台電工程月刊926期(10月)目錄

新及再生能源：
NEW AND RENEWABLE ENERGY :

火力發電：
FOSSIL POWER GENERATION :

電力系統：
POWER SYSTEM :

減　　碳：
CARBON REDUCTION :

以 PLEXOS 模型為基礎之年度電源運用計畫平台建置研究

Development of an Annual Power Resource Utilization Planning Platform Based on the PLEXOS Model

李孟穎* Lee, Meng-Ying
陳冠彰* Chen, Kuan-Chang
邱雅暄* Chiu, Ya-Hsuan
蔣佳佑** Jiang, Jia-Yo
翁郁棋** Weng, Yu-Chi
賴鋼樺*** Lai, Kang-Hua
何亮霖*** Ho, Liang-Lin
楊宗霖**** Yang, Tsung-Lin

摘 要

年度電源運用計畫乃台電公司產銷計畫與燃料採購規劃的依據。在近年能源與淨零轉型推動下，減煤與環保限制、溫室氣體減排目標、再生能源發展目標等，逐漸對我國電源規劃與電力調度帶來挑戰。

為精進年度電源運用計畫評估程序，本研究以 PLEXOS 軟體為核心，建立一套完善之作業程序與介面系統，整合並建構電源規劃模擬所需參數與限制條件，將當年度可用燃料資源與環保政策納入評估程序，並配合 IPP 機組合約、歷史實績、負載預測、以及各類外部限制條件，實現可根據每月實績及限制滾動更新之年度電源運用計畫，再藉由可視化圖表分析與比較模擬結果，以利探討當年度不同外部限制情境或能源情勢對於年度電源運用計畫的影響，預先因應未來負載變化或各類影響電源運用之政策與發展趨勢。

Abstract

The annual power resource utilization plan serves as the foundation for Taipower's production, sales, and fuel procurement strategies. With the ongoing energy and net-zero transition, challenges such as coal reduction policies, environmental constraints, greenhouse gas emission targets, and the expansion of renewable energy have significantly impacted power resource planning and dispatch operations in Taiwan.

To enhance the evaluation process for annual planning, this study develops a comprehensive operational procedure and interface system centered on the PLEXOS modeling platform. The system integrates essential parameters and constraint conditions required for power resource simulations, incorporating current-year fuel availability, environmental regulations, independent power producer (IPP) contracts, historical operational data, load forecasts, and a variety of external limitations.

By enabling rolling updates to the annual plan based on monthly performance and constraint changes, the platform facilitates dynamic scenario analyses. Visualization tools further support comparative assessments of simulation outcomes under different policy or energy context scenarios, helping anticipate future load variations and adapt to emerging regulatory and development trends in power system operations.

關鍵詞(Key Words)：電源規劃(Power Resource Planning)、最佳化模擬(Optimization Modeling)、電力調度(Power Dispatch)、整合資源規劃(Integrated Resource Planning)、平台開發(Platform Development)。

*工業技術研究院
**德瀚資訊有限公司
***拓圖科技有限公司
****台灣電力公司綜合研究所

大量再生能源下大型(輸電級)儲能應用發展

Transmission-Level Energy Storage Applications for Large-Scale Renewable Integration in Taiwan

張家銘* Chang, Chia-Ming
鄭信宣* Tang, Samuel Sin-Shuan
謝曉惠** Hsieh, Hsiao-Hui
廖清榮** Liao, Ching-Jung
戴孜青*** Tai, Tzu-Ching
郭政謙* Kuo, Cheng-Chien

摘　要

隨著能源轉型，我國以短期 2025 年再生能源占比達 20%為發展目標。然而，再生能源滲透率的提升，電力系統的穩定度將備受考驗。近年許多國家已將電池式儲能做為再生能源發展的配套措施，透過加入適量的電池式儲能系統以輔助電網供電，帶來可靠、安全與經濟的效益。本研究主要針對台灣電力系統於 2025 年，電池式儲能系統的應用技術進行研究。探討未來大量再生能源搭配儲能系統之情境。透過 PSS/E 軟體，模擬電池式儲能系統的應用，如：虛擬慣量、輔助服務及系統電壓的支撐能力。

Abstract

As part of Taiwan’s energy transition, the government has set a near-term target of achieving a 20% share of renewable energy in the electricity mix by 2025. However, the increasing penetration of renewable energy poses significant challenges to power system stability. In recent years, many countries have adopted battery energy storage systems (BESS) as a complementary solution to support renewable integration, enhancing grid reliability, safety, and cost-effectiveness.

This study investigates the technical applications of battery storage systems in Taiwan’s power grid by 2025, with a focus on scenarios involving high shares of renewable energy. Utilizing PSS®E simulation software, the study models the integration of battery storage systems to evