyond their capacities to withstand. They will also be able to develop relevant plans for adaptations, such as climate impact monitoring and analysis for electric towers, to enhance the resilience of all the company's power facilities.

II. Mitigating the impact of pollution

(i) Managing air pollutant discharge

The company will establish specific eco-friendly power distribution principles (*i.e.* during periods of poor air quality, and provided there will be no negative impacts on the power supply, generation from coal-fired units can be reduced and LNG unit generation can be prioritized to lower the environmental burden) and purchase air pollution prevention devices for the renewal and modification of equipment to reduce air pollution through a multi-pronged approach.

(ii) Improving water conservation and material control

On one hand, Taipower will renew and expand its combined cycle fuel units and adopt improved zero-effluent discharge planning for newly constructed units to effectively increase the waste water recycling rate and reduce the volume of effluent generated. The company will also pursue improvements to existing units to achieve the goal of improving the concentration of pollutants in effluents. As for material controls, Taipower will learn from the industry case benchmark's – such as decommissioned nuclear plants in other countries (*i.e.* Zion Nuclear Power Station in the U.S and Zorita Nuclear Power Station in Spain) and ensure due implementation of relevant plans for the decommissioning of the First Nuclear Power Plant. This will allow Taipower to achieve effective storage and management of radio-active wastes.

III. Focus on circular innovation

(i) Establish circular business models

Through the recycling, auctioning or development of alternative uses for inorganic materials such as fly ash/bottom ash, cement power poles, ceramics and solid putty, Taipower will strive to expand its circular economic model. The company will also work to extend product lifecycles and test the lease/rental model for equipment in place of purchase.

(ii) Improve resource usage efficiency

The company will develop new ways to reuse all of the by-products generated from the process of power generation. Examples include the development of operating manuals for the use of coal fly ash-based materials in maritime engineering projects, the promotion of coal fly

ash-based materials in maritime engineering and the development of products such as artificial aggregate made from coal fly ash controlled-low-strength-materials (CLSM). This will include the use of wastes as part of new raw materials to increase the waste re-use rate. Other key materials that can be re-used include gypsum, power cable spools and prestressed power poles. In addition, Taipower will also attempt to improve its overall energy resource use efficiency through the purchases of ultra-supercritical pressure units and combined fuel cycle units while routinely carrying out major unit overhauls and maintenance in order to maintain optimum unit performance and increase generation efficiency.

IV. Improve management systems

(i) Integrate environmental management systems

Taipower will gradually adopt and gain ISO management certification for all power plants, construction and engineering units and offices. The company will also introduce the latest ISO 50001 energy management system certification at all thermal plants.

(ii) Develop intelligent management

By taking into account the specific characteristics of business operations, Taipower will provide a specific definition of “intelligent management” for each of the four major business units and the construction system. For example, the Power Generation Division’s definition will entail the adoption and construction of digital surveillance and AI systems at facilities. The Power Distribution and Service Division’s task will involve the deployment of smart meters. The Transmission System Division will engage in the construction of smart grids while the construction/engineering system will construct digital monitoring and surveillance systems at construction sites. These actions will facilitate the development of intelligent management throughout the entire company.

V. Foster ecological harmony

(i) Manage biodiversity

Taipower shall collect relevant data through environmental assessment and monitoring of areas in close proximity to power facilities while conducting relevant investigations and compiling geographical information. Through the use of GIS analysis, the data will allow the

company to learn about species distribution at sites near power plants and may serve as a reference for preservation studies and management plans. For instance, Taipower will conduct studies on the groups and clusters of disputed species in peripheral sites near power plants as the basis for the company's measures of ecological preservation. These measures will be undertaken in a spirit of "serving living organisms" to maintain and promote biodiversity at peripheral sites near power facilities.

(ii) Plan for establishing symbiosis between facilities and ecologies

Taipower will promote the effective integration of power facilities and their surrounding ecological environments and endeavor to push for the planning of ecologically-friendliness at all existing generation facilities across Taiwan. With "minimum destruction and maintaining original landforms and species" as a guiding principle, Taipower will commit to creating power facilities that co-exist in harmony with local ecologies. For example, the company will work on forested areas and native tree species in order to create ideal habitats for native bird and insects species at appropriate locations within the premises of the First and Second Nuclear Power Plants.

VI. Expand engagement

(i) Deliver environmental information from the perspective of the power industry

Through activities such as visits to facilities, environmental education and training, promotional events and online video content coupled with other advocacy efforts such as the Green Grid, White Paper on the Environment, multimedia website, green exhibitions and so forth, Taipower will strive to deliver relevant information to and educate the general public on various environmental issues from the perspective of the power industry. This will help the public to gain a better understanding of the issues at hand and Taipower's responses.

(ii) Leading the cause in energy transition

By hosting and participating in international exchange events in the energy sector, publishing green energy industry related papers and strengthening low-carbon technology exchanges and connections with

collaborating partners, Taipower will promote the sharing of information related to energy transition and the mechanisms of dissemination while presenting the company's plans and progress.

3.4 Mechanisms of management and evaluation for environmental sustainability

In order to ensure effective control over the implementation of environmental policy, Taipower has designed comprehensive mechanisms of management and assessment. These function through the implementation of routine assessment and evaluation of outcomes for different departments. The corresponding benefits from implementation are analyzed, initiating discussions on how improvements can be made to ensure green actions are moving the company towards achieving its environmental goals. In addition, based on the progress made, Taipower will issue public statements at intervals of 3-5 years. These statements will present the status of target accomplishments so that the general public will be kept up to date on the progress that Taipower has made in the domain of environmental sustainability.

The overall performance evaluation and management mechanism for Taipower and its various divisions and systems is comprised of two tiers. The first tier is applied at the unit level whereby all relevant units will conduct internal reviews at the end of the Q2 each year in order to propose suggestions on improvements and relevant actions to be taken based on the progress and status of implementation achieved. The second tier is applied at the group level and management will conduct a company-level evaluation at the end of each year to examine the progress of the company's overall implementation and promotion of its environmental policy. Should the review of progress be found to fall below expectations or behind schedule, the responsible units will propose suggestions for rectification (*i.e.* adjusting the targets, contents or participants in action plans) based on the actual progress and status of implementation achieved.

IV. Green Reality

4.1 Green Power

Low-carbon energy transition and supplying Taiwan with stable green power have always been goals that Taipower has endeavored to achieve. The company has adopted a down-to-earth approach to the construction of renewable energy facilities. The existing plans for inland and offshore wind, solar and geothermal power are summarized in Figure 7.

