6 Agent of Environmental Friendliness

The Implication of Agent of Environmental Friendliness

The operation of a business is bound to have an impact on the environment. As an energy enterprise, Taipower must face the challenge of maximizing positive impacts while minimizing negative impacts. As the economy develops, Taipower must continue to pursue cleaner energy and low-carbon transformation. Taipower will work with society and enterprises to seek more energy-efficient operating methods as it pursues carbon value and environmental sustainability.

Major Investments

- In 2020, the establishment of an index system for promoting the ranking of ecological fields was completed; Linkou and Dalin Power Plants established a new version of the energy management system.
- The environmental protection capital expenditure in 2020 was approximately NT$4.75 billion, of which nearly 90% came from equipment capital investment in renewable energy. The environmental protection recurring expenses were about NT$3.63 billion, of which NT$950 million were related to air pollution prevention and control.
- In 2020, Taipower commissioned the Fisheries Agency to handle fish fry releases with an expenditure of NT$3.5 million.

Performance Highlights

- The wastewater-reclamation ratio at thermal power plants exceeded the original target of 73% and reached **79%** in 2020. The net carbon emissions of thermal units decreased by **6.52%** compared to the target base year (2016) of the Environmental White Paper.
- In 2020, coal ash production was 2.209 million tons with a reuse rate of **89.7%**. The desulfurized gypsum ($CaSO_4 \cdot 2H2O$) production was 29.6 tons with a reuse rate of **98.6%**.
- SF_6 gas was reclaimed in 2020, reducing the total amount of CO_2e by approximately **1.09 million tons**.
- The climate risk assessment of each generation, transmission and distribution unit was completed. **Three major system demonstration sites** (Taichung Power Plant, the Operation Office of Taipei Power Supply Area, and Kaohsiung District Sales Office) were constructed.
- The project planning for the **Linkou Marine Ranch** was completed along with conservation work for life below water and one marine ranch research plan.
- **The inspection plan for ecological integration at power facilities** was completed. The plan put forward specific visions for ecological restoration and environmental maintenance in the areas around power facilities.

Future Plans

To meet the 2025 commitment outlined in the Environmental White Paper, Taipower will continuously strive to reduce the environmental impact of various power facilities while enhancing the efficiency of utilizing various energy resources. In response to air quality and climate issues, Taipower has adjusted its energy structure, increased the use of gas and renewable energy, and improved pollution prevention equipment and other measures, which enabled the Company to reach the target of halving air pollution by 2030 ahead of schedule in 2019. At the 2020 Environment Month conference, Taipower revised the emission reduction target and raised the commitment target by more than 60% for 2025 and 70% for 2030 compared to 2016. In addition to achieving these targets ahead of schedule, Taipower also voluntarily set more stringent objectives and is actively fulfilling its environmentally friendly promises.

6.1 Strengthening Environmental Management

6.1.1 Environmental Policy and Goals

The operation of the electric power industry must take into account energy quality, energy safety, and environmental sustainability. Taipower adheres to the corporate mission of supplying stable electricity for the diversified development of society in an environmentally friendly and reasonable-cost manner and the corporate vision of transforming into a prestigious, trustworthy world-class power utility group. The Company is actively responding to the major environmental issues and development trends faced by the energy industry. For example, in response to the United Nations Sustainable Development Goals (SDGs) and the international vision for achieving a carbon-neutral transformation by 2050, Taipower has planned an environmentally long-range development path. Taipower's Chairman of the Board personally signed Taipower's environmental policy in April 2019 and publicly disclosed it, demonstrating Taipower's green commitment for future generations.

Through the six major strategic aspects and the corresponding development of 12 strategic dimensions, Taipower's Environmental White Paper serves as the basis for the follow-up promotion of sustainable environmental management. Through development goals and action plans, Taipower integrates its business divisions to achieve the benefits of "one integration" (internal and external), "two reductions" (carbon reduction and emission reduction), and "three transformations" (intellectualization, ecological, and circularization). Through a multi-pronged approach, Taipower will create environmentally friendly power facilities, a comprehensive model of green environmental protection, a sustainable and inclusive power generation, transmission, distribution, and sales enterprise system.

Taipower's Environmental Policy

Taipower's Environmental White Paper

Six Strategic Objectives and Achievements of the Environmental White Paper

Strategy	Key strategic dimension	Achievements in 2020	Target values for 2025
Respond to climate change	**Promote mitigation procedures**	Net emission intensity of thermal power units (greenhouse gas) has been reduced by 6.52% as compared to 2016	Net emission intensity of thermal power units will be reduced by 15% as compared to 2016
Protect environmental quality	**Manage air pollution emissions**	Achieved the 2025 target value ahead of schedule: Air pollution emission intensity was reduced by 60% compared to the Environmental White Paper base year (2016)	Air pollution emission intensity will be reduced by 60% compared to 2016
Focus on circular innovation	**Establish a circular business model**	Completed the compilation of a coal ash marine engineering manual	Implement a circular resource supply model
Refine management systems	**Develop intelligent management**	Intelligent management and service coverage reached 46% (including the deployment of smart meters in one million households representing 69% of the total national total power consumption)	Intelligent management and service coverage will reach 65% (including the cumulative deployment of smart meters in three million households, representing 81% of the total national total power consumption)
Create ecological inclusiveness	**Plan the fusion of ecology and facilities**	Completed the establishment of an index system for promoting the ranking of ecological fields	Establish at least three ecologically inclusive plans for power facilities
Expand internal and external engagement	**Deliver information on electricity and the environment**	Achieved the 2025 target ahead of schedule: Annual communication of environmental protection information reached 990 thousand people	Annual communication of environmental protection information will reach 700 thousand people

Implementing Environmental Impact Assessments

Improperly managed power facilities can have several potential impacts on local communities. These impacts may include water, air, and soil pollution, noises and vibrations, odors, waste, toxic substance pollution, site subsidence, radiation pollution, and damage to natural resources, landscapes, sociocultural, and economic environments. Taipower is committed to the principle of minimizing these environmental effects and is actively engaged in effective environmental impact management. Through pre-development assessments and communication, public reviews, post-assessment improvements to plans, and a framework for continuous monitoring during construction, the impact of development activities on the environment and the community is minimized. In 2020, Taipower had no violations of environmental laws or regulations. Please refer to QR Code for information on Taipower's achievements with development project and environmental impact assessment implementation.

