CHAPTER 03

Provider of Sustainable Power

Development Vision

A stable supply of electricity is crucial to public livelihood, industry, and economic development. By continuously providing a stable power supply throughout Taiwan, Taipower plays a vital role in the nation's overall economic development. As energy transition continues, the proportion of renewables used will rise. As renewables increase, the unstable nature of their generation will make meeting future electricity demands challenging.

Taipower is eagerly developing diversified energy sources on the supply side. It has prioritized three major areas of development: renewable energy, low-carbon gas, and the renewal of coal-fired power plants with ultra-supercritical (USC) generation units. These measures are expected to stabilize the electric system. Other measures include improving the reliability of power generation, transmission, substations and distribution. Meanwhile, Taipower is continuing to make good use of opportunities in power dispatching and constantly upgrading its thermal power generating units to increase the proportion of gas-fired energy. Taipower will continue to implement its energy transition goals and enhance the Company's operational capabilities and market competitiveness.

Performance Highlights

- Strengthened the power transmission and substation systems. The total investment in the 7th Transmission and Substation Revision Project will be about NT$236.9 billion (to 2025). By the end of 2022, substation capacity had reached 16,141.18 KVA (93.56%) and 1,824.13 circuit kilometers (96.01%) of lines had been completed.
- In 2022, the total length of underground transmission cable reached 4,702.7 circuit kilometers.
- The gross thermal efficiency of all thermal power plants has increased year on year, from 46.10% in 2021 to 46.26% in 2022.
- In 2022, wind power generated 1,072.2 GWh and solar power generated 402.7 GWh.
- The progress of renewal, expansion and new thermal generating unit projects in 2022 was as follows: the Linkou Plant (100%), Phase 1 of the Tonghsiao Plant (99.87%), the Datan Plant (87.84%), the Hsinta Plant (57.65%), the Taichung Plant (23.27%), the Union Plant (12.12%), Phase 2 of the Tonghsiao Plant (5.87%), the Talin Gas Plant (0.15%).

Providing Quality Electricity Service

3.1.1 A Stable Power Supply and Generation System

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A Stable Power Supply and Installed Capacity

In recent years, Taiwan's power consumption has repeatedly hit historical highs. Since Taipower is responsible for ensuring a stable power supply, this has meant persistently pushing power development projects and planning to launch new generating units every year. In terms of managing the operation of thermal power generating units, apart from refining various operational maintenance strategies, Taipower has established a licensing system and a retraining mechanism for staff with the goal of ensuring stable daily operations. With regards to Nuclear power plants, the main management measures include analyzing and reviewing operational weaknesses that are identified by each nuclear power plant, strengthening the management of activities during major maintenance periods, implementing equipment improvements and upgrades, and reviewing unplanned incidents that have occurred during the year.

Total Amount and Composition of Power Generation from 2020 to 2022

	2020		2021		2022	
	Billion kWh	Percentage	Billion kWh	Percentage	Billion kWh	Percentage
Net amount of power generated and purchased	238.9	100.0%	248.8	100.0%	250.7	100.0%
Amount of power generated	183.9	77.0%	189.1	76.0%	188.3	75.1%
Pumped storage hydro	3.1	1.3%	3.2	1.3%	3.1	1.2%
Thermal	147.0	61.5%	155.2	62.4%	156.0	62.2%
Nuclear	30.3	12.7%	26.8	10.8%	22.9	9.1%
Renewable energy	3.4	1.4%	3.9	1.6%	6.3	2.5%
Amount of purchased power	55.1	23.0%	59.7	24.0%	62.5	24.9%
Privately-owned thermal	40.6	17.0%	42.7	17.1%	43.7	17.4%
Renewable energy	10.4	4.3%	11.9	4.8%	15.3	6.1%
Cogeneration	4.1	1.7%	5.1	2.1%	3.4	1.4%

Average Availability Rates for Power Plants from 2020-2022

Unit: %

Unit		Energy type	2020	2021	2022
Thermal	Steam	Coal	86.82	89.12	85.71
		Oil	87.01	92.74	89.67
		LNG	95.51	82.33	94.09
	Combined cycle	LNG	87.98	88.13	89.49
Hydro		Hydro	96.81	96.09	95.37

Average Availability Rates for Nuclear Power Plants from 2020-2022

Unit: %

Year	NPP1		NPP2		NPP3	
	Reactor 1	Reactor 1	Reactor 1	Reactor 1	Reactor 1	Reactor 2
2020	-	-	87.29	88.81	99.36	86.71
2021	-	-	50.43(Note 1)	98.02	88.09	88.85
2022	-	-	-	88.95	87.64	99.67

Annual availability of nuclear power units = Annual interconnection generation hours/Total annual hours

Note: 1. Reactor 1 of Nuclear Power Plant 2 (NPP2) was originally scheduled to remain shut down from February 25, 2021 until the expiration of its license on December 27, 2021 due to a full fuel pool. However, in order to maximize the supply efficiency of the nuclear fuel before decommissioning, the reactor's life was extended until July 2, 2021 in a decreased power operation mode. It was then shut down for maintenance until the expiration of the operating license on December 27, 2021. The reactor then entered the decommissioning stage.

Increasing the Reliability of the Power Supply

Taipower has a complete power dispatch and reliability management mechanism. Specific action plans are as follows:

The Power Dispatch and Reliability Management Mechanism

Regular Review and Analysis	
Execution method	• Conduct regular electromechanical system incident review meetings • Conduct regular power dispatch system incident review meetings
Execution status	• Electromechanical system incident review meetings were held each month to review and analyze the causes of electromechanical outages for systems above 161kV and make follow-up improvements. • Power dispatch system incident review meetings were held every two months to ensure the normal operation of energy management system (EMS) related software and hardware as well as peripheral equipment. This helped to maintain the safe and stable operation of power dispatching.
Risk Management Implementation	
Execution method	• Given the impact of different power incidents on power dispatching reliability and stability, power shortages affecting system stability and safety were listed as risk control events. Risk levels were determined according to the degree of impact and measurement standards in different scenarios. Relevant measures were also formulated for tracking and control. • Quarterly follow ups on reviews and execution. • Conducted a general review at the end of the quarter and set future control objectives.
Execution status	• On January 10, 2023, a review of the execution and effectiveness of the response to power shortages affecting system stability and safety for the fourth quarter of 2022 was conducted. • On February 13, 2023, a meeting was held to review the execution responses to power shortages affecting system stability and safety in 2022. These meetings also conducted continuous adjustments and set control objectives for 2023.
Personnel Training	
Execution method	• In preparation for the future electricity market transaction mechanism defined in the Electricity Act, regular on-the-job training was carried out to relay concepts of electricity market operations and quotations for business personnel. • Online dispatchers trained and conducted license certification examinations for new dispatchers. Licensed personnel may renew their licenses after completing a certain number of retraining hours every three years.
Execution status	• The training center conducted the first Electric System Reactive Power and Voltage Adjustment Seminar. The training targeted on-duty or business-related personnel from the dispatch centers (central, regional, distribution), power plants, IPPs and ultra-high voltage substations with a total of 22 participants. • Dispatchers who passed the examination after completing a training internship can participate in the dispatcher license examination. No dispatcher licenses were issued in 2022 due to the pandemic. Despite this, 3 senior dispatchers and 6 dispatchers were approved for license renewals.

Taipower actively implements the power supply management mechanisms listed in the table above. This approach helps to ensure a stable power supply throughout Taiwan. Despite this, ensuring reliable power supplies for offshore islands is more challenging because they are not connected to the main island's grid. Therefore, Taipower is proactively assisting the offshore islands in improving their electric systems to ensure offshore users have access to the same electricity quality and services as are available on the main island. For example, the electric system in the Kinmen area has been improved by adopting the group operation model for generators and substations in the area. This resolves problems with overly concentrated units and lines at the Tashan Plant. It also helps to avoid complete blackouts in the area should an electrical system outage occur.

		2020		2021		2022	
		Target	Performance	Target	Performance	Target	Performance
The average duration of outages (minutes / household · year)	Working blackout	12.253	11.696	12.213	11.732	12.176	11.298
	Outage blackout	4.547	4.235	4.487	4.644	4.424	3.638
	Total	16.8	15.931	16.7	16.376 (43.516)[1]	16.6	14.936 (91.285)[2]
The average number of outages (times / household · year)	Working blackout	0.064	0.059	0.064	0.059	0.064	0.057
	Outage blackout	0.196	0.171	0.196	0.174	0.196	0.129
	Total	0.260	0.230	0.26	0.233 (0.864)[1]	0.26	0.185 (0.467)[2]

Note:
1 Excluding the power outage incidents on May 13 and May 17, the average interruption frequency per household in 2021 was 0.233 (times/household, year), and the average interruption duration per household was 16.376 (minutes/ household, year).
2 Excluding the power outage incident on March 3, the average interruption frequency per household in 2022 was 14.936 (times/household, year), and the average interruption duration per household was 0.185 (minutes/ household, year).

Line Loss Rate from 2020 to 2022

2020	2021	2022
3.97%	3.53%	3.82%

Responding to the Nationwide Power Outage of March 3, 2022

At 9:07 a.m. on March 3, 2022, the lock-out trip of a communication bus protection relay at the Hsinta Power Plant activated the protection mechanism for five extra-high voltage (EHV) substations including Longqi and Lubei. Generating Units in southern Taiwan at Dalin, Nanpu, Hsinta, NPP3, Mai-liao, Chiahui and Fong Der were all affected and tripped. This reduced the supply capacity by 10.50 GWh in total – the equivalent of one-third of the electricity demand in Taiwan on that day – and affected about 5.49 million households. The power was fully restored at 9:31 pm.

The incident was caused by the failure of an operator to confirm the insulated gas pressure during the isolation switch test during the environmental shutdown and overhaul of Generator 2 at the Hsinta Power Plant. The error resulted in a short-circuit grounding fault in the switchgear, which triggered subsequent events. Due to the imbalance between supply and demand in the southern region caused by the tripping of the generator, the system automatically disconnected for its own protection. The power system in Taiwan is affected by instantaneous frequency changes, and the imbalance between power supply and demand caused outages in the southern region. Some users in the central and northern regions also experienced power loss due to low-frequency relay actuation.

Taipower has reviewed and responded proactively to the power outage on March 3. In particular, the Company has acted to mitigate problems due to human negligence. Taipower will continue to conduct a comprehensive review and develop improvement measures. In addition to implementing on-site standard operation procedures, reviewing various preventive mechanisms, and completing the interface for construction, Taipower is refining the operations and maintenance mechanisms of its power facilities and working to strengthen personnel risk analysis and management capabilities. It is also working to comprehensively enhance grid resilience so as to avoid the recurrence of similar incidents.

Facing the Challenge of Natural Disasters

Natural disasters are a significant challenge for Taipower's operations. In terms of internal management, Taipower has a complete disaster prevention and emergency response system, with comprehensive disaster prevention policies and regulations. In addition to all kinds of disaster education and training, random checks are conducted so that all units can effectively and promptly respond to natural disasters and major power supply outages.

In terms of external responses, Taipower's branch offices issue at least one local press release every day before, during, and after each typhoon to reinforce public awareness of disaster prevention and preparation. The Company has also established the Taipower 1911 customer service hotline, a power outage inquiry and notification system on the official website, and an "apply/repair" function on the Taipower mobile application for the public to report blackouts. Branch offices have additionally established real-time communication channels through social media community groups, telephone, fax or e-mail, and other channels based on regional characteristics. This is to ensure comprehensive control and that the power recovery status of users can be confirmed, so that incidents are handled as soon as possible.