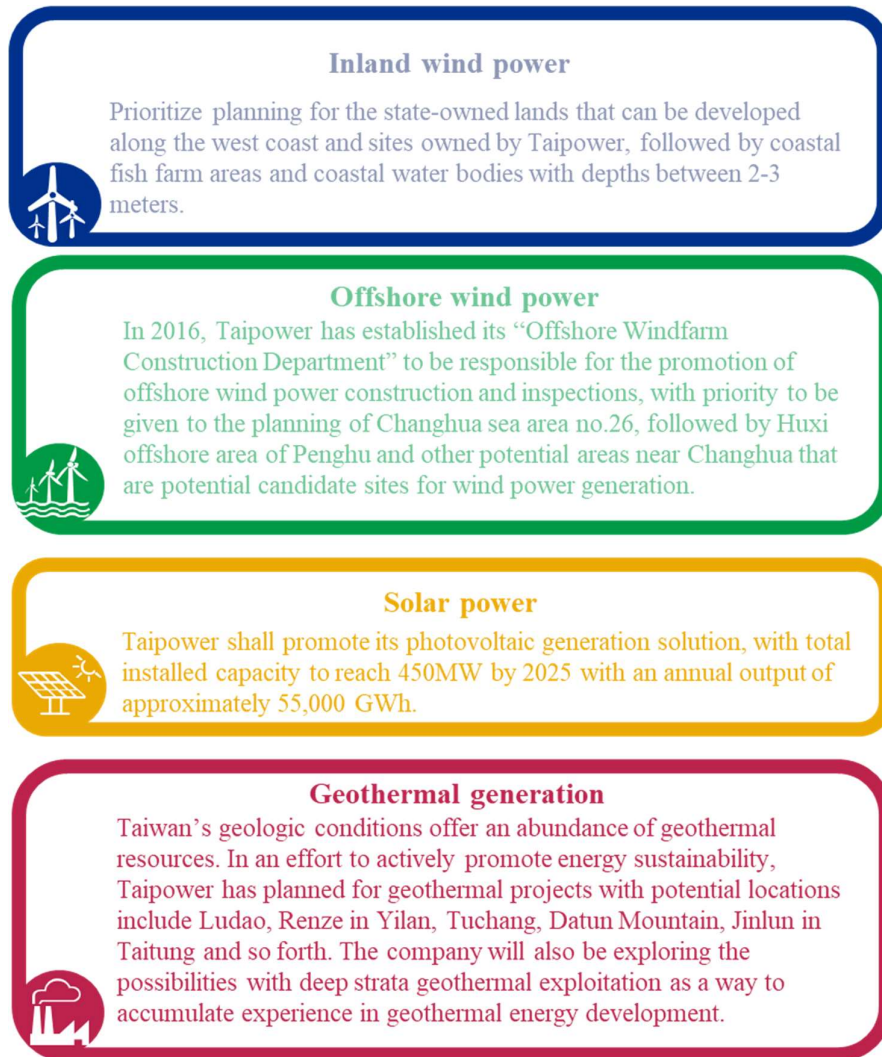


Figure 7. Taipower’ s plan for renewable energy development

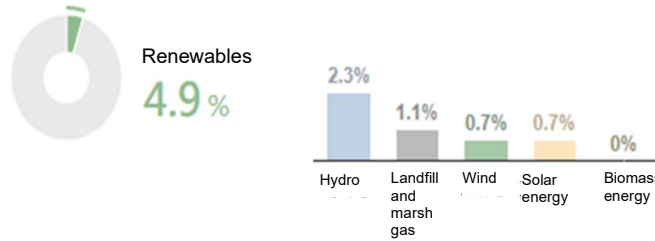


Figure 8. Proportional breakdown of the types of renewable energy purchased in 2017

Renewable energy constituted 4.9% of Taipower’s total purchased power in 2017 and the company will continue to work towards achieving an installed renewable energy capacity of 4,405MW by 2030. Relevant information on the status of renewable energy developments and prospects has been made available and fully disclosed on Taipower’s website. Simply scan the QR code below to learn more.



Taipower’s information disclosure area — Overview of renewable energy development

4.2 Green facilities and ecologies

Taipower has transcended its traditional role and function by seeking to develop and operate power plants that can co-exist in symbiosis and harmony with natural ecologies. In doing so, the company has effectively transformed itself from a consumer of natural resources into a creator of natural capital. Taipower has built upon the concept of the 3Rs (reduce, reuse and recycle) by incorporating elements of circular economies to create an expanded framework of 7Rs (Reduce, Reuse, Recycle, energy Recovery, Repair, Re-design and Re-think). The company will use these 7Rs as a guideline in the construction of ecological power plants so that they are no longer facilities that consume resources to generate power, but instead are production facilities that generate ecological value. This approach will help to shape Taipower into a world-class power utility group that can take pride in its ability to co-exist harmoniously with the environment.

Taipower has already achieved moderate success in its promotion of ecological power plants that seamlessly integrate environmental education and restoration. Through continual monitoring and recording, these ecological power plants have become vital sources of valuable ecological monitoring data.

Examples of such facilities include the Wanda Ecological Power Plant (which has received accreditation as an Environmental Education Field) and the Linkou Power Plant Aquafarm where circular economy concepts have been adopted.

I. Circular symbiosis with land ecologies – Wanda Ecological Power Plant

Back in 2003, while conducting an environmental impact assessment for the Songlin Branch of the Wanda Power Plant, Taipower inadvertently discovered a unique species of soybean in the lush mountains surrounding the site. The species was confirmed as endemic to Taiwan by experts. Moreover, the species had not been sighted for almost 50 years in Nantou. The company promptly committed resources to the rehabilitation of the area. Following 8 years of monitoring and testing and another 3 years of rehabilitation, the company finally succeeded in re-growing the soybean. The feat is comparable to the rehabilitation of the Formosan landlocked salmon in the Chichiawan stream and became the first crucial step in the transformation of the Wanda power station into an ecological power plant.

After continuous efforts to achieve breakthroughs in terms of ecological preservation, Taipower established the Wanda Power Station Environmental Education Center in June of 2015. The center was created to provide a source of knowledge and information about the area's surrounding ecological resources, hydro power generation and the results of the rehabilitation that Taipower had committed itself to. In addition, Taipower collaborated with the Wanda Branch of Qinai Elementary school to train students at the environmental education center as a way of introducing them to the world of natural ecology and power generation in the hopes of fostering greater awareness and appreciation of environmental protection in future generations. In 2017, the facility received certification from the Environmental Protection Bureau and became an officially accredited site for environmental education. In the foreseeable future, the center will continue to serve as a prime example of the creation of natural capital as more resources from multiple parties will be integrated through the center to further strengthen its functionality as an educational site for power generation and environmental protection.