Environmental Impact Assessments Achievements

6.1.2 Environmental Accounting

In 2008, Taipower implemented an environmental accounting system (EAS) which requires employees to input environmental accounting codes for specific tasks or activities such as purchase requisitions, purchasing, reimbursements, and so forth through their business or accounting systems. All operations are managed and compiled by Taipower's EAS to compute the costs of environmental protection, occupational safety, and health for each unit. Environmental accounting is divided into capital expenditures (depreciation and amortization of fixed assets related to environmental protection) and recurring expenses (reimbursement of environmental protection-related expenses) for the collection of environmental protection-related expenses. Information is also compiled in the environmental accounting management system to make reimbursement more convenient and to accurately evaluate Taipower's investment in environmental protection expenditures. This approach indicates that, in 2020, Taipower's environmental protection capital expenditure was approximately $4.75 billion and its recurring environmental protection expenses were about $3.63 billion.

In 2020, Taipower also made some major improvements to its environmental accounting process. These improvements are as follows:

Alignment with Environmental Protection Management Goals

In accordance with international environmental accounting standards, Taipower connected brought its environmental accounting into alignment with its actual environmental management goals and changed its accounting method so that only environmental expenditures are calculated. The new version of the accounting principles preferentially removes industrial health and safety expenditures and adds renewable energy expenditures. This directly aligns Taipower's EAS with the environment category, thus allowing Taipower to focus on environmental protection issues.

Optimized Accounting Codes

The new accounting method merges and adds codes based on environmental protection categories. The optimized environmental accounting coding method helps employees identify the correct code more intuitively when filling in reports, reducing the chance of false information or omission.

Improved the Calculation Method with a Refined Definition of Cost Units

In the past, environmental protection-related expenses for Taipower's turnkey projects were not included in environmental accounting. As a result, Taipower's efforts in environmental protection could not be fully reflected in its environmental accounting. The new model includes the environmental accounting calculation. Moreover, the cost centers of each unit are divided into environmental and non-environmental cost centers according to the attributes of each unit and department. The new version includes a standard process for staff to attribute the reported expenses to environmental protection-related expenditures when requesting, purchasing, or reimbursing operations, and strengthens the environmental accounting calculation methods.

Reduced Human Input Errors and Regular Debugging

In the past, environmental accounting of labor costs, water and electricity bills was reliant on reporting from each unit on its proportion of environmental-related expenses. There was no standard calculation method, and follow-up tracking was impossible. This became a potential risk. In 2019, the HR expenses, water and electricity bills were linked to environmental protection cost centers. Considering the degree to which the unit's business is related to environmental protection, the accounting information was directly brought into the system for calculation. After the adjustment of statistical principles in environmental accounting, the system's functions were refined. For example, capital expenditures are now applicable to environmental asset code recognition methods, and environmental cost center judgments are automatically assessed by the back-end system to avoid errors caused by human judgment.

In addition, the optimization of statistical principles was also designed and planned for in the periodic output of abnormality reports. The system is set to automatically send a list of abnormalities every half a month to remind employees to make corrections to mistakenly filed, obsolete codes by a set deadline. Through the mechanisms of debugging and auditing, the rates of omission and error are reduced.

6.2 Toward the Goal of Low-Carbon Electricity

In response to the low-carbon transition trend of the global energy industry, Taipower is committed to developing high-efficiency generation technologies, adjusting its generation structure, and continuously increasing the proportion of renewable energy to reduce the electricity carbon emissions factor. Taipower has adopted the following methods to achieve energy transition and move towards low-carbon electricity:

- **Transformation from coal to gas-fired:** Elevate the proportion of gas and continue the trend of primarily gas with coal as support, making the gas ratio higher than that of coal
- **Coal-fired unit upgrades:** Gradually replace coal-fired units with ultra-supercritical units with better generation efficiency
- **Gas-fired unit upgrades:** Gradually phase out old gas-fired combined-cycle units and replace them with new-type combined-cycle gas-fired units with better generation efficiency

In recent years, Taipower has actively engaged in energy transition. Apart from reducing the carbon emission factor of electricity each year, Taipower has continued to achieve its goal of decreasing air pollution and providing cleaner electricity for industries and individuals in Taiwan through the use of cleaner energy.

Taipower's Environmental Policy - Short, Medium, and Long-Term Goals

	Short-term goal (by 2021)	Medium-term goal (by 2025)	Long-term goal (by 2030)
Strategy ／ **Respond to climate change** Key strategic dimension ／ **Promote mitigation procedures**	Net emission intensity of thermal power units (greenhouse gases) will be reduced by **7%** compared to 2016	Net emission intensity of thermal power units (greenhouse gases) will be reduced by **15%** compared to 2016	Net emission intensity of thermal power units (greenhouse gases) will be reduced by **20%** compared to 2016

Thermal Power Generation

Taipower actively manages the power consumption in its plants. The Company sets targets for annual power consumption in plants that do not exceed the average performance of the previous three years. Taipower is also gradually phasing out older units and replacing them with new ones. As it does so, it plans to introduce high-efficiency generating units and to enhance existing units through various operations and maintenance measures. The current gross efficiency of lower heating values (LHV, gross) at thermal plants rose from 45.64% in 2019 to 46% in 2020. Generation efficiency has continued to improve in recent years. Taipower will continue to strengthen its international exchanges and cooperation efforts and introduce related knowledge and technologies in electricity and environmental protection.

The Efficiency (Gross LHV) of Taipower's Thermal Plants from 2018 to 2020

Item	2018	2019	2020
Efficiency (Gross LHV) (%)	44.81	45.64	46.00

Power Consumption in Thermal Power Plants from 2018 to 2020

Item	2018	2019	2020
Plant power consumption (billion kWh)	5.562	5.494	5.569
Plant power consumption rate (%)	3.62%	3.76%	3.65%

Sulfur Hexafluoride (SF_6) Reduction

Sulfur hexafluoride (SF_6) is a greenhouse gas with extremely high global warming potential. After long-term use, the gas gradually escapes into the atmosphere. Nevertheless, as it is an essential insulating material for power equipment it is widely used in Taipower's substation equipment for power generation, transmission, and distribution. In response to this issue, Taipower has continuously promoted reduction methods for more than ten years. Efforts to develop an on-site SF_6 reclaimed emission reduction method, were reviewed and approved by the Environmental Protection Administration in 2020, and are publicly applicable to other electricity enterprises. Taipower units that manage substation equipment have SF_6 maintenance management procedures. Relevant units carry out SF_6 reclamation and purification work as part of procedures for overhauling substation equipment. After the equipment is overhauled, the purified SF_6 will be backfilled to the equipment to reduce greenhouse gas emissions. The industry is also encouraged to recycle SF_6 to mitigate climate change problems and achieve the goals of circular economy and resource regeneration.

Climate Adaptation Strategies and Actions

Taipower's power plants and transmission systems are located in mountains, along coasts, and in river basins. Power infrastructure is spread over complex terrain, making climate change issues more important. Therefore, to cope with these issues, Taipower is actively preparing climate adaptation actions to adjust the constitution of power plants and improve grid resilience. In cooperation with the Ministry of Economic Affairs Bureau of Energy's Climate Change Adaptation Guidance Program of Energy Industry Taipower has conducted risk assessments for strong wind and flooding at 44 units (excluding offshore islands) at power generation (hydro and thermal power) facilities and transmission and distribution systems. The Company has also established a demonstration case for an adaption strategy for power generation and the distribution system. Moreover, Taipower autonomously launched a Kaohsiung District Branch Office Climate Change Adaptation Research Project in 2019, selected power equipment with higher climate risk-tolerance in 2020, and reinforced the protective abilities of hydro and thermal power plants as well as transmission and distribution systems to reduce environmental impacts and strive for sustainable operations.

Furthermore, Taipower subsequently began a parallel expansion of the above mentioned demonstration to each unit in sequence. This has resulted in the establishment of demonstration cases for solar power and land-based wind power risk assessment and initiated a climate change adaptation plan for the generation system. In addition to continuing to cooperate with the Bureau of Energy, Taipower will launch relevant projects simultaneously and independently to enhance Taipower's ability to adapt to climate change.

6.3 Reducing Use of Energy and Resources

6.3.1 Fuel Usage Management

In order to be environmentally friendly, Taipower has chosen to use fuels with low-ash, low-sulfur, and low-nitrogen content. The Company's policy seeks to stabilize the use of coal, and gradually shift to gas. This will help to ensure that coal-fired power plants are able to maintain their operating permits while new and renewed gas-fired units and facilities are constructed, ensuring the power supply is stabilized, energy requirements are met and pollutant levels in fumes generated by thermal power remain lower than legally required levels.

Taipower's Use of Fuels from 2018 to 2020

Item	2018	2019	2020
Gas (million cubic meters)	14,085	13,371	15,075
Coal (million tons)	29.009	27.443	26.937
Fuel oil (thousand kiloliters)	1,601	1,103	758
Nuclear fuel (ten thousand pounds)	164.86	116.41	155.5

Note: The above amounts are actual consumption

To reduce emissions in line with regulatory requirements, power plants need to add environmental protection equipment and facilities. Coal used must be high in calorific value, low in ash, and low in sulfur content. Since the properties of coal vary from mine to mine and country to country, power plants use blending methods to meet a power plant's requirements for coal ash, calorific value, and sulfur. Taipower has added additional quality requirements for its coal procurement. For example, the Company has decided to reduce the ash content of its Indonesian coal from 11% to 8% and sulfur from 1.1% to 0.9%. Further restrictions on mercury content have been imposed. While Taipower exercises strict control of emissions from downstream power plants in its supply chain, the Company works even harder to deliver on its commitments to upstream areas of its supply chain. Please refer to Chapter 2.5 for information on Taipower's management and performance in fuel procurement.

Xinda Power Plant combined-cycle gas-fired units thermo-element upgrades

6.3.2 Enhancing the Energy Efficiency of Taipower's Operations

Management of Productive Resources

Taipower's total thermal greenhouse gas emissions in 2020 were about 92.66 million tons of CO_2e . Its primary sources of greenhouse gas emissions included thermal power generation, coal storage yards, fuel-consuming equipment such as vehicles and engines, insulation gas for power switches, refrigeration and air-conditioning equipment, etc. Although there are no emission restriction or disclosure regulations in Taiwan, the Company's has taken the initiative to limit greenhouse gas emissions by inviting relevant units to conduct inventories and internal verifications each year. Moreover, a third-party notary unit is invited to carry out external verification of thermal greenhouse gas and to publicly disclose that the Scope 1 greenhouse gas emissions of Taipower and its thermal power units (coal, fuel, and gas-fired) are 93.35 million tons.

In 2015, Taipower implemented an energy management system for power plants. Taipower has assisted six units, including the Taichung, Datan, Xingda, Nanbu, Dajia River, and Daguan plants in successfully obtaining new verification certificates. Taipower also completed the establishment of the energy management systems of the Nanbu, Dajia River, and Daguan plants. The system was also established in the Linkou and Dalin plants in 2020. This process is expected to reach completion by 2021 with plants receiving external verification certificates.

Greenhouse Gas Emissions from 2018 to 2020

Unit: 10,000 tons of CO_2e

Year	CO_2	CH_4	N_2O	SF_6	HFC
2018	9,753	25	33	13	2
2019	9,082	25	31	10	2
2020	9,266	23	30	13	3

Emissions of Thermal Power Units from 2018 to 2020

Unit: 10,000 tons of CO_2e

Item	2018	2019	2020
Emissions of coal-fired units	6,340	6,009	5,934
Emissions of oil-fired units	512	352	244
Emissions of gas-fired units	2,889	2,720	3,088

Non-Productive Resource Management

In 2020, Taipower gave impetus to power-saving in conjunction with the Executive Yuan's Electricity Efficiency Management Plan for Government Agencies and Schools by setting a goal of zero growth in annual power consumption compared to the previous year. Moreover, in accordance with the Ministry of Economic Affair's Water Saving Normalization Action Plan, Taipower promotes water conservation. The General Management Office will coordinate these efforts while other branches and power plants will be driven through promotions to implement various measures that constituted a comprehensive energy-saving and carbon-reduction scheme. Taipower will also track its energy consumption (paper, water, power, fuel) on a monthly basis and conduct annual assessments to select units with excellent performance.

Taipower's Non-Productive Power Consumption from 2018 to 2020

Item	2018	2019	2020
Consumption (GWh)	120.7	119.6	118.1

Taipower's Non-Productive Water Consumption from 2018 to 2020

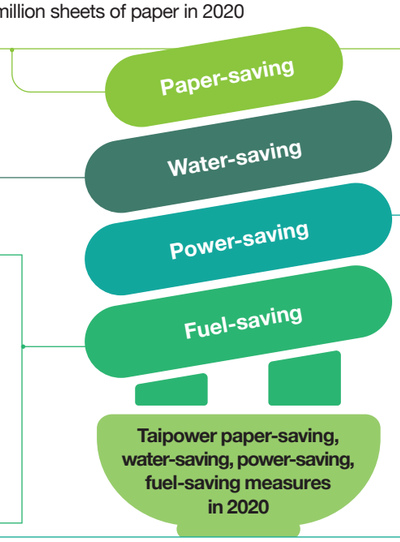
Item	2018	2019	2020
Consumption (Tons)	1,251,845	1,302,211	1,328,077

Results of Non-Productive Resource Management

- In line with the Water Saving Normalization Action Plan, Taipower actively promoted the installation of water-saving equipment in offices, at construction sites, and in employee dormitories. Old water-consuming equipment was replaced and water-saving measures such as water-saving advocacy, water management, pipeline facilities leak inspection, and rainwater reclaim and reuse were strengthened.

- Continued to implement paper-reduction measures such as electronic exchanges of official documents and online approvals, with the performance reaching 70% and 85%, respectively
- Advocated for employee use of double-sided printing to save 2.37 million sheets of paper in 2020

- Promoted ride-sharing measures in vehicle dispatching and reinforced vehicle maintenance and inspection to reduce fuel consumption
- Drew up a budget to accelerate the replacement of old fuel-consuming vehicles and made good use of electric vehicles
- Saved 4,240 liters of fuel in 2020 compared to 2019



- In cooperation with the Electricity Efficiency Management Plan for Government Agencies and Schools, Taipower actively promoted the replacement of old energy-consuming equipment (air conditioners, lamps, etc.) in each unit to enhance electricity efficiency.
- Indoor temperatures were kept between 26-28°C in each office and combined with circulating fans to increase comfort levels while reducing the use of air conditioning
- An energy-saving operation control mode for elevators in each building was adopted and elevator operation was suspended during off-peak hours, off-hours, and holidays
- Operated energy-consuming equipment and business machines in all offices in an energy-saving manner; for example, the power supply for water dispensers was turned off automatically during off-hours and regular holidays to save standby power
- High energy-consuming offices, such as the headquarters building, adopted energy management systems to analyze the building's electricity, equipment operation energy consumption to strengthen energy-saving management results

6.4 Minimizing Environmental Impacts

6.4.1 Response Measures to Air Pollution

The Company has formulated air pollution management strategies for thermal power plants. These include load reductions during periods of poor air quality and sufficient power supply. Taipower also conducted a comprehensive inventory of existing control equipment, planned to set up high-efficiency air pollution control equipment, and continuously improved on air pollution improvement measures for thermal power plants in three stages: short, medium, and long-term. These measures ensure a balance is achieved between power supply and environmental protection. The short, medium, and long-term goals are detailed below. It is particularly worth mentioning that Taipower has achieved its target ahead of schedule in 2020. At the 2020 Environment Month conference, it demonstrated the Company's efforts to improve air pollution by further increasing its commitment and revised the emission reduction target by more than 60% for 2025 and 70% for 2030 compared to 2016.

Taipower's Environmental Policy - Short, Medium, and Long-Term Goals

Strategy / Key strategic dimension		Short-term goal (by 2021)	Medium-term goal (by 2025)	Long-term goal (by 2030)
Protect environmental quality / **Manage air pollution emissions**	Original target	Air pollution emission intensity will be reduced by **30%** compared to 2016	Air pollution emission intensity will be reduced by **40%** compared to 2016	Air pollution emission intensity will be reduced by **50%** compared to 2016
	Revised target in 2020 Environment Month	Air pollution emission intensity will be reduced by **30%** compared to 2016	Air pollution emission intensity will be reduced by **60%** compared to 2016	Air pollution emission intensity will be reduced by **70%** compared to 2016

In recent years, the issue of haze hazard has been of great concern to the public. As such, Taipower has continued to manage air pollution actively through various plans and management methods. Taipower coordinated its implementation of environmental protection dispatching during periods of poor air quality to voluntarily reduce load. For sulfur oxides (SO_x), nitrogen oxides (NO_x), and particulate pollutants (PM), the best available control technologies have been applied. To specifically control the air pollutant emissions generated by the operation of each power plant, Taipower chooses to use low-ash and low-sulfur fuels and is switching to clean energy (natural gas) in its fuel selection (source control). In addition, continuous flue gas emission monitoring instruments are installed in the smoke fontanels of various thermal power plants to accurately assess the concentration of pollutants in the flue gas, enabling equipment efficiency to be maintained in the best state, and minimizing the emission of pollutants in flue gas. Consequently, Taipower's flue gas pollutants are far lower than regulatory standard values.

The Actual and Regulatory Values of Major Air Pollutants from 2016 to 2020 Unit: kg/GWh

	PM		SO_x		NO_x	
	Actual value	Regulatory value	Actual value	Regulatory value	Actual value	Regulatory value
2016	22	77	306	589	308	379
2017	21	70	296	479	270	360
2018	20	67	183	403	213	317
2019	14	61	125	346	158	283
2020	7	60	102	303	137	264

Management of Stationary Emissions

Short-term responses: Coal-fired unit loads are reduced during periods of poor air quality and the dispatching of gas-fired units is prioritized

Since 2015, the Company has demonstrated its environmental concern by voluntarily implementing load reductions and emission controls at coal-fired power plants, while also ensuring the ongoing stability of the power supply system. Since November 2017, Taipower has also adhered to the amended Emergency Prevention Measures for Sever Air Quality Deterioration issued by the Environmental Protection Administration (EPA). When the EPA issues next day air quality forecasts that reach early warning stages, Taipower voluntarily undertakes load reduction early in the morning so that reductions don't impact the delivery of a safe and sound power supply. In addition, on day's that have poor air quality, if more than one-third of air quality zones have deteriorated to the early warning stage, autonomous load reduction and emission reduction measures are evaluated and initiated. Between the implementation of these measures and the end of December 2020, a total of 3,182 load reduction and emission reduction operations had been performed.

Principles of Load Reduction in Response to Air Pollution Grading

Load reduction action	Criteria	Action plan
Voluntary load reduction	The Air Quality Index (AQI) forecast for the following day is published each day at 4:30 PM on the Taiwan EPA's Air Quality Monitoring Network website. Voluntary load reductions are initiated if the AQI forecast reaches the red level early warning or higher (i.e., AQI >150)	Provided there will be no impact on power supply safety, Taipower arranges for coal-fired power plants in the designated zones and upwind areas to implement load reductions during off-peak hours at night (i.e., between midnight and 7:00 AM)
Enhanced voluntary load reduction	When one-third or more of air monitoring stations in various areas have reached red alert early warnings, on the EPA's Air Quality Monitoring Network website, enhanced voluntary load reductions are initiated	If the estimated result will not impact power supply safety, Taipower arranges for coal and oil-fired power plants in the designated areas to implement load reductions
Mandatory load reduction	When the air quality index reaches its worst level (i.e., AQI > 200, 300, or 400), mandatory load reduction occurs	Each power plant reduces emissions as stipulated in the Emergency Response Procedures for Air Quality Deterioration to reduce actual daily emission by 10, 20 or 40%

Load Reductions due to Air Pollution in 2020

All power plants in Taiwan	Frequency of load reduction (times)	Amount of load reduction (MWh)		
		Annual overhaul (maintenance)	Non-annual overhaul (maintenance)	Total
Voluntary load reduction	783	3,308,414	5,302,602	**8,611,016**
Enhanced voluntary load reduction	89	190,885	279,498	**470,383**
Total	**872**	**3,499,299**	**5,582,100**	**9,081,399**

Medium-Term Actions: Adopting End-of-Pipe Reductions and Adhering to Emission Standards for Gas-Fired Generating Units

The Company has carried out a comprehensive inventory of its existing control equipment, and plans to install high-efficiency air pollution control equipment, use overhaul periods to improve the local functions of control equipment, and enhance the removal efficiency of the control equipment as much as possible through operational practices. Meanwhile, Taipower will introduce more advanced and efficient air pollution prevention and control equipment, install equipment in new power plants or renew equipment in existing plants to effectively reduce the emission of air pollutants, and set up continuous automatic monitoring equipment for flue gas emissions. In addition, Taipower's air pollution control improvement plan for particulate pollutants (PM), nitrogen oxides (NO_X), and sulfur oxides (SO_X) are shown in the following table. Taipower will invest a total of $70.229 billion between 2015 and 2024 in these initiatives. The measures are expected to reduce particulate matter by 398 tons/year, sulfur oxides by 7,118 tons/year, and nitrogen oxides by 10,319 tons/year. For more information, please refer to the annual report of the Department of Environmental Protection.

Air Pollution Control and Improvement Plan

Air pollutant	Preventive measure
Particulate matter (PM)	– Install highly efficient electrostatic precipitators (EP) with a dust removal efficiency of 99.8% – Build dust-proof grids around coal yards and configure regular sprinkler systems – Use closed facilities for transportation and unloading of coal, frequently compact coal piles and clean roads – Use chemicals to stabilize the surface of long-term storage coal piles and plant windbreaks around them so that coal dust will not escape
Nitrogen oxides (NO_X)	– Install low NO_X burners (LNB) and selective catalytic reduction (SCR) equipment
Sulfur oxides (SO_X)	– Install flue-gas desulfurization (FGD) equipment to remove more than 95% of sulfur oxide

Long-Term Actions: A Power Source Shift from "Mainly Coal with Supportive Gas" to "Mainly Gas with Supportive Coal"

The proportion of renewable energy has been increased in line with the national energy policy. In addition, the thermal generation structure has been adjusted from "mainly coal with supportive gas" to "mainly gas with supportive coal." In other words, the future power generation fuel structure will be dominated by natural gas. According to the power development plan, all thermal plants, with the exception of the ultra-supercritical coal fired units at Linkou and Dalin, will operate gas-fired units. Still more gas-fired units are being newly added at the Xiehe, Datan, Taichung, and Xingda plants. This measure will ensure both air quality and a stable power supply. After the new gas-fired units at the Taichung and Xingda plants are completed and commercialized, some of the existing coal-fired units will be decommissioned or converted to standby, which will have a positive effect on maintaining ambient air quality.

Monthly and Annual Reports

Management of Mobile Emission Sources

According to Environmental Protection Administration (EPA) analysis, diesel trucks account for the largest proportion of emissions from among the various kinds of mobile pollution sources. This led Taipower to make an inventory of its large diesel vehicles that meet the phase one and phase two environmental protection standards. The Company is also cooperating with the EPA to replace older vehicles. It is estimated that 67 kg of $PM_{2.5}$ emissions will be eliminated for each old large diesel vehicle removed. Meanwhile, large diesel vehicles that meet phase three standards are equipped with smoke filters to reduce pollution. It is expected that this will reduce $PM_{2.5}$ emissions by about 10 kg per year for each phase three diesel vehicle.

Management of Fugitive Emission Sources

The Company's fugitive emission sources include coal yards and construction sites. For construction projects, Taipower announced Promotion and Management Guidelines on Environmentally Friendly Measures for Green Construction Sites of Taiwan Power Company in 2018. The Company's projects will incorporate these guidelines. The appendix to the guidelines, Environmental Protection Construction Regulations of Taiwan Power Company, require contractors to formulate Environmental Protection Management Plans and set up environmental protection management personnel, who should be full-time and have the qualifications of Class B air pollution control or above (one qualified personnel is required for project contracts of NT$50 million, two qualified personnel for project contracts above NT$200 million), to reduce air pollution from construction projects.

To reduce emissions from coal yards, Taipower set up dust-proof needing around older, open yard perimeters and uses sprinklers to inhibit the escape of coal dust. With technological progress and increasingly robust environmental quality requirements, Taipower's coal storage yards have gradually been converted from open to indoor storage. The Linkou, Xingda, and Dalin Power Plants have all built indoor coal bunkers, and the Taichung Power Plant is planning to construct indoor coal bunkers. Work on these projects is currently underway and will further restrain the escape of coal dust upon completion.

▼ Taichung Power Plant closed-trough conveyor belt system can reduce the escape of coal dust

6.4.2 Effluent Management

Water Resources Management

Taipower tracks its wastewater discharge in accordance with Environmental Protection Agency rules, follows the progress of legal and regulatory revisions, and develops corresponding solutions for possible risks. For example, 24 new control items were added to the effluent standards for power plants at the end of 2017. New ammonia nitrogen control items were added in 2021, and control limits were tightened for the effluent of the flue gas desulfurization of coal-fired units on mercury, arsenic, and selenium. In 2019, the Water Pollution Control Measures and Test Reporting Management Regulations were also amended, requiring periodic test reporting of wastewater according to the announced items and frequency. If power plants violate the effluent standards, they will be punished according to law.