Taipower's Disaster Rescue and Reconstruction Management Policy and Implementation Powers and Responsibilities

Execution time	Management strategy and refinement	Executive unit
Twice a year	Every year in January and April, Taipower holds Extraordinary Disaster Prevention and Review Meetings to review the deficiencies and areas for improvement in disaster prevention and response from the previous year. The meetings aim to establish a disaster prevention plan for the current year and confirm the organization and command system for disaster prevention and response.	All branch offices
Once a year	Take stock of manpower, vehicles, and equipment data for each regional operational office (including contractors) to facilitate integrated scheduling and utilization of manpower and equipment. Conduct various types of disaster prevention and response promotions, education, and drills to enhance proficiency in disaster prevention and response operations.	Department of Distribution and all branch offices
Before typhoons	At the pre-typhoon preparedness meeting, based on the government's forecasted information (projected typhoon paths and intensities), we reviewed certain mountainous areas or outlying islands that may become isolated due to road closures or the suspension of ferry services. Personnel, machinery, and materials are deployed in advance to facilitate prompt repair of power facilities and reduce disaster losses.	Department of Distribution and all branch offices
When a disaster occurs	Through the Emergency Response Task Force, the mutual support mechanism is activated in a timely manner, swiftly mobilizing manpower and equipment to handle disaster repair and restoration of electricity. It cooperates with the disaster relief efforts of various levels of government, sets up forward command posts, and provides timely information on disaster situations, repair progress, and instructions for user cooperation. This information is made available for local governments and opinion leaders to reference and take appropriate measures, and provides necessary assistance and shortens the time required for disaster recovery.	All branch offices
No warning throughout the year	Enhanced communication and coordination operations are conducted for reporting distribution system disaster situations. Regular training sessions are held for various types of disasters and emergency event alerts, and unannounced drills are implemented to improve the timeliness of disaster notifications.	Department of Distribution

Guidelines and planning for future power plant construction, renewal and expansion projects

- The government annually reviews the future electricity supply and demand situation to ensure a stable power supply. The process involves the evaluation of the overall power system, and makes plans for additional power sources based on factors such as electricity demand growth and the decommissioning of existing units.
- Taipower is fulfilling the government's energy transition policy by increasing its use of natural gas, reducing its use of coal, developing green energy, and working to achieve net-zero emissions by 2050. The Company considers a stable power supply an important principle and prerequisite to these measures and is gradually moving towards a low-carbon and low air pollution emissions energy supply system. It plans to gradually reduce coal consumption and carbon emissions by reducing the load on existing subcritical coal-fired units and constructing new gas-fired units, while ensuring system stability with a reliable gas supply for new gas-fired units. Moreover, the feasibility of retaining older equipment for emergency operation is evaluated based on national security considerations.
- Taipower has aligned with the government's policy to expand the use of natural gas for power generation. It is actively promoting the development of new gas-fired power generation projects and purchasing natural gas power from independent power producers (IPP). This is projected to add approximately 18.84 GW of power from gas-fired units between 2022 and 2028.
- To accommodate the impending large-scale integration of solar and wind powered renewable energy, Taipower plans to utilize pumped-storage hydropower as a large-scale energy storage system to enhance system security and stability. The planned sites currently include the Guoming Pumped Storage Hydroelectric Project (350 MW) in the Dajia River and the Shimen Pumped Storage Hydroelectric Project (44 MW). Taipower continues to search for suitable pumped-storage sites across Taiwan for further development.

Ensuring Nuclear Power Safety

Taipower adheres to the concept of "defense-in-depth" to ensure the safe operation of its nuclear power plants. Taipower aims to:

- Ensure that nuclear power facilities have the highest standard of design, construction, supervision, and quality control in accordance with regulatory mandates. Additionally, geographical considerations are taken into account for each unit's equipment. Potential natural disasters, such as earthquakes, tsunamis, typhoons, tornados and floods, are evaluated in detail to provide "defense-in-depth" thinking that can cope with burst outages.
- Utilize multiple physical barriers that are designed to prevent leakages of fission products from nuclear reactors.
- Employ different and redundant security systems that are well maintained and in operation. These systems must be tested regularly according to regulations to maintain a high degree of readiness to respond to any contingency.

In practice, the Company's approach to "defense-in-depth" incorporates the following four lines of defense.

Defense-in-Depth

The 1st Defense (Prevention)	The 2nd Defense (Mitigation)	The 3rd Defense (Emergency Preparedness)	The 4th Defense (Strategy)
Evaluations and prevention are conducted in advance based on various extreme conditions.	Disaster mitigation is executed to prevent the leakage of radioactive materials from nuclear power plants.	If disaster mitigation fails to prevent external leakages of radioactive materials, protective actions will be taken to reduce radiation exposure outside the plant.	Ultimate Response Guidelines (URG) were developed as a basis for decision making and are based on current design benchmarks for earthquake resistance and tsunami prevention at nuclear power plants, emergency operating procedures and severe nuclear outage handling guidelines.

Taipower has joined the United State-based Nuclear Procurement Issues Corporation (NUPIC) and regularly participates in meetings. This allows the Company to obtain audit information on purchase vendors for each nuclear power plant. This helps ensure the quality and safety of equipment and components. Taipower also abides by the Enforcement Rules of the Nuclear Materials and Radioactive Waste Management Act. The Company submits reports on radioactive waste treatment, storage, and final disposal to the competent authority, along with annual reports on operations, radiation protection, and environmental radiation monitoring. Taipower's management and outage response mechanism for nuclear energy are described in the table below

Taipower's Nuclear Energy Management and Outage Response Mechanism

Routine preparedness	Organize emergency response plan training	• The emergency staff of nuclear power plants and the Nuclear Emergency Preparedness Executive Committee are given regular training according to the expertise of their task forces to maintain outage handling capacity. • Emergency response training includes both general and professional training. The above-mentioned emergency staff undergo general training once every two years and professional training annually.
	Organize in- and out-of-plant emergency response plan drills	• In addition to holding an in-plant drill once a year at each nuclear power plant, Taipower coordinates with the central and local governments, military police, medical services and other resources to conduct one nuclear safety drill every year at each operational nuclear power plant. Taipower invites experts and scholars, in addition to representatives from competent authorities, to evaluate the response measures of these drills so that the emergency response plans and actions can be gradually improved. • In 2022, Taipower held the large-scale "Nuclear Safety Drill No. 28" at the Third Nuclear Power Plant (NPP3). The First (NPP1) and Second Nuclear Power Plants (NPP2) also conducted emergency response planning drills in July and November respectively.
	Construct and implement emergency preparedness performance indicators	Each nuclear power plant will implement the following three emergency preparedness performance indicators and report on them to the Atomic Energy Council every quarter as part of the control measures taken by the nuclear energy regulatory entity to ensure the preparedness of nuclear power units. 1. Drill/drill performance. 2. Participation in the drills of the emergency response organization. 3. Reliability of the warning and notification system.
Response operations in case of outages	Take emergency measures	• When a nuclear outage occurs, the nuclear power plant will perform unit rescue operations in accordance with the provisions of the emergency response operating procedures of the plant. • If the outage cannot be effectively controlled and may affect the people or environment outside the plant, the relevant government units shall activate the National Nuclear Emergency Response Center, the Nuclear Radiation Monitoring and Dose Assessment Center, the Regional Nuclear Emergency Response Center, and the Nuclear Emergency Support Center, as per the Nuclear Emergency Response Act. These entities will jointly perform various disaster relief operations outside the plant where the outage occurred to ensure the safety and well-being of the public.
Post outage recovery operations	Damage assessment and recovery measures	• After the cause of a nuclear outage has been eliminated and the National Nuclear Emergency Response Center has confirmed that all emergency response measures have been completed, the emergency response organization's mandate will be lifted. • After receiving notification from the Nuclear Emergency Recovery Committee, Taipower will carry out recovery operations such as facility damage assessments and recovery according to the task division for each unit. • Taipower is responsible for the recovery of the units within the plant. Accordingly, it has developed and established disaster recovery plans and operating procedures. The emergency control team leader for the plant will command an in-plant restoration effort that carries out recovery operations based on the plant's situation.

3.1.2 A Robust Transmission and Distribution System

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In response to the planned energy transition, Taipower has vigorously promoted renewable energy. However, due to geographical limitations, solar and wind power generation are mostly concentrated in the central and southern regions of Taiwan. Moreover, as the nation's high-tech industry continues to develop, the power demand of the country's Science Parks is increasing, creating a trend towards concentration in power supply and load centers. Faced with such arduous challenges, Taipower's transmission and distribution system will need to effectively and reliably deliver the power generated by plants in various places to the distribution system and ultra-high voltage (UHV) users. To accomplish this, Taipower has rolled out projects such as Phase 1 of the Offshore Wind Power grid reinforcement, a UHV substation expansion at the Southern Taiwan Science Park, and a Baoshan UHV substation construction project that strengthens grid power integration capabilities and introduces static synchronous compensation equipment that improves regional voltage control. The projects are expected to provide sufficient, high-quality, safe, stable, and reliable power to expedite the development of the nation's high-tech industry and enhance international competitiveness.

Improving the Accessibility of Power

In order to comply with the Electricity Act and exercise social responsibility by maintaining the public's rights and interests through a stable power supply, Taipower has established 24 branch offices, 265 service centers, and 2 customer service centers in Taiwan. Additional power supply facilities are installed to increase the availability of power supply in cooperation with local construction and applications. The Company also regularly convenes Timely Power Supply Review Meetings in response to individual applications for electricity and to continuously improve the accessibility, stability, and reliability of power services and ensure the right of equal access to required power services.

Currently, only a few remote areas have no electricity supply. This is typically due to limited access that inhibits the movement of construction equipment and engineering vehicles to the sites and makes the placement of poles difficult. Additionally, setting up electricity in some remote areas may have an impact on the local environment and natural landscape. With the exception of these remote areas, the national power supply penetration rate has reached 100%.

Strengthening Power Transmission and the Substation System

In response to economic growth, Taipower continues to strengthen the overall power grid through power transmission and substation projects, reinforcement of transmission capacity for the main line system, and optimization of power supply capacity for ultra-high voltage, large-scale customers. The Company is also working to complete construction projects as scheduled while maintaining quality.

Strengthening the Infrastructure of the Power Grid

The grid is a connective hub between the power generator and the customer. A sound power grid can effectively reduce the possibility of power outages and maintain the quality of the power supply. Over the years, Taipower has built a dense network around the country to ensure that people are able to conveniently access and use electricity. Regular maintenance of related facilities is an important part of maintaining a stable power supply. Taipower will continue to promote plans that increase the power grid's resilience, replace old facilities and lines in order to reduce the line loss rate year by year, and to maintain the high-quality supply of electricity.

Taipower's current uses the System Average Interruption Duration Index (SAIDI) and the System Average Interruption Frequency Index (SAIFI) as performance indicators for power supply reliability. In March 2022, the 303 power outage incidents affected the power supply to 5.529 million households and caused the SAIDI score to increase to 91.285 minutes/household, and the SAIFI score to increase to 0.467 times/household. However, if this incident is excluded, the SAIDI score was 14.936 minutes/household, and the SAIFI score was 0.185 times/household.

Additionally, as intermittent renewable power, which may affect system stability, is added to the grid in greater quantities, Taipower is devoted to grid-connection dispatching and strategy research. As such, the Company has built a generation information consolidation platform and other related systems to help it actively respond to future challenges.

In consideration of expected global climate changes, the unstable nature of renewables which are likely to cause an imbalance between supply and demand, and the aging of existing power transmission and distribution facilities, the entire system of power generation, transmission and distribution should continue to undertake various prevention and system improvement measures. Consequently, Taipower will constantly strengthen line maintenance and equipment improvements to reduce outages and to ensure power supply quality.

Increasing the Reliability of Power Distribution

To reduce the cost of generation and increase power supply capacity, the distribution and sales system utilizes a target value for the distribution line loss rate that is allocated by the Department of System Operations. Branch offices are instructed to find improvements for lines and for anti-distortion of electricity measures to reduce network losses. Additionally, in consideration of the distribution system's adaptability and wheeling capabilities in the event of outages, Taipower has formulated distribution system planning guides and established management targets to reduce feeders with currents exceeding 300A.