Figure 9. Overview of the environmental education resources available at the Wanda Ecological Power Plant

II. Symbiosis with ocean ecologies – Aquafarms

In adopting the concepts of circular economy and eco-friendliness, Taipower initiated an “aquafarm” project at power plants situated in coastal areas. The project uses the flue gases from facilities for algae cultivation. The algae are subsequently used for the purpose of carbon fixation. The cultivated algae, along with warm water discharge (including the desulfurized sea water produced by desulfurization systems) from power plants, was also utilized for experimental fry farming. This not only gives new circular value to the by-products of the generation process at the facilities but also facilitates the greening of the local ecologies, thereby turning the participating power stations into ecological plants that can co-exist with the environment in harmony.

The construction of the aquafarm at the Linkou Power Plant has already commenced and a designated taskforce has been established to prepare required hardware and infrastructure such as a net cage for the warm water discharge channel, a control field for farming and so forth. In addition, Taipower has been working with the National Taiwan Ocean University in implementing the first phase of cage culture at the aquafarm by utilizing the higher temperatures from the warm water discharge channel to help cultures survive through winter, periods of low temperature and other hazards from cold weather while maintaining their rate of growth. As the Linkou power plant is equipped with a photosynthetic algae reactor

which is capable of capturing carbon dioxide derived from the process of algae cultivation using flue gas, thereby achieving the goal of carbon reduction. Moreover, the algae that has been cultivated through carbon fixation has been made into fish food that is used to raise the fish that are kept in the net cage. This creates a unique circular economy that is exclusive to the power plant. As of the end of October 2018, records on the impact of warm water discharge from the power plant on the ecologies of fish, oysters and large algae cultures are summarized in the table below:

Table 7. Outcome of the ecological experiment conducted at the Linkou Power Plant Aquafarm in 2018

Species	Outcome of the aquafarm experiment
Milkfish	Milkfish were originally selected as “workers” responsible for removing algae that had grown on nets at the aquafarm. However, the experiment conducted in 2018 found that milkfish had adapted well to the environment of the net cage with its warm water discharge. The fish had remained fairly energetic even when the water temperature reached 39 degrees Celsius in the summer season. This made the fish ideal candidates as the species of choice for the warm discharge water of the fish farm in a tropical region. Hopefully, through the use of warm water discharge from power plants, Taipower will be able to mitigate the losses of milkfish suffered by fish farm operators in southern Taiwan during cold winters.
Brindle bass	The brindle bass that were raised in the net cage connected to the warm discharge water channel grew twice as fast as those in the control area (<i>i.e.</i> at brindle bass farms). This is largely due to the relatively warmer environment found at the aquafarm in winter and spring when temperatures are relatively lower in the sea. Taipower also conducted tests for heavy metals (<i>i.e.</i> methyl mercury, lead, cadmium and so forth) on the brindle bass that were raised in the aquafarm and found the samples to comply with food, safety and sanitation standards for aquatic animals.
Algae and oysters	By using the flue gas from the power plant for the cultivation of algae, Taipower not only effectively recycles gaseous waste but also reduces the volume of GHG emitted. While the outcomes were effective and desirable in terms of GHG reduction, the algae and oysters that were cultivated in the net cage with warm water discharged had trouble adapting to the environment. Taipower will be re-assessing the feasibility of this solution in the near future.

In the future, Taipower will continue to carry out experimental farming and the cultivation of marine organisms. The company will also continue to promote the practice at more power plants so that facilities in coastal areas can create more value within a circular economy. This will enable Taipower to fulfill its corporate responsibilities in the domains of economy and environment.

While a number of facilities have already achieved successful implementation, including the Wanda, Dajia River, Linkou, Datan and Taichung Power Plants, Taipower will continue to push for more facilities to incorporate the concepts of ecological-friendliness and circular economics to facilitate harmonious co-existence between power plants and the natural environment. With the “One Plant-One Feature” framework, Taipower hopes to create a series of sustainable ecological power plants.