All Taipower's power plants follow the ISO14001 management system and conduct regular compliance inspections. In view of the risks that may arise from ordinance revisions, relevant plans are developed for measures such as increasing the frequency of testing, decreasing pollution emissions at source by process control, and evaluating the need for additional treatment equipment to improve wastewater treatment efficiency over the long term. In 2020, Taipower did not violate water consumption or water quality regulations. As Taiwan's water supply was at less than 10%, Taipower did not take water or use water from places with serious or extremely serious benchmark shortages. To ease its water usage, Taipower installed MED-type desalination equipment at the Dalin Power Plant and handed the right of use to the plant in February 2018. It is currently in operating normally with a designed water production capacity of 2,000 tons per day. The Taichung Power Plant is also currently constructing desalination equipment.

2020 Water Consumption for Generation at Taipower's Thermal Power Plants Unit: m³

Power Plant		Volume of Tap Water	Volume of Desalinated Water	Total
Thermal Power Plant	Xiehe	254,067.0	0.0	254,067.0
	Linkou	527,112.0	0.0	527,112.0
	Datan	435,908.2	0.0	435,908.2
	Tongxiao	507,130.0	0.0	507,130.0
	Taichung	4,573,878.0	0.0	4,573,878.0
	Xingda	2,149,171.0	0.0	2,149,171.0
	Dalin	330,814.0	241,636.0	572,450.0
	Nanbu	115,245.0	0.0	115,245.0
	Jianshan	0.0	50,926.0	50,926.0
	Tashan	0.0	15,000.1	15,000.1
	Total	**8,893,325.2**	**307,562.1**	**9,200,887.3**

Wastewater Reuse

Taipower actively pursues a goal of zero wastewater discharge. Rainwater collection (at power plants and dormitories) and wastewater reuse projects have been pursued to reduce the use of tap water inside power plants through comprehensive planning.

Through the utilization of various water-saving measures, the wastewater recovery results for 2020 are as follows (Note that flue gas desulfurization, FGD, wastewater is not reused as it contains a high salt content which is likely to cause equipment corrosion and soil salinization. As such it is not included in the calculation of wastewater volumes).

Reclaimed and Reused Wastewater in Thermal Power Plants Unit: Tons

Item	2018	2019	2020
Reuse of Rainwater	230,087.3	96,557.9	108,959.0
Reuse of Effluent and Wastewater from Processes and Boiler Blowdowns	2,172,782.9	2,605,645.9	2,682,750.82

Rainwater storage and utilization essentially provide an alternative water source. It is an economical and practical water source development model because it does not consume energy or cause pollution. Thermal power plants have implemented measures for rainwater reclamation and wastewater reuse for years. The main uses of the reclaimed water are for green irrigation, electrostatic precipitators, ash discharge, vacuum pump sealing water, bottom ash water, and dust suppression for coal piles in coal yards. These measures have become normal water use principles for thermal power plants. Taipower records the daily usage of demineralized water in unit operation. If there is any abnormality, Taipower tracks it immediately, and advocates and implements water conservation so that employees can sincerely cherish water resources and develop habits for water conservation.

Reclaimed Water Volumes of Taipower's Thermal Power Plants in 2020 Unit: m³

Power Plant		Reclaimed Volume of Rainwater	Reclaimed Volume of Wastewater	Total
Thermal Power Plant	Xiehe	214	48,571	48,785
	Linkou	1,998	312,886	314,884
	Datan	0	167,020	167,020
	Tongxiao	0	158,528	158,528
	Taichung	8,459	829,532	837,991
	Xingda	98,024	789,610	887,634
	Dalin	0	328,248	328,248
	Nanbu	264	42,806	43,070
	Jianshan	0	5,519	5,519
	Tashan	0	31	31
	Total	**108,959**	**2,682,751**	**2,791,710**

6.4.3 Waste Management

Potential Environmental Impact of Waste

Taipower has taken mitigation and improvement measures to minimize the impact of waste generated at various stages of power generation, transmission, distribution, and sale in the value chain. The following outlines mitigation and improvement measures exercised for each type of generation:

Main waste	Environmental Impact of waste	Materiality Narrative	Mitigation and Improvement Measures
Thermal Power			
Wastes and by-products are generated after fuel use, such as coal ash (fly ash and bottom ash) and desulfurized gypsum	The emission of particulate pollutants produced by fuel combustion easily affects air quality and human health and may also have an impact on the nearby ecology	Thermal power generation (including gas and coal) accounts for approximately 78.5% of Taipower's total generated and purchased power	· Taipower has formulated an air pollution management strategy for thermal power plants (Please refer to 6.4.1) and response measures to air pollution. For example, coal-fired thermal power plants are equipped with dust collection equipment to remove particulate pollutants in the smoker, and flue gas desulfurization equipment is installed to remove sulfur oxides from flue gas and improve air quality · Sulfur oxides combined with a limestone slurry produce desulfurized gypsum ($CaSO_4 \cdot 2H_2O$) through chemical reactions such as absorption, neutralization, oxidation, and crystallization. This can be reused in the cement and fireproof board industries
Nuclear Power			
The main wastes can be divided into high and low-level radioactive wastes. The low-level radioactive wastes include the radioactive wastes (comprising radioactive waste resins, waste liquids, residues, radiation protection clothing, parts, etc.) generated during regular operations, equipment maintenance, or improvement projects on the nuclear power plant. High-level radioactive waste refers to the used nuclear fuel withdrawn after the operation of the nuclear power plant	Radioactive material has a long half-life. If it is released carelessly, it may affect the surrounding ecology, human health, and pollute the surrounding soil and water resources	If radioactive waste is improperly disposed of, the degree of harm and the scope of its impact may be enormous. Moreover, because radioactive material has a long half-life, the impact time may last for tens or hundreds of years	Taipower actively handles, disposes, and manages radioactive waste appropriately to effectively isolate it from the environment. Please refer to the Waste Management Mechanism section for Taipower's plans for high and low-level radioactive waste
Hydropower, Wind Power, Solar Power			
Decommissioned units and equipment	There is no waste produced during the power generation process, and the product life cycle of units and equipment is enduring, resulting in low environmental impact	The power generation processes of hydropower, wind power, and solar power units rely on natural resources, and the unit life cycles are enduring, so there is no materiality at present	Regarding renewable energy equipment that may be decommissioned, Taipower will entrust a compliant disposal company to carry out waste cleaning and transportation and will evaluate the reuse of resources to minimize environmental impact

