# 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<br>• 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.<br>• 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.<br>• Quarterly follow ups on reviews and execution.<br>• 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.<br>• 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.<br>• 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.<br>• 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.<br>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.<br>• 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.<br>• 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.<br>1. Drill/drill performance.<br>2. Participation in the drills of the emergency response organization.<br>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.<br>• 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.<br>• 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.<br>• 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 |