Table 8. Ecological power plants planned for the future

Location	Ecological highlight
Zhuolan	A butterfly and firefly ecology rehabilitation experiment
Gaopin	A butterfly ecology rehabilitation experiment
Xiehe	A <i>Lycoris aurea</i> ecology rehabilitation experiment
Linkou	An aquafarm with algae and microalgae cultivation experiments
Taichung	A carbon-reduction technology park (carbon capture and reuse, plant factory, pollutant effusion control and integrated renewable energy testing)
Nanbu	A microalgae cultivation
Jianshan	An ecological pond with Chinese water chestnut cultivation and a warm water discharge farming experiment
Xingda	<ul style="list-style-type: none"> ● Planning for a 41.25-hectare salt flat wetland preservation area ● Yongan Salt Field Office historical site preservation
Dalin	<ul style="list-style-type: none"> ● An ecological pond ● An ecological tree (renewable energy and botanical display)

4.3 Air pollution prevention

In recent years, smog has become an issue of concern for the general public and as such, Taipower has adopted various plans and management approaches to achieve active control over air pollution by reducing the load of thermal power during periods of poor air quality. Taipower’s handling and control of sulfur oxide (SO_x), nitrogen oxide (NO_x) and particulate matter (PM) has been achieved by implementing careful monitoring and restriction of air pollutant emissions at all relevant power plants. Apart from choosing fuels with low ash, low sulfur and low nitrogen content (source control) and prioritizing the use of clean energy (such as LNG), Taipower has also installed continuous emission monitoring devices in the flues of thermal power plants in order to

achieve accurate monitoring of pollutant concentrations in flue gas and to keep all equipment running at optimal efficiency so as to reduce the emission of pollutants through flue gas to the minimum.

In 2015, Taipower launched specific measures to reduce power generation loads at power stations as a way to reduce emissions. Provided power supply was not affected, Taipower began to lower loads for coal-fired units and prioritize the deployment of gas-fired units to lessen the environmental burden during periods of poor air quality. By 2017, Taipower had improved upon the practice and expanded the scale of its implementation in conjunction with the Environmental Protection Agency’s policy of implementing output reductions at different levels. Currently, when air quality forecasts reach red alert (unhealthy) levels, Taipower reduces output in the area of concern pre-emptively between 24:00-07:00 hours. In addition, should 1/3 of the real-time air monitoring stations predict a red alert on any given day, Taipower activates automatic output reduction. The principles of tiered load reduction are shown in Table 9 below.

Table 9. Tiered load reduction principles

Load reducing action	Criterion	Action plan
Eco-friendly load reduction	The Taiwan Air Quality Monitoring Network (managed by the EPA) publishes forecasts of the air quality index (AQI) for the following day at 4:30PM daily. Eco-friendly load reduction will be initiated when the AQI reaches a red alert level (AQI>150).	After assessment and determining that power supply will not be compromised, Taipower will arrange for coal-fired power plants in the affected and windward area to reduce output in advance during the off-peak periods such as at night time (i.e. between 24:00-07:00 hours).
Automatic load reduction	When real-time data captured by 1/3 of the air monitoring stations in any given area reaches red alert (unhealthy) levels as shown on the Taiwan Air Quality Monitoring Network.	After assessment and determining that power supply will not be compromised, Taipower will arrange for coal-fired or fuel-fired power plants in the affected area to reduce output.
Mandatory load reduction	When air quality reaches unhealthy or worse levels (AQI> 200, 300, 400).	Pursuant to the Emergency Control Measures for the Prevention of Air Quality Deterioration, all power plants shall reduce their allotted daily emission allowance by 10%, 20% or 40%.

In addition to the practice of load reduction at thermal power plants as a means of reducing air pollution, Taipower will also be actively involved in the renewal of its facilities and the acquisition and installation of air pollution prevention devices. Table 10 below is a summary of the air pollution prevention improvement measures that have been planned and adopted by Taipower and their anticipated outcomes.

Table 10. Air pollution prevention improvement measure at different power plants and their results

Power plant	Improvement measure	Duration	Results
Xiehe Power Plant	Switching to fuel with a lower sulfur content (lower than 0.3%)	Between 2018 to 2024	Reduction of SO _x by approximately 2,000 tons/year
Linkou Power Plant	Unit renewal and overhaul	Between 2016 to 2019	Comparison of hourly emission standards before and after improvement: <ul style="list-style-type: none"> ■ PM (mg/Nm³): reduced from 36 to 20 ■ SO_x (ppm): reduced from 200 to 30 ■ NO_x (ppm): reduced from 300 to 30
Datan Power Plant	<ul style="list-style-type: none"> ● Modification by introducing new low NO_x burners (LNB) for generators #1-#6 ● Installation of selective catalytic reduction (SCR) equipment on generators #3-#6 	Between 2018 to 2022	Reduction of NO _x by approximately 2,401 tons/year
Tongxiao Power Plant	Unit renewal and overhaul	Between 2018 to 2020	Comparison of hourly emission standards before and after improvement: NO _x (ppm): reduced from 40 to 18
Taichung Power Plant	<ul style="list-style-type: none"> ● Improvement of existing air pollution prevention equipment for generators #1-#4 ● Improvement of existing air pollution prevention equipment for generators #5-#10 (by Executive Yuan) ● Construction of 2 indoor coal storage units 	<ul style="list-style-type: none"> ● Improvement of generators #1-#4 shall be carried out between 2017 to 2019 ● Improvement of generators #5-#8 shall be carried out between 2018 to 2022 	<ul style="list-style-type: none"> ● After the improvements on generators #1-#4, the facility will be able to reduce PM emission by approximately 61 tons/year, SO_x by approximately 503 tons/year and NO_x by approximately 2,154 tons/year ● After the improvements on generators #5-#10, the facility will be able to

