CHAPTER 04

Leader of Smart Grid Development

Development Vision

Technology is changing our world at an astonishing pace. The wave of artificial intelligence (AI), rapid changes in information and communications technology (ICT), breakthroughs and innovations of big data, blockchain, and cloud technology have all overturned the business models of the past and revolutionized many industrial applications. Taipower is committed to using research and innovation to propel the development of low-carbon electric power. The Company actively invests in smart grid deployment, introduces new technologies, improves its management efficiency, and increases its operational effectiveness. It has also applied itself to meeting the important infrastructural demands of renewable energy.

Taipower is in alignment with the government's policies and plans. In the short term, the Company is focused on enhancing operational flexibility, developing a stable power supply network with a high proportion of renewable energy, and strengthening its flexible dispatching capabilities for grid supply, demand, and outages. In the medium term (by 2025), the Company will be focused on reinforcing grid resilience and establishing a safe and highly adaptable grid that can respond to climate change. In the long term (by 2030), Taipower will have implemented reforms in the electricity industry, increased the prevalence of low-carbon energy, devoted itself to the development of a safe and reliable grid, and propelled open and transparent information and fair market transactions.

Performance Highlights

- By the end of 2022, there had been more than 2.108 million AMI installations encapsulating 81% of the nation's power use information. It is estimated that 3 million AMI smart meters will be deployed by 2024.
- In 2022, the real-time monitorable capacity of renewables reached 4.26GW.
- The deployment of 100 kilometers of optical cables, 42 sets of fiber optic communication systems, 720 communication circuits, and 590 sets of routers was completed in 2022.

4.1 Smart Grid General Planning

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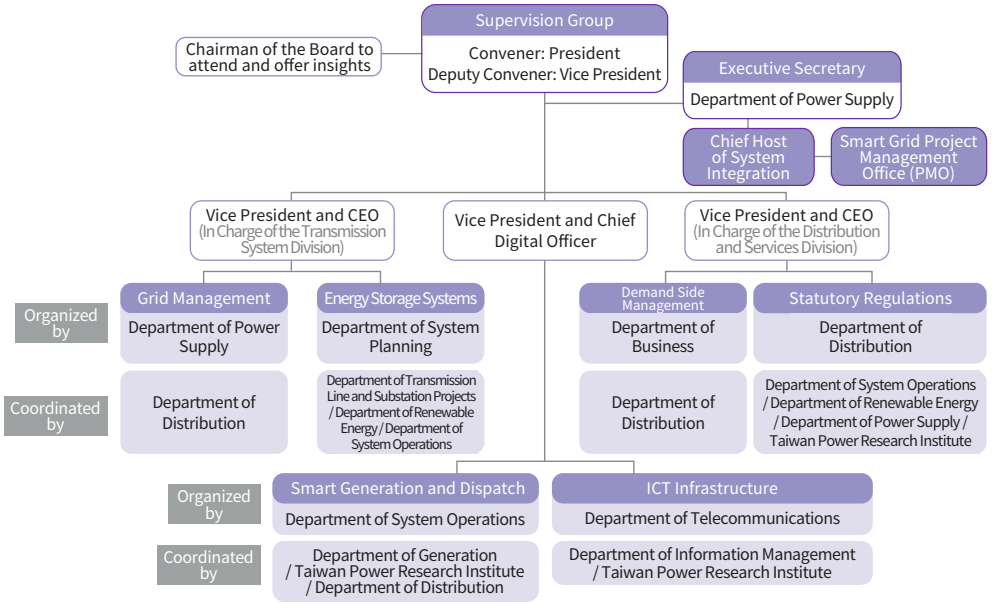
Smart grids are vital to driving energy transition, leading industrial transformation and new economic development. Taipower is proactively reducing the impact of renewable energy generation's intermittency, enhancing grid resilience, and strengthening and consolidating power transmission and distribution systems. Additionally, tthe Company is committed to improving disaster prevention and troubleshooting capabilities while increasing the system's supply and demand performance, incorporating load management methods and enhancing user participation opportunities through progressively building a stable and effective smart grid.