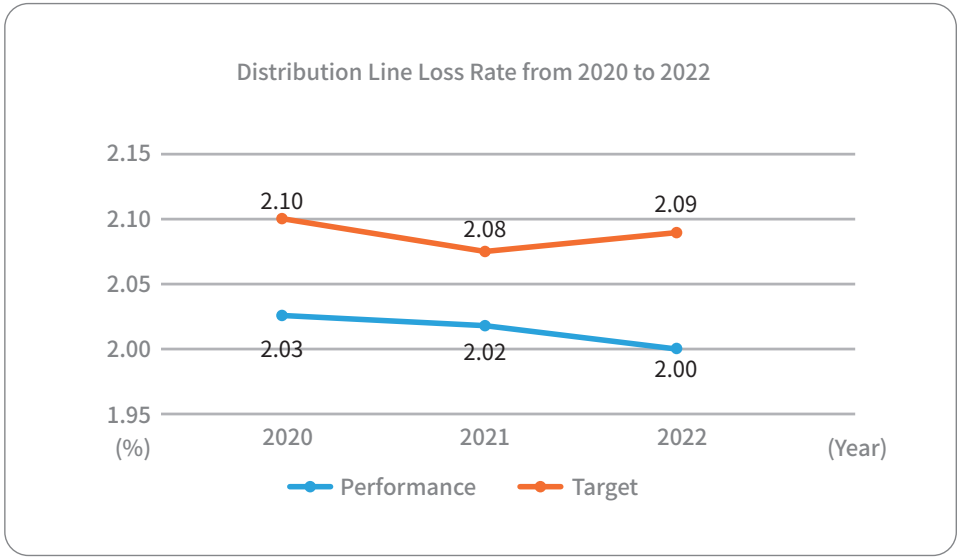
All branch offices and the Department of Distribution regularly conduct high voltage outage review meetings on assessments and improvements in power supply reliability. They review the average outage performance of the distribution system, the causes of major outages, and formulate improved countermeasures to determine the best improvement strategy for each outage situation. The Company also conducts yearly reviews of possible risk factors that affect the stability and reliability of the power supply. These reviews include risk management controls for the following year. Implementation performance is then tracked and reviewed regularly. In addition, Taipower regularly organizes on-the-job education and training for maintenance personnel and dispatchers to advance their professional skills and strengthen maintenance capabilities

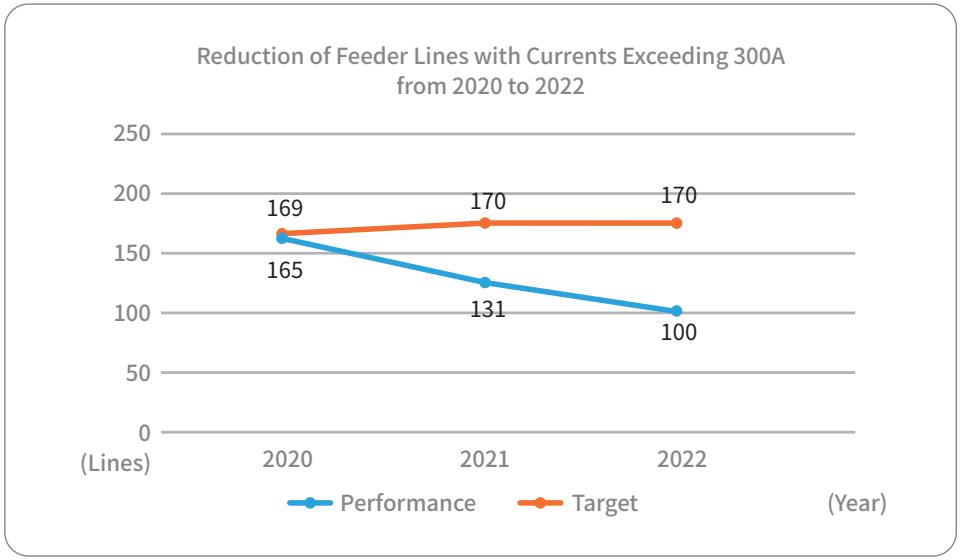
Taipower is working to strengthen its audit operations by evaluating and examining equipment operation periodically, and by supervising each branch's outage prevention and improvement plans to reduce the possibility of human negligence and improper operation.

As Taiwan moves towards energy transition and a new generation of power supply systems, Taipower has accelerated the automation of its distribution feeders. This not only helps to improve the quality of the power supply but also enables fault detection. Through the remote control of on-site automatic line switches, outage areas can be isolated promptly to reduce the scale of power failures. At present, a feeder automation system has been implemented for industrial, vital metropolitan, and remote areas that are difficult to repair, with a penetration rate of about 81.57%. In the future, Taipower will continue to push forward and raise the target value for feeder construction, and is expecting to achieve full feeder automation by 2025.

Distribution Feeder Automation Installations from 2020 to 2022

Performance	2020	2021	2022
Feeder Automations (Number)	7,815 lines	7,969 lines	8,384 lines
Switch Automations (Number)	1,304 units	1,422 units	2,180 units





3.2 Planning for New Sources of Energy

3.2.1 Planning for New Sources of Energy

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The Power Transition Responds to Policy and Public Opinion

Demand for electricity is growing at the same time as a number of large generating units are being decommissioned. In consequence, Taipower has adopted a strategy that is in line with the government's energy transition policy by reducing coal, increasing gas, and developing green and nuclear-free energy.

This entails promoting the development of renewables and actively planning new low-carbon, gas-fired units while improving environmental protection equipment at existing coal-fired units to reduce air pollution emissions. Through these strategies, Taipower will ensure a stable power supply and meet the 2025 energy ratio target. The development direction of Taipower's energy transition plan is as follows:

Prioritize the Development of Renewables and Create a Friendly, Grid-Connected Environment

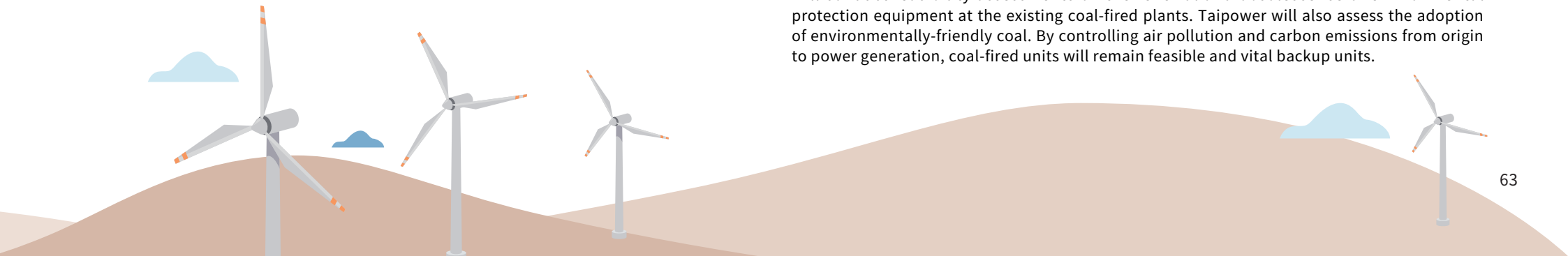
Taipower has vigorously worked to provide the impetus for the establishment of renewables, such as offshore and onshore wind, solar, geothermal, and small-scale and micro-hydropower. However, to maximize the development of renewables, both active development and joint development with private operators are necessary. For this reason, Taipower has continued to strengthening grid construction, creating a friendly, grid-connected environment for private applications, and collaborating with the private sector to fully stimulate the development of renewables.

Actively Promote Gas-fired Generation Projects and Build Natural Gas Receiving Terminals

Gas-fired units produce less carbon and are cleaner than coal-fired units. Therefore, Taipower has committed to renewing and expanding the number and scale of gas-fired generation plants. Projects include the Tonghsiao renewal, the Datan expansion, the Hsinta renewal, new construction at Taichung, and renewal at Hsieh-ho. To ensure the stability of the natural gas supply for power plants and national energy security, Taipower has considered regional balance and the integration of ports and plants in determining its planning direction. The Company pushed forward the construction of its own natural gas receiving terminals in the Taichung and Keelung Ports (Hsieh-ho), while CPC Corporation is building a third natural gas receiving terminal. Through the joint efforts of the two companies, it is hoped that the construction of natural gas unloading facilities can be expanded, power dispatch flexibility and supply stability can be increased, and the goal of ensuring a friendly environment by reducing air pollution and greenhouse gas (GHG) emissions can be achieved while maintaining energy supply security and the overall power supply economy.

Coal-fired Units Serve as Vital Backups

International energy policy has tended to pursue diversified energy ratios. In Taiwan, 97.4% of domestic energy depends on imports, and the power system is an independent grid. To ensure a stable power supply, energy security, and diversification, it is necessary to maintain some coal-fired generation. At the same time, Taipower is aware of the impact of coal-fired generation on air pollution and greenhouse gas emissions. To ensure a sufficient power supply, Taipower will conduct feasibility assessments on the renewal and obsolescence of environmental protection equipment at the existing coal-fired plants. Taipower will also assess the adoption of environmentally-friendly coal. By controlling air pollution and carbon emissions from origin to power generation, coal-fired units will remain feasible and vital backup units.



Short, Medium, and Long-Term Plans for Energy Transition

In accordance with the government's energy policy, Taipower moved towards low-carbon power and renewable development while maintaining an actual reserve capacity of 12.2% in the Taipower system in 2022. The overall generation structure was 43.4% gas-fired, 34.8% coal-fired, 9.1% nuclear energy, 1.4% fuel oil, 8.6% renewable, and 2.6% from other power generation sources (including pumped storage and cogeneration). The proportion of Taipower's gas-fired generation first exceeded that of coal-fired generation in 2019. As gas-fired generation projects are successively commercialized, the 2025 target of 50% gas-fired generation will be achieved.

Short-Term Actions

Since Taiwan is small and densely populated, land for power plants and lines is difficult to obtain. With the prevalence of the not-in-my-backyard (NIMBY) sentiment and concerns over greenhouse gas emissions attracting intense attention from the general public, the promotion of plant construction has been greatly hindered and takes a long time. Additionally, some of the existing nuclear power plants have been shut down prematurely, causing power supply shortages and making it difficult to plan the addition of conventional thermal power sources to replace them in the short term. To reduce the risk of power shortages, the following response measures were proposed:

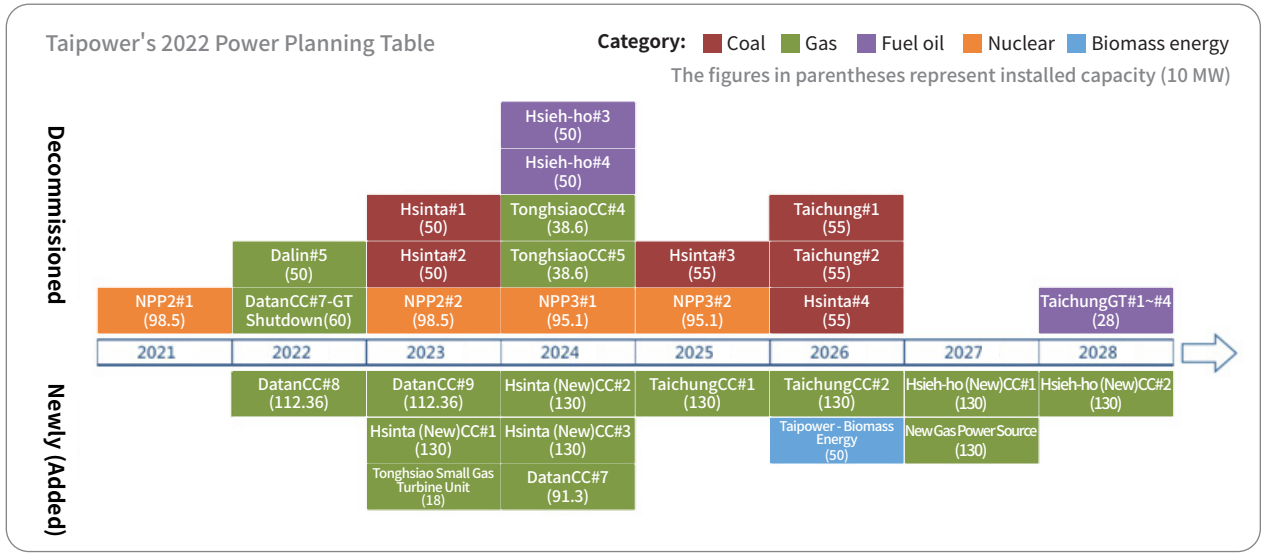
- Strengthen various demand-side management measures to depress peak power demand.
- Review the feasibility of using aging units as emergency backups.
- Ensure the stable operation of existing units and that the construction of new power generation units remains on schedule.

