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再生能源：
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輸 變 電：
TRANSMISSION AND TRANSFORMATION：

能源與環境：
ENERGY AND ENVIRONMENT：

工程技術：
ENGINEERING TECHNIQUES：

太陽光電發電系統運轉效能分析及診斷評估技術

Operational Efficiency Analysis and Diagnostic Evaluation Technologies of Solar PV Systems

詹麒璋* Chan, Chi-Chang
曾美惠* Tseng, Mei-Hui
謝建俊* Hsieh, Chien-Chun
林武煌** Lin, Wu-Huang
胡克鴻** Hu, Ke-Hung
許天成** Hsu, Tien-Cheng

摘　要

國內太陽光電系統設置容量逐年擴增，單一案場之容量也愈來愈大，系統運維管理將成為相當重要的關鍵工作，運維管理能做得好，才能確保整體系統發電的長期安全性與可靠度。本研究為台電公司電源開發處與工研院綠能所合作，共同進行太陽光電系統運轉效能分析及診斷評估技術之發展建立，並以再生能源處永安鹽灘地太陽光電發電系統及台中龍井太陽光電發電系統二處實際案例進行PV電廠運轉效能分析及檢測、診斷、評估，除了解該系統的運轉狀況及發電性能外，並驗證運轉效能分析及診斷評估技術與方法的可行性與應用效益，利用此方法與技術將可掌握系統發電狀況，達到提升太陽光電系統運轉效能及提升電廠安全性與可靠度之效益。本文限於篇幅僅針對永安鹽灘地案場作執行說明與案例探討。

Abstract

The installed capacity of domestic solar photovoltaic (PV) systems is increasing year by year, and the single site capacity PV is also getting larger. The quality of system operation and maintenance (O&M) management is becoming a key factor for PV systems to maintain long-term security and reliability. This research is based on the development of solar PV system's operation efficiency analysis methods and diagnostic evaluation technologies developed by the Power Development Department of Taiwan Power Company (TPC) and the Green Energy and Environment Research Laboratories of Industrial Technology Research Institute (ITRI). Two actual cases are used to examine PV power plant's operation performance analysis and detection, diagnosis, and evaluation at two TPC PV power plant sites, one at Kaohsiung Yong'an Salt Land, the other at Taichung Longjing. In addition to understanding the operation status and power generation performance of the two systems, another purpose of this study is to verify the feasibility and application benefits of the operation efficiency analysis methods and diagnostic evaluation technologies. The aforesaid

*財團法人工業技術研究院綠能與環境研究所
**台灣電力公司電源開發處

methods and technologies may help us keep track of the power generation status of PV systems, so as we may improve the system operation efficiency and the security and reliability of PV power plants. Due to the limitation of length, we regret that this article can only introduce the implementation and the case study of Yong'an Salt Land.

關鍵詞(Key Words)：太陽光電發電系統(Solar Photovoltaic Power Generation System)、系統建置規劃評估(Planning Assessment for System Building)、運轉效能評估(Operational Effectiveness Evaluation)、系統診斷分析(System Diagnostic Analysis)、系統更新改建(System Renewal and Reconstruction)。

大量再生能源併入下彈性機組與儲能調度的研究

Research on the Scheduling of Flexible Generators and Energy Storage Systems under High Renewable Generation Proportion Scenario

吳元康* 江宇双* 黃崢亮* 寧家慶**
Wu, Yuan-Kang Chiang, Yu-Shuang Huang, Cheng-Liang Ning, Chia-Ching

摘 要

台灣再生能源占比逐年提升，然而再生能源的變動與不確定性對未來傳統機組調度帶來極大的挑戰。因此，電力系統的發電彈性在大量再生能源併入下更形重要，其中加入彈性發電機組以及儲能系統是提升電力系統彈性最直接的方法。本研究的主旨在於探討發電彈性對於機組排程成本的影響。在研究過程中，分別使用彈性指標來評估系統的發電彈性值，並考慮再生能源發電的多情境分析。接著考慮實際水火力機組調度的限制條件、彈性內燃機組以及儲能系統的調度、以及再生能源削減。最後，本研究依據各季節再生能源的發電特性，具體建議彈性機組與儲能可以準備的合適容量。研究結果指出，當系統加入適當彈性內燃機組以及儲能系統後，可有效率地降低機組排程的成本。本研究的成果可以供未來大量再生能源併入下增加彈性機組與儲能系統的參考。