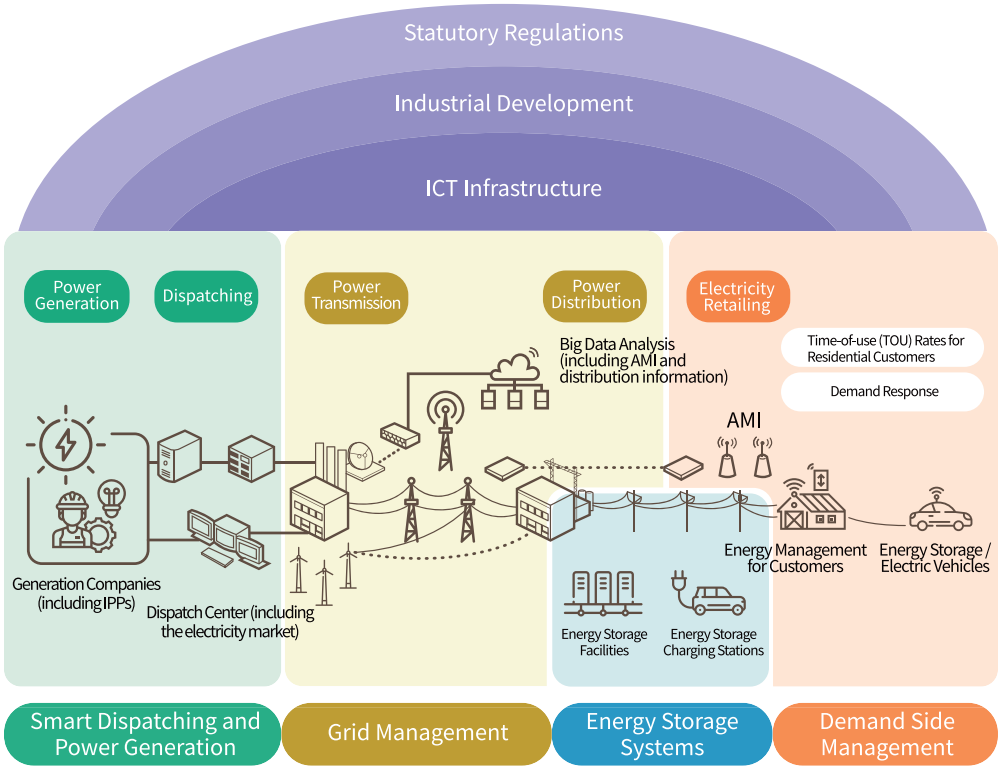
In developing the smart grid, the priority objectives are: (1) responding to the challenges of renewable energy grid connections, (2) strengthening the resilience of existing grids to enhance power supply quality in the face of extreme climate, and (3) encouraging user participation in energy conservation to improve power system operating efficiency. In response to the broader Smart Grid General Plan, Taipower formed an internal Smart Grid Task Force with the Company's president as convener. Regular meetings with relevant units are held to review projects, execution status, and future planning directions.

Smart Grid Task Force



Smart Grid Action Plan

On March 27, 2020, Taipower began to carry out smart grid construction in accordance with The Smart Grid Master Plan as approved and amended by the Executive Yuan's Bureau of Energy. The plan is oriented towards problem-solving and system integration, and is divided into 7 key strategic areas, 21 specific practices, and 14 checkpoint objectives. Taipower is mainly responsible for five areas, 17 specific practices, and 13 checkpoint targets. The Company continuously implements and reviews its performance in these areas to strengthen its energy management and grid resilience.



The Smart Grid General Planning Framework

Key Strategic Areas (7 items)	Specific Practices (21 items)
Smart dispatching and power generation	· Establish a renewable energy generation monitoring system · Establish an energy trading platform · Establish a big data damage monitoring system for the boiler tubes of coal-fired units · Undertake ancillary service demand research
Grid management	· Apply and promote transmission system data in planning, operations, and maintenance · Apply and promote feeder automation system data
Energy storage systems	· Construct an energy storage system at a Taipower site · Establish an ancillary service procurement mechanism
Demand side management	· Establish a low voltage Automated Meter Infrastructure (AMI) · Apply AMI data · Review electricity price structures and run trials on dynamic prices · Review and run trials on various demand response schemes
ICT infrastructure	· Enhance security of the smart grid information program · Enact a smart grid data application plan · Establish an upgrade plan for backbone/regional fiber optics communication systems · Introduce an electrical IoT communication system to the plan
Industrial development	· Expand product and system services (Industrial Development Bureau) · Drive enterprises to participate in the electricity market (Industrial Development Bureau)
Statutory regulations	· Review current electricity-related regulations (Bureau of Standards, Metrology and Inspection) · Refine renewable generation system interconnection technology (Taipower) · Develop national standards for smart grids and establish an equipment testing platform (Bureau of Standards, Metrology and Inspection)

Smart Grid Performance in 2022

Taipower experienced several major achievements this year within the five fields under its purview. They are described as follows:

Smart dispatching and power generation

The Company consolidated existing renewable energy generation and established an information management platform, created platforms for power market trading and coal-fired unit big data monitoring, and introduced a Distribution-level Renewable Energy Advanced Management System (DREAMS). The real-time monitoring capacity of renewable energy (GW) reached 4.26 GW in 2022.