The accumulation of coal ash also has potential hazards. Taipower takes steps to control ash levels effectively. Fly ash load is measured at the angle of repose of the full silo, and the load combination is carried out by considering wind force, seismic force, soil transverse force, silo wall ring stress, temperature stress, and other forces. The Company also considers the extreme conditions of an empty silo and a full silo adjacent to it, analyzes and confirms that the bearing force, deflection, displacement, subsidence, angular variables, and other items are safe to minimize potential hazards. Coal ash accumulation is classified according to the degree of potential hazards as follows:

Diameter, Height, and Level of Fly Ash at Coal-fired Power Plants

Power Plant	Linkou	Taichung	Dalin	Xingda
Number of Silos	2	10	2	4
Diameter (m)	16.5	12~15	16	17
Height (m)	36	20	26.6	24
Control ash level (m)	28	10	22	20

Waste Management System

Taipower established a By-product Resource Utilization Steering Committee to develop strategies and response plans for maximizing by-product resource utilization through cross-unit cooperation. Its responsibilities include the development and implementation of coal ash and gypsum removal strategies, review of the current coal ash bidding specifications in power plants, the application for a green mark for fly ash and gypsum products, and planning related incentive mechanisms that enhance the utilization rate of fly ash concrete at all units.

For nuclear energy-related waste, Taipower has completed short, medium, and long-term planning schemes in accordance with its responsibilities for the treatment, storage, and disposal of high and low-level radioactive waste.

	Short-term	Medium-term	Long-term
Storage and disposal process for low-level radioactive waste	Before 1996, waste was sent to the Lanyu low-level radioactive storage yard for temporary storage. Since 1996, it has been temporarily stored in the low-level radioactive storage depots of power plants.	A temporary storage facility is planned for the medium term and material will be transported to the facility for storage.	Transport from short-term facilities or mid-term temporary storage facilities to a final disposal site.
Storage and disposal process for used nuclear fuel	In keeping with international norms, the used nuclear fuel is stored in a dry storage facility after temporary storage in a used nuclear fuel pool.		

Utilization of Industrial Waste

Reuse of Coal Ash and Desulfurized Gypsum

Waste	Reuse practice	2020 production	2020 reuse volume	2020 reuse ratio
Coal ash	Taipower has encouraged its engineering units to use fly ash in civil construction projects and to fill trenches. This raises the volume and utilization rate of fly ash and reduces the environmental burden.	2,209 thousand tons	1,982 thousand tons	89.7%
Desulfurized gypsum	To improve air quality, coal-fired thermal power plants have flue gas desulfurization equipment installed to remove sulfur oxides from flue gas. Limestone slurry is then used to create gypsum through the chemical processes of absorption, neutralization, oxidation, and crystallization. The resultant desulfurized gypsum ($CaSO_4 \cdot 2H_2O$) can be used by local cement and fire-retardant board makers.	296 thousand tons	292 thousand tons	98.6%

Bidding for Industrial Waste

Other industrial wastes, such as waste wire and cables, as well as metal scraps generated during Taipower's operations, are recycled by waste disposal contractors that acquire the materials through an open bidding process. In accordance with regulations, bidders must be qualified Waste Disposal Organizations and perform their operations according to regulations to reduce the environmental risks involved in waste treatment.

6.4.4 Promoting Circular Economy

In response to the international trend of energy transition and the government's 5+2 Innovative Industries Plan, Taipower has listed the circular economy as one of its key projects for promoting sustainable operations. The Company has pledged to create efficient and sustainable energy resource utilization with circular mindset and to implement the concept of circular economy, and carry out two dimensions of establishing a circular economic business model and improving resource efficiency to promote various circular economic measures. The Company hopes to transform from the linear economic mindset of the past into a circular economic model that gives increased consideration to sustainable development.

Taipower's Short, Medium and Long-Term Environmental Policy Goals

Strategy ／
Focus on circular innovation

Key strategic dimension ／
Establish a circular business model

Short-term goal (by 2021)	Medium-term goal (by 2025)	Long-term goal (by 2030)
Inventory of potential circular materials and development of a feasible business model pilot	Implement the circular resource supply model	Establish a circular economy system

In order to better implement its environmental policy commitments, Taipower held an Expert Advisory Commission in October 2020. The commission conducted in-depth discussions on the Taipower circular economy strategic framework and promotion plan for product service applications. Considering the unique circular economy mindset of the power industry, Taipower needs to explore the possibility of constructing a recycling loop from planning and design, resource procurement and power manufacturing infrastructure to power supply, sales, services, and to the final stages of disposal and reclamation. The strategic blueprint framework of the circular economy starts with energy and resources. In terms of energy, Taipower specializes in and continuously strives to optimize the efficiency of power generation, transmission, and distribution, and gives consideration to the development of power reclamation.

In terms of resources, power infrastructure is Taipower's largest asset. The concept of circular construction is being incorporated into the design, procurement, construction, maintenance, operation, and decommissioning of relevant infrastructure and generation equipment.

Taipower used the events of its "Environment Month" in May 2021 to disclose the strategic blueprint framework to the public (see p.10 of the special issue of this report). To implement a circular economy within Taipower, the Company has produced more than 20 action plans through hosting a World Café event in May 2021. In the future, it will combine these plans with the circular economy strategy framework to create a circular economy action plan.

Circular Economy World Café

In 2021, Taipower hosted World Café events for the first time. The event mainly targeted internal employees as the key communication group. The purpose of the events was to break the vertical management structure and use a horizontal communication mode to assemble supervisors of all units and systems above the team leader rank. In a relaxed, but focused atmosphere, the ideas and intelligence of employees from all units were brought together to produce a Taipower circular economy action plan. In the future, Taipower expects the World Café model to become a fixed feature of communication and discussion on sustainability issues.