Abstract

The proportion of renewable power generation (RPG) in Taiwan has been increasing in recent years. However, the fluctuation and uncertainty of RPG pose a huge challenge on generation scheduling/unit commitment. Therefore, the flexibility of generation scheduling has emerged as an important issue when more and more RPG integrating into the power system. Flexible generators and energy storage systems (ESSs), among others, are two of the most direct methods to improve power system flexibility. The main purpose of this research is to explore the impact of generation flexibility on the costs of generation scheduling/unit scheduling. In this research, we used an index to evaluate the generation flexibility of power systems under different renewable generation scenarios, taking into consideration the factors of the constraints of unit commitment of hydro and thermal units, scheduling of flexible internal combustion engines (ICE) and energy storage systems, and curtailment of renewable power generation. Based on seasonal characteristics of renewable generation, we concluded that the cost of generation scheduling may be

*國立中正大學電機系
**台灣電力公司輸供電事業部電力調度處

significantly reduced when flexible ICE units and ESSs are accommodated. The results of this study may serve as reference for Taipower to get ready for a high proportion RPG scenario in the future.

關鍵詞(Key Words)：再生能源 (Renewable Energy)、機組調度(Unit Commitment)、發電彈性(Generation Flexibility)、彈性指標(Flexibility Index)、內燃機組(Internal Combustion Engine)、儲能系統(Energy Storage System)。

架空輸電線路防猴裝置創新技術

An Innovative Approach of Overhead Transmission Line Anti-monkey Device

陳永樂* 吳清木* 陳武昌*
Chen, Yung-Le Wu, Ching-Muh Chen, Wu-Chang

王家興* 王俊仁* 李炫輝* 吳啓瑞*
Wang, Chia-Hsing Wang, Chun-Jen Li, Syuan-Huei Wu, Ci-Ruei

摘 要

傳統的防猴設備裝置於架空輸電線路支持物上，有桿身加裝流刺網、不鏽鋼鋼板、烤漆鐵板、刮刀刺網、支線加裝PVC管並塗抹黃油等等，但長達60年的時間，我們不斷在改進及補強這些裝置，還是發生了猴害，造成線路跳脫事故，還造成維護及施工人員傷痕累累。專注的觀察猴子的習性，我們發現這個猴齊天的後代，真的無從防堵、牠可以飛上導線、走在線上及爬過刮刀刺網，直到接近送電線而發生閃絡事故。「輸電設備與大自然共生共存」，只要送電線不要跳脫，何不讓輸電線路融入大自然，讓路過的飛禽走獸不受傷，為了達成這個理想，我們創新了絕緣膠帶纏繞輸電線工法，成功的証實能100%達到防猴效果，並提升供電品質及確保人員安全。

Abstract

Traditionally, anti-monkey devices are installed on overhead transmission line supports, such as poles with barbed wire fence, stainless steel plates, painted iron plates, concertina wire fence, branch lines with PVC pipes and grease, etc. In spite of continuously improving and strengthening the devices in the past 60 more years, damages caused by monkeys still occur, e.g., accidents of line tripping and injuries of maintenance and construction personnel. By observing monkeys' habits, we realize that it is almost impossible to block them- they jump on wires, run on wires, and crawl over the barbed wire fence before they approach transmission lines and cause flashover accidents. "Transmission equipment coexists with nature." Only if the lines do not trip and the creatures do not get hurt, why not let transmission lines and the nature merge into one. To achieve the aforesaid goal, we innovated a construction method by wrapping 25kV Heat Shrinkable Busbar Insulation Tape around the transmission line. It is proved the method is 100% effective in anti-monkeys, improving quality of power supply, and ensuring the safety of personnel.

關鍵詞(Key Words)：架空輸電線路 (Overhead Transmission)、25kV級熱融膠的熱縮式絕緣膠帶(25kV Heat Shrinkable Busbar Insulation Tape)、阻斷電氣路徑(Galvanic Isolation)。

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*台灣電力公司輸供電事業部高屏供電區營運處

新式鐵塔接地電阻改善方式與成果分析

Achievement Analysis of a New Method Improving Grounding Resistance of Towers

曾國光* 黃俊文* 許　文* 尤子瑋**
Tseng, Kuo-Kuang Huang, Jung-Wen Syu, Wun Yu, Tzu-Wei

摘　要

本文係研究一種新式鐵塔接地電阻改善方式，在有限的土地範圍內規劃出三維接地網的建構方式施作，並藉由低電阻係數的土壤包覆接地線，而達到降低鐵塔接地電阻效益。將該研究應用於69kV屏東~長治線#65、＃66、＃67及屏東~內埔線＃37、＃38、＃39等6座鐵塔，經驗證確實可有效大幅降低鐵塔接地電阻值，這對輸電線路防止雷害事故助益甚大。藉由本文的說明，提供一種新式鐵塔接地電阻改善方式[1]，希望可作為日後設計人員在遇到類似案件時之參考。