Grid management

Plan, operate, and maintain transmission system data, and consolidate information to strengthen the management of power transmission and distribution assets. In 2022, the average failure time of transmission system equipment was 0.373 hours/year.

Energy storage system

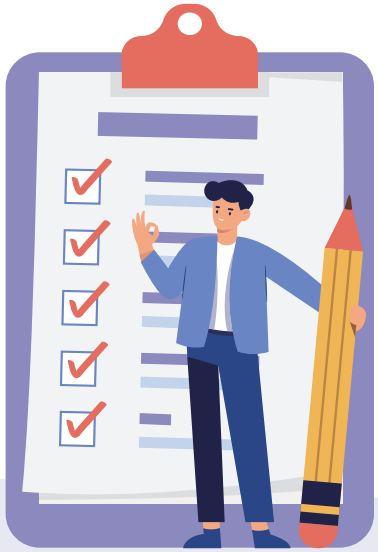
The capacity of energy storage systems reached 150.8 MW.

Demand side management

Taipower is targeting potential power-saving users in its deployment of smart meters. By the end of 2022, a total of 2.108 million high-voltage AMIs had been installed.

ICT infrastructure

Completed the installation of 100 kilometers of optical cables, 42 optical fiber communication systems providing 720 communication circuits, and installed 590 sets of routers in 2022.



Smart Grid Performance and Target

Review Objectives	2022 Target		2022 Performance	2025 Target (Approved Version)
1. Real-time monitorable capacity of renewables (GW)	7 GW		4.26 GW (Wind power 1.52 GW; Solar photovoltaics 2.74 GW)	16.5 GW
2. Accuracy of renewable forecasts (Day-ahead / hour-ahead error rate %)	Wind power	13% / 6.5%	8.78% / 4.8%	10% / 5%
	Solar photovoltaics	12% / 6%	5.00% / 3.42%	10% / 5%
3. Ancillary service reserve (MW)	Regulation reserve	1,000 MW	1,000 MW	1,300 MW
	Real-time reserve	1,100 MW	1,149 MW	1,100 MW
	Supplemental reserve	1,100 MW	1,193 MW	1,100 MW
4. Number of electrical and mechanical accidents (Times / year)	16		8	15
5. Equivalent Unavailability Factor (EUF) of coal-fired power plants (Total hours of equiva lent tube rupture outage)	Under 1.35% (Under 118 hours / unit / year)		0.09% (7.5 hours / unit / year)	1.2% (105 hours / unit / year)
6. Average time for transmission system equipment failure (Hours / year)	1.44		0.373	1.42
7. The ratio (%) of power recovery outages for downstream automated feeders (within five minutes)	35%		49%	70%
8. Capacity of energy storage systems (MW)	102 MW		150.8 MW	590 MW[Note]
9. AMI smart meter infrastructure (cumulative number of households)	2 million households		2.108 million households	3 million households (by 2024)
10. AMI user power use data available online for inquiry (hours)	Within five hours		Within five hours	Within four hours (Two hours for TOU customers)
11. Participation in demand response scheme (GW)	2.6 GW		2.77 GW	2.8 GW
12. Bandwidth improvement of backbone / regional fiber optics system (Gbps)	100Gbps backbone network optimization		✓Completed on-site installation of 590 sets of IP-MPLS system area network (10Gbps) routers. ✓Completed the draft plan for the next-generation optical transport network (OTN) system.	Regional 10Gbps (Complete in 2023)
13. Introduction of IDS information security protection	Promote experimental sites (8 domains)		Building completed on 8 domains	Complete all dispatch centers (32 domains)

Note: According to the "National Power Resource Supply and Demand Report for the Year 2022" published by the Bureau of Energy in July 2023, Taipower has set a target to install 1000MW of energy storage batteries by 2025.

The Smart Grid Index (SGI)

The Singapore Smart Grid Index (SGI) is an international assessment of smart grid development. It evaluates the progress of power companies in implementing smart grid initiatives based on seven main themes: customer empowerment and satisfaction, cybersecurity, renewable energy, integration of distributed energy resources, power reliability, data analysis and monitoring, and control. The research covers the Asia-Pacific region, Europe, and the Americas.

The report surveyed a total of 94 power companies from 39 countries worldwide. Enedis, a subsidiary of the French electricity holding group EDF, achieved the highest score of 98.2 and secured the top position. Taipower and UK Power Networks (UKPN) tied for second place with scores of 94.6. Taipower has consistently maintained its position on the list, outperforming other well-known Asian power companies from Japan and South Korea.