To encourage a full discussion of circular economic issues, the Chairman gave Taipower employees expectations and encouragement at the beginning of the meeting and organized several World Café education and training events to prepare staff beforehand. On the day of the World Café, Chairman Charles Huang of the Taiwan Circular Economy Network and Managing Director Niven Huang of KPMG Climate Change and Sustainable Services Asia-Pacific Region were invited, to emphasize the spirit of a circular economy and its connection with sustainability. Through the three rounds of discussions in the second half of the meeting, a condensed a circular economy action plan was produced with Taipower's characteristics and will be implemented in Taipower's future operations.

6.4.5 Environmental Sustainability Strategy Refinement

Taipower is committed to minimizing the negative impact on the surrounding environment during operations and maximizing its positive influence on society and the environment. In addition to carrying out neighborhood activities at power plants, such as beach cleaning, fish fry releasesing, green space adoption, and building artificial reefs, Taipower continues to conduct environmental education and carefully evaluates environmental factors before power plant expansions and unit additions. Moreover, Taipower conducts in-depth communication with local stakeholders to ensure legality and compliance and to achieve win-win situations for society, the environment, and Taipower.

Taipower's Short, Medium, and Long-Term Environmental Policy Goals

	Short-term goal (by 2021)	Medium-term goal (by 2025)	Long-term goal (by 2030)
Strategy／**Refine management systems** Key strategic dimension／**Develop intelligent management**	Coverage of intelligent management and services will reach **52%** (Including the cumulative deployment of smart meters in **1.5 million households**, representing **69%** of the total national power consumption)	Coverage of intelligent management and services will reach **65%** (including the cumulative deployment of smart meters in **three million households**, representing **81%** of the total national power consumption)	Coverage of intelligent management and services will reach **82%** (including the completion of smart meters installations in **six million households** after a feasibility assessment of smart meters, representing **85%** of the total national power consumption)
Strategy／**Create ecological inclusiveness** Key strategic dimension／**Plan the fusion of facilities and ecologies**	Produce at least **one** ecologically inclusive plans for power facilities	Produce at least **three** ecologically inclusive plans for power facilities	Produce at least **five** ecologically inclusive plans for power facilities
Strategy／**Expand internal and external engagement** Key strategic dimension／**Deliver information on electricity and the environment**	Annual communication of environmental protection information will reach **480 thousand people**	Annual communication of environmental protection information will reach **700 thousand people**	Annual communication of environmental protection information will reach **750 thousand people**

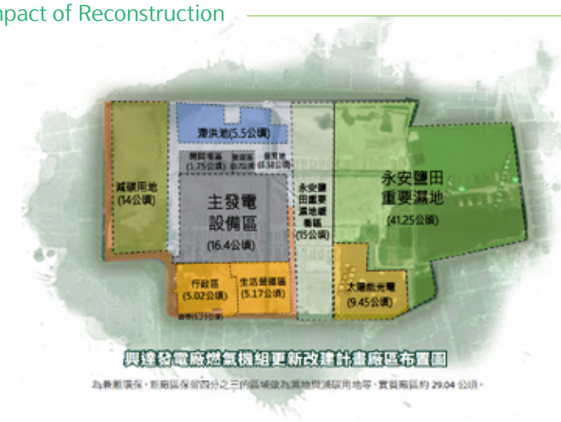
Power Facilities Coexisting with Ecology

Zhangbin Solar Power Plant - Little Tern Conservation

During the construction of the Zhangbin Solar Power Plant, about 7.4 hectares of land in the southwest corner of the property was reserved to set up a landscape balancing reservoir and collect rainwater through channels to serve as drinking water for little terns and other creatures. Meanwhile, about one hectare of gravel ground was laid in the center of the landscape balancing reservoir to create a mini "ecological island," that allows the little terns to nest, spawn, and brood. In addition, a bird-watching pavilion was set aside for academic monitoring and research. At the periphery of the plant area, the green belt of a windbreak was cultivated to reduce wind speeds, filter salt, and provide a place for birds to shelter from the disturbances of the outside world.

Xingda Power Plant - Reducing the Environmental Impact of Reconstruction

In order to reduce the environmental impact of the renovation project at Xingda Power Plant, a non-development area was set aside. The area includes 41.25 hectares of wetland, 15 hectares of buffer zones, 5.5 hectares of retarding basin, 14 hectares of carbon reduction land, as well as 13.81 hectares of green belt and conservation land. In other words, three-quarters of the area will be used for environmental protection. In response to the construction, an additional silt retarding basin will be installed to prevent drainage or flooding during the construction period from affecting the fish farm. In addition, during cold weather in winter, contractors' heavy vehicles are required to enter the work area after 9 a.m. to avoid disturbing the bio-routine of the fish farm.



Jingshan Branch Plant of the Zhuolan Power Plant - A Hydroelectric Plant That Does Not Interrupt Water Supply

Zhuolan's Jingshan Power Plant is one of Taipower's small hydropower plants. Due to its small scale, the amount of soil and rock excavation and disposal during the construction period was small. Therefore, there was no need to set up a separate soil and rock stacking yard. After the completion of the power plant, remote monitoring equipment, and communication lines were installed. The monitoring mode is controlled remotely by the adjacent power plants and has a very slight impact on the surrounding environment. In addition to increasing the output of renewable energy, it also reduces carbon emissions. Furthermore, Water Resources Agency required Jingshan Power Plant to carry out ecological discharges and to design dedicated control pipelines to regulate them according to rainfall, weather, and downstream water demands. When the downstream water demand surpasses the plant's generation consumption, or when the water supply is insufficient for power generation while downstream ecological water demands still need to be maintained, the water supply is met through the dedicated pipelines, and the ecological needs are taken into account. This is pioneering work in the design of power plants.

Changhua Offshore Phase One Wind Power - Win-Win Situation of Energy, Fishermen, and Ecology

To avoid affecting the harvest of oysters, the submarine cable for the Changhua offshore wind power plant adopted a horizontal deflection drilling method in the near-shore area to submerge the cable 21 meters under the seabed. The original length was about 380 meters, but to protect the environment and the farming of oysters the cable length was extended to 950 meters, completely avoiding the oyster breeding area. To solve the problem of piling noise, two measures were taken. The first was to reduce noise by using a bubble curtain. Bubble curtains are a common method that involves a bubble boat continuously producing bubbles on the seabed around the piling. In the process of escaping to the surface, the bubbles absorb part of the noise. The second measure involved hiring cetacean observers to guard the area. If a whale or dolphin was found, the piling was suspended until the whale or dolphin had moved on.