Medium-Term Measures

Taipower continues to push forward with replacing its old plants with new thermal power plants. To facilitate the balance of power supply in Taiwan, improve generation efficiency, and work in conjunction with the government's low-carbon sustainability policy, Taipower has implemented renewal and expansion projects in the northern, central, and southern regions. At present, the renewal and expansion projects include wind, solar, thermal, and hydropower generation.

Long-Term Power Development

Due to growing power consumption and the successive decommissioning of various units, Taipower has planned its long-term power development projects until 2028 with the goal of meeting electricity needs and remaining aligned with the government's energy transition policy and various environmental requirements. The plan is shown in the figure below:



Note: The decommissioning and addition of thermal and nuclear power units by Taipower between 2021 and 2028 is based on the "National Power Resources Supply and Demand Report for the Year 2021" by the Ministry of Economic Affairs.

3.2.2 Renewable Development

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Promoting Renewable Energy

In terms of stimulating renewable development, Taipower has adopted friendly grid connection, demonstration and leadership, and system stability as its three main strategies.

(I) Friendly grid connection: Taipower will strengthen grid infrastructure, provide sufficient feeder capacity, boost the growth of renewable capacity, and assist privately built renewable generators with connecting to the grid smoothly.

(II) Demonstration and leadership: In addition to continuing to invest in renewable developments such as solar, onshore and offshore wind power, Taipower will participate in advanced high-tech energy demonstration projects. The Company will take the initiative to cooperate with industry, government, and academia in development, and then lead the private sector by promoting renewable investment through media publicity, education, and skill development.

(III) System stability: Despite the intermittent nature of renewable generation, Taipower is maintaining system stability and security while raising the penetration rate of renewables through technologies such as smart generation and dispatching, demand-side management, and energy storage facilities.

As the scale of green power production increases, so will the demand for grid connections. Taipower is laying the foundation to meet this need as part of its energy transition policy. In 2021, it finalized Phase 1 of the Green Energy Project and is scheduled to develop a renewable generation system with a total installed capacity of 160 MW between 2022 and 2024. The system will include solar photovoltaic, onshore wind power, geothermal power generation, and other energy types. Regarding the current status of renewable development, solar and wind power are the main focuses of work. In 2022, wind power generation reached 1072.2 GWh and solar photovoltaic generation reached 402.7 GWh.

Renewables Generation Status

	Deployments	Installed Capacity (MW)	Generation in 2022 (GWh)	Number of Households Accommodated
Wind Power	25 sites 192 units	415.24	1,072.2	298,000
Solar	54 sites	287.45	402.7	112,000

Note: According to Taipower's open data statistics, the average monthly power consumption for a typical residential user is 300 kwh and the estimated annual power consumption is about 3,600 kwh.

In response to government policies, Taipower will continue to work on raising the proportion of renewable energy and researching and developing potential renewable sources. Through these actions, the Company hopes to achieve lower carbon emissions and more sustainable electricity for users in Taiwan.

Government and Taipower Renewable Development Targets

	Government's Target		Taipower's Target	
Development Timeline	2025		2025	
Item of Promotion	Capacity (MW)	Power Generation (billion kWh)	Capacity (MW)	Power Generation (billion kWh)
Hydropower	2,122	5	1,825	3.52~4.8
Onshore Wind Power	886	2.2	408.2	1.08~1.15
Offshore Wind Power	5,617	12.3	403.7	1.38~1.59
Solar Photovoltaic	20,000	22.8	469.1	0.58~0.66
Geothermal Power Generation	20	0.102	1.4	0.009~0.01
Fuel Cells	0.7	0.0009	-	-
Biomass Energy	778	4.1	-	-
Total	29,423.7	46.5009	3,107.4	6.57~8.21

Note: The government targets are based on the "Overall Strategy of Green Energy Implementation" briefing by the Bureau of Energy, Ministry of Economic Affairs on July 11, 2021.

The Current Status of Renewable Energy

Taipower will continue to play a leading role in the renewable power industry. In addition to hydropower generation, which has a century of history, the Company has also developed a complete plan for wind and solar power in recent years. Taipower is also investing in research and development for emerging fields such as geothermal and biomass energy. The current development status of renewables promoted by Taipower is as follows:

Current Status of Renewable Energy

Hydropower	To comply with the government's renewable energy policies and continue developing sustainable and stable conventional hydroelectric power, there are currently plans for a number of small-scale hydroelectric projects at various sites. These projects include the Jingshan Small Hydropower Project at the Liyutan Reservoir, the Hushan Small Hydropower Project, the ChiChi Nanan 2 Small Hydropower Project, and the First Phases of other small hydropower projects across Taiwan. The total installed capacity of these projects will reach 26.011 MW. Of the projects, the Jingshan Small Hydropower Project at the Liyu Lake Reservoir began commercial operations in September 2022. The remaining projects are scheduled to gradually begin commercial operations between 2023 and 2024.
Wind power	Since 2000, Taipower has been pursuing wind power development. By the end of 2020, the Company had completed the Jhongtun Wind Power Demonstration Project, Phases 1 to 5 of the Wind Power Generation Project, Penghu's Huxi Wind Power Project, and Kinmen's Jinsha Wind Power Project. There are currently 18 wind fields and 171 wind turbines in operation with a total installed capacity of approximately 306 MW. Phase 1 of the Offshore Wind Power Project is deploying 21 offshore wind power generators in the open sea off Fangyuan Township with a total installed capacity of about 109.2 MW, and an annual power generation capacity of 362 GWh. The project began commercial operations on December 30, 2021. In addition to continuing to develop land-based wind power, Taipower is also expanding wind power in offshore areas. In accordance with the government's plan to promote offshore wind power, Taipower will pursue ongoing planning and development in this area. It is expected that land-based wind power will reach 370MW of generation capacity in 2025. Along with offshore wind power this will help achieve the development capacity target of 403.7 MW.
Solar power	Phase 1 of the Solar Power Project was implemented in 2008. Since that time, a large number of solar photovoltaic systems have been built and, by the end of 2022, approximately 287 MW of solar PV installations have been completed. This includes the Tainan Salt Fields Solar PV Project, which is the largest solar PV project in Taiwan with a capacity of 150 MW. In 2020, the planning for the Green Energy Phase I project was initiated, aiming to add an additional 110 MW of solar PV capacity within the three-year period from 2022 to 2024.
Geothermal power generation	In cooperation with CPC, Taipower is undertaking the Yilan Renze Geothermal Generation Project with a capacity of 0.84MW. It is expected to be operating in 2023.
Biomass power generation	As Taiwan transitions to net-zero emissions, there is an urgent need to increase the number reliable and stable low-carbon energy sources. Internationally, wood pellets, as a carbon-neutral fuel, have been used with coal-fired power units for many years. The relevant technologies are mature and have already been commercialized. In consideration of the successful cases of international coal-fired power plants being transformed into biomass power plants, Taipower has formulated a plan to retrofit its decommissioned coal-fired units into low-carbon biomass units. Taipower plans to retrofit Hsinta's existing coal-fired Unit 1 into a biomass power unit after its decommissioning. The estimated capacity of the retrofit is expected to reach 500MW, with a planned target of generating 3,000 GWh of renewable energy annually.