Abstract

This study aims to develop a new method to improve ground resistance of transmission towers. A three-dimensional grounding grid was planned and constructed within limited land area accompanied with grounding wire covered by soil of low resistivity to reduce grounding resistance of towers. The method was applied to six TPC towers, namely 69kV Pingtung~Changzhi line #65, #66, #67 and Pingtung~Neipu line #37, #38, #39. As the results indicated, the method may significantly reduce grounding resistance of transmission towers and add great value to preventing lightning accidents of transmission lines. We are happy to see the results of this study to serve as reference for future applications of the like.

關鍵詞(Key Words)：鐵塔(Tower)、接地電阻(Ground Resistance)、電阻係數(Resistivity)。

*台灣電力公司輸供電事業部高屏供電區營運處
**台灣電力公司輸供電事業部供電處

運用 GOOSE 配置測試程序驗證 IEC 61850 GOOSE_1 策略應用

The Strategic Application of IEC 61850 GOOSE_1 Verification via GOOSE Configuration Test Program

黃顯順*
Huang, Hsien-Shun

摘　要

當兩饋線於短時間內同時故障，流經主變二次側Main之故障電流大於下游饋線之故障電流，致使Main的保護協調51/51N動作時間可能較饋線51/51N動作時間快而造成越級跳脫事故，為避免越級跳脫事故造成更大的供電損失，故發展IEC 61850 GOOSE_1策略來加速兩饋線同時故障跳脫，避免越級動作以提高系統供電穩定能力。惟傳統採用硬線測試電驛之方式測試GOOSE_1邏輯耗時太長，且測試需停止所有饋線之送電，為改善這兩項缺點，故開發此GOOSE配置測試技術程序，不但可大幅度縮短測試時間，亦可在不停電狀況下針對欲汰換之電驛做單體測試，經實際於蘇東D/S驗證本文可行且必要，可供所有電驛同業做參考。

Abstract

When two feeders fail simultaneously, the fault current flowing through the secondary side of a main transformer might be greater than its downstream feeders, resulting the main transformer's 51/51N protection coordination reaction time faster than the feeders' 51/51N reaction time, and cause an overreach trip accident (OTA). To prevent huge power losses caused by OTA, IEC 61850 GOOSE_1 strategy has been developed to accelerate and enable the said two feeders to trip simultaneously, so as to prevent OTA and enhance stability of power supply. As it takes longer time to test GOOSE_1 logic via traditional hard-wire test relay method and needs to cut off the power supply of all feeders, the modular GOOSE configuration test program is developed to improve the shortcomings. The application may significantly shorten the test time and can be performed without cutting the power supply of all feeders. The test results verified by SuDong D/S have proved the feasibility and necessity of the application and may serve as reference for the company.

關鍵詞(Key Words)：IEC 61850、GOOSE_1策略應用(GOOSE_1 Strategy Application)、GOOSE配置(GOOSE Configuration)。

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*台灣電力公司輸供電事業部台北供電區營運處

台電公司碳限制議題研析

The Analysis of Carbon Constraint Issues for Taiwan Power Company

溫桓正* Wen, Huan-Cheng
趙德琛* Chao, Der-Chen
張語妮* Chang, Yu-Ni
顏素絹** Yen, Su-Chuan
白凱棣** Pai, Kai-Ti
陳秀玟** Chen, Hsiu-Wen

摘　要

政府間氣候變化專門委員會指出，為實現《巴黎協定》目標，全球須在本世紀中葉達到淨零排放(溫室氣體排放量與碳匯量達成平衡)，以避免最嚴重之氣候影響。截至2021年8月，全球已有134個國家(含歐盟)宣示淨零排放。

我國《溫室氣體減量及管理法》明定減量目標為「2050年排放量必須減少至2005年排放量50%以下」，為我國氣候變遷政策之法治基礎。近年因應國際減碳趨勢，各界關注我國是否有加強碳限制之作為，環保署刻正啟動溫管法修法，預期提高我國減量目標，因台電公司為能源部門之主要排放者，將面臨電力排碳係數、碳定價管制及淨零排放等碳限制困境，皆會對台電公司造成衝擊。