Power plant	Improvement measure	Duration	Results
		during scheduled overhauls ● Improvement of air pollution control for generators #5-#10 shall be carried out between 2022 to 2025 ● The indoor coal storage units will be inaugurated in 2021 and 2024 respectively	reduce PM emission by approximately 325 tons/year, SOx by approximately 6,615 tons/year and NOx by approximately 8,165 tons/year ● The two indoor coal storage units will reduce PM emission by approximately 12 tons/year
Xinda Power Plant	Increase the number of SRC catalytic layers from 2 to 3 on generators #1 and #2	Between 2017 to 2018	Reduction of NOx by approximately 281 tons/year
Nanbu Power Plant	Modification by introducing new low NOx burners (LNB) for generators #1-#4	Between 2016 to 2019	Reduction of NOx by approximately 360 tons/year
Dalin Power Plant	● Generator #1 and #2 Overhaul Projects ● Combustion calibration for generator #5 and introduction of a new low NOx burner (LNB) for generator #6	● Improvement of generators #1-#2 shall be carried out between 2018 to 2019 ● Improvement of generators #5-#6 shall be carried out between 2018 to 2019	● Comparison of hourly emission standards for generators #1-#2 before and after improvement: ■ PM (mg/Nm ³): reduced from 43 to 20 ■ SOx (ppm): reduced from 160 to 30 ■ NOx (ppm): reduced from 140 to 30 ● Reduction of NOx by approximately 719 tons/year after the improvements on generators #5-#6

Table 11 is a comparison of Taipower's actual performance on major air pollutant control and legal requirements. The table reflects the fact that while relevant regulations have become more stringent, Taipower has endeavored to maintain its substantial lead in performance when compared to the legal requirements.

Table 11. Comparison between Taipower’s actual performance on major air pollutant controls and the legal requirements

Year	Particulate Pollutants (Kg/GWh)		Sulfur Oxide (Kg/GWh)		Nitrogen Oxide (Kg/GWh)	
	Actual value	Legal requirement	Actual value	Legal requirement	Actual value	Legal requirement
2007	31	172	493	1,156	446	617
2008	33	175	443	1,119	423	579
2009	27	168	388	989	413	522
2010	33	187	342	977	354	473
2011	27	183	356	940	364	489
2012	28	177	328	892	327	472
2013	27	181	302	862	327	444
2014	27	145	305	842	312	442
2015	26	96	315	652	307	410
2016	22	67	306	587	308	416
2017	21	52	296	552	270	416
2018	20	46	182	368	213	329

Notes:

- The values for legal requirements were derived from specific emission standards for each power plant multiplied by each unit’s flue gas emissions and capacity factor to determine the emission of pollutants, which was then divided by the power generated by the unit to derive the emission intensity of pollutants.
- The actual emission values were derived from specific emission concentrations for each power plant multiplied by each unit’s flue gas emissions and capacity factor to determine the emission of pollutants, which was then divided by the power generated by the unit to derive the emission intensity of pollutants.

V. Co-creating New Opportunities

Taipower’s Environmental Policy and strategic goals are symbols of the profound sentiment the Taipower community feels for its land. It also represents our sincere desire to create the best possible environment for future generations. By achieving the short, medium and long-term goals that we have formulated from the 12 environmental strategic dimensions, we will strive to create power facilities that are environmentally friendly, climate resilient at capable of creating a low-carbon environment for power generation. Taipower will work systematically and holistically towards its goal of becoming one of the world’s best power utility groups –one that champions the cause of sustainability as it

brings unites its green partners in commitment to the cause. This will allow us to become reliable protectors of the environment on our island home.