2022 BENCHMARKING RESULTS

Utility	Country/ Market	Score
Enedis	FRA	98.2
TaiPower ★	TWN	94.6
UKPN	GBR	94.6
ConEd	USA	92.9
WPD	GBR	92.9
CitiPower	AUS	91.1
DEWA	ARE	89.3
SP Energy Networks	GAR	89.3
SDGE	USA	87.5
FPL	USA	85.7

4.2 Smart Grid Application – A Vehicle-to-Grid Bi-directional Charging System

Taipower Partnered with Gogoro to Build the World's First Electric Scooter V2G Battery Exchange Station

As a result of the trends of energy transition, working to achieve net-zero-carbon emissions, and the increasingly widespread adoption of electric vehicles, the effective conversion of substantial electricity demand into power supply poses a significant challenge. To meet this challenge, Taipower, in addition to actively pursuing the development of renewable energy sources, is exploring innovative approaches beyond the conventional paradigm of large-scale power plant construction. By leveraging emerging technologies, Taipower aims to introduce diverse power sources. As part of this effort, Taipower is collaborated with Gogoro, a prominent electric scooter manufacturer, to establish the world's first electric scooter battery swapping station featuring Vehicle-to-Grid (V2G) functionality. This pioneering initiative expands upon the internationally acclaimed battery swapping business model by incorporating the added capability of bidirectional power transmission. Consequently, it not only facilitates the creation of a decentralized energy storage virtual power plant but also fosters enhanced grid stability and cultivates novel business models for electricity trading, thus fostering a mutually beneficial future.

Unlike the current battery swapping stations that only support one-way charging, the V2G battery swapping station has the capability of bidirectional charging and discharging. It also has a power capacity of 60 kWh, which can provide electricity for an average household's needs for 4 to 5 days. With the integration of an energy management system, it can intelligently schedule charging, turning the distributed battery swapping stations into decentralized energy storage stations that can also feed electricity back to the grid. As of November 28, 2022, Gogoro has deployed a total of 12,292 battery swapping cabinets across Taiwan, with a total system battery capacity of 1.59 GWh (including the battery swapping stations and batteries on electric scooters). This amount of electricity is sufficient to power the entire city of Taipei for 53 minutes.

At the demonstration site of Taipower's V2G technology, the Energy Management System (EMS) has integrated V2G battery swapping stations/charging piles, small-scale green energy/storage units, and controllable loads. The system has successfully completed functional verification related to V2G technology. Currently, the demonstration site is conducting tests with a schedule of charging from 8 a.m. to 12 p.m. and discharging from 4 p.m. to 8 p.m. This will provide understanding on whether there is an incentive for business operators to feed electricity back to the grid under different electricity pricing schemes. It also allows for the calculation of energy consumption during the charging and discharging process. The results show that from January 1, 2022 to November 18, 2022, a total of 10,452 kWh of electricity has been fed back to the grid, indicating that there is an incentive to attract business operators to feed electricity back to the grid.

In addition to focusing on system design to reduce electricity loss, ongoing research endeavors also involve leveraging the advanced capabilities of the Gogoro Network, such as its big data analytics, artificial intelligence (AI), and machine learning. By harnessing these technologies, participants aim to enhance the intelligent management of batteries, and ultimate achieve grid balance. The ultimate goal is to transform the smart battery swapping platform into an indispensable energy storage facility within the power grid.

Future Research Development and Prospects

In response to the government's energy transition and the transformation of the power industry ecosystem, as well as to achieve the phase goal of net-zero transformation by 2025, Taipower is making changes to both generation forms and fuel types. Simultaneously, the Company is decommissioning and replacing old units with high-efficiency and environmentally friendly equipment such as advanced ultra-supercritical units to improve power generation efficiency and reduce air pollutant emissions.

Furthermore, the power generation, grid, and user consumption patterns are shifting from the traditional centralized model to a decentralized model where distributed generation facilities are combined with energy storage systems to form microgrid structures. User demand response is coordinated through neighboring microgrids, while the overall power supply stability is balanced through a large-scale transmission network. This approach aims to simultaneously meet electricity demand and grid reliability, reducing the probability of grid accidents.

Taipower's research and development efforts focus on promoting new technologies, addressing operational issues, and dealing with significant company and government decisions. The "6-3-1 Research and Development Investment Portfolio" is used to plan and formulate research and development directions. The Future Power Technology Forecasting Program is utilized to identify key technological developments that enhance grid resilience, ensure stable power supply, drive energy transition, and facilitate corporate transformation. The development of high and low voltage systems, energy storage, and other technological plans are designed to meet future operational development trends, align with electricity market demands, achieve a sustainable balance in society, the economy, ecology, and environment, and to create new value in the development of innovative technologies for the enterprise.