本文掌握國際溫室氣體減量相關議題及發展情勢，評估國內政策與法規對台電公司之碳限制及影響，並探討困境下之因應對策，為台電公司建構碳限制管理能力。

Abstract

As the IPCC (Intergovernmental Panel on Climate Change) special report on global warming suggests, human society needs to reach net-zero emissions (NZE) before 2050 to avoid severe climate impacts. By July 2021, a total of 134 countries have made the pledge. According to the Greenhouse Gas Reduction and Management Act (the Act), the legal foundation for Taiwan to cope with climate change, Taiwan shall reduce GHG emissions by 50% by 2050, comparing with its emission level of 2005. In response to the global trend of NZE and EU's carbon border adjustment mechanism (CBAM), the Environmental Protection Administration (EPA) has initiated amendment of the Act. As we all know, the energy sector is the main emitter of GHGs. Therefore, NZE policy and relevant regulation, e.g., carbon reduction target and carbon pricing policies, will certainly pose challenges for Taiwan Power Company (TPC). This article aims to evaluate the impacts of carbon constraint policies and relevant regulations and explore the coping strategies for TPC.

關鍵詞(Key Words)：電力業(Electric Power Industry)、淨零排放(Net Zero Emissions)、溫室氣體(Greenhouse Gases, GHGs)、電力排碳係數(Electricity Carbon Emission Factor)、碳定價(Carbon Pricing)、碳限制管理(Carbon Constraint Management)。

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*台灣電力公司環境保護處
**永智顧問有限公司

建置供電單位防災預警系統及應用即時動態定位(RTK)評估之可行性研究

Feasibility Study on Establishing Disaster Early Warning System for TPC's Power Supply Departments and RTK Applicability Assessment

周昱緯* Chou, Yu-Wei
徐力平** Hsi, Lee-Ping
韓仁毓*** Han, Jen-Yu
張嘉峰** Chang, Chia-Fong
林子剛**** Lin, Tzu-Kang
廖惠菁** Liao, Hui-Ching

摘 要

臺灣位於環太平洋地震帶及夏季颱風常經之路徑上，因此，地震、颱風等天然災害頻仍，加以臺灣地區坡陡流急、地質脆弱，故山區易因地震、颱風、豪雨等天然災害而導致邊坡崩塌、土石流等災害，危及山區輸電鐵塔之安全。因應近年來極端氣候對塔基邊坡滑動影響供電穩定之問題，本文應用定置型傾斜計等邊坡監測儀器搭配即時動態定位系統，於台電公司345 kV大觀、明潭~鳳林線，以及161 kV鳳林~花蓮線之5座山區鐵塔，辦理塔基邊坡防災預警系統建置及應用即時動態定位評估研究，本研究並規劃由動態定位系統、結構監測系統、塔基監測系統及環境監測系統等四大系統組成之感測系統來進行目標鐵塔之監測工作，並由後臺管理系統提供預警功能，於塔基監測管理平台中以燈號顯示監控設備之警示訊號，使鐵塔維護管理人員可透過使用者監測介面，獲取雲端資料數據，立即掌握監測鐵塔之狀況。

Abstract

Taiwan is located on the Pacific Rim Seismic Belt and the moving paths of typhoons. Natural disasters, such as earthquakes and typhoons, are not only frequent, but constantly intensified by steep slope, rapid river and fragile geology. Mountainous areas especially are prone to natural disasters, as it is said, slope collapse, mudflow and landslide due to earthquakes, typhoons, heavy rains, among others. These disasters pose threats to power transmission towers in mountainous areas. In response to the problems, the application of in-place inclinometers, surface tiltmeters, and real time Kinematic (RTK) positioning technique have been used at five TPC transmission towers- the towers of 345kV Daguan, Mingtan ~ Fenglin Line, and 161kV Fenglin ~ Hualian Line. This research aims to establish a disaster prevention and early warning system and assess the applicability of RTK for slopes with tower foundations. The monitoring system is composed of four subsystems, namely RTK system, structural monitoring system,

*台灣電力公司綜合研究所
**財團法人臺灣營建研究院
***國立臺灣大學土木工程學系
****國立陽明交通大學土木工程學系

geotechnical monitoring system, and environmental monitoring system. At the same time, a data analysis and management system is built to calculate and manage the monitoring data and to provide early warnings. The warning signals of the monitoring instrument, displayed with lights in the tower monitoring and management system (TMMS), may enable the tower maintenance and management personnel to obtain cloud data through TMMS and keep track on the towers under monitoring in real time.

關鍵詞(Key Words)：即時動態定位(Real Time Kinematic Positioning)、邊坡監測(Slope Monitoring)、監測管理系統(Monitoring and Management System)、防災預警(Disaster Prevention and Warning)。