The Current Status of Renewable Energy Grid-Connections

Taipower is cooperating with the government to promote the development of renewable energy. While ensuring the safe operation of the grid, Taipower has adjusted its grid connection strategy with reference to technology and the latest international development trends. It has also considered financial operating conditions that meet the demands of renewable grid-connection expansion. The number of applications for various types of solar power plants and the corresponding accumulation of capacity are as follows (as of April 19, 2023):

Accumulated Number of Cases and Installed Capacity of Various Types of Solar Power

Case Status		Cases (Number)	Capacity (MW)
Accepted Cases	Under review but not yet approved (A)	4,963	10,161.57
	Approved but currently without a signed contract (B)	6,447	41,225.21
	A contract has been signed but not currently connected to the grid (C)	57,436	14,242.72
	Subtotal (=A+B+C)	68,846	65,629.51
Grid-Connected Cases		56,078	10,539.23
Official Power Purchase Cases		51,010	8,352.61

Committed to Renewable Energy Efficiency

To improve the efficiency of renewable energy power generation, Taipower conducts regular preventative maintenance inspections to reduce unit failure rates. The Company also selects components that use materials with low-carbon footprints to reduce its environmental impact. By strengthening the maintenance of ventilation and air-conditioning equipment in renewable energy power plants and by installing energy-saving control equipment, the power consumption of plants has been reduced. At present, Taipower's onshore plants have set a future target of achieving a basic availability rate of 92.5%. In the future, Taipower will enhance its technical management capabilities and refine its wind energy forecasting system to reduce its failure rate. Meanwhile, through the establishment of a big data analysis system for wind plants, the Company will track the health status of its wind turbines, conduct fault prediction diagnosis, and optimize maintenance schedules. Taipower will also strengthen its management and maintenance of essential component inventories. For solar power, the appropriateness of night power consumption in the photovoltaic field is checked to avoid unnecessary energy consumption and elevate the overall power generated by facilities.

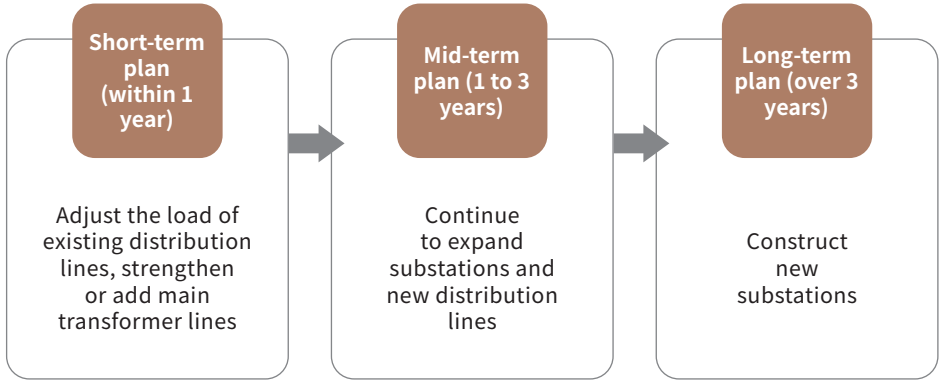
Average Availability Rates of Renewable Energy from 2020 to 2022

	2020	2021	2022
Availability rate of wind power (%)	93.03	92.61	92.05
Capacity factor of solar power (%)	16.02	16.44	16.16

Note:Annual Wind Power Availability Rate = Unit Generating Hours (Including Standby Hours) /Annual Number of Hours
Solar Power Capacity Factor = Annual Power Generation of Units / Device Capacity * Year-Round Hours

Countermeasures to the Renewable Energy Challenge

Since government policy has placed a strong emphasis on solar photovoltaic power, Taipower must meet the demand for large-capacity, ground-based, solar photovoltaic grid connections as soon as possible. Branch offices located in the grid-connected hot zones actively visit local governments and solar photovoltaic installation operators. The offices guide installation operators to integrate with the grid through a centralized deployment method to avoid wasting Taipower's investment. Meanwhile, Taipower has continued to both implement its distribution-grade power grid reinforcement project that will enable increased renewable grid-connections and to promote short, medium, and long-term model plans:



Taipower is cooperating with the Ministry of Economic Affairs to plan a capacity allocation mechanism for joint booster stations. This will allow the Company to maximize its utilization of limited power transmission resources. To date, Taipower has formulated capacity allocation guidelines and operating procedures. In addition, Taipower has planned specific solar photovoltaic areas so it can appropriately allocate resources to developing joint booster stations with the capacity to accelerate renewable grid-connections.

To facilitate easy accessibility to information, Taipower established a renewable application progress query system so that the public can make immediate inquiries regarding the status of project applications. There is also a distribution-grade renewable capacity query system that guides developers that are searching for sites to build solar photovoltaics in areas where the grid-connecting capacity is still abundant. As Taipower is actively promoting wind, solar, geothermal, and small hydro renewable energy development projects, it is necessary for the Company to provide a friendly, grid-connection environment for private industry that is seeking to pursue green energy power generation. These steps are facilitating Taipower's move towards actualizing the government's goal of 20% renewable energy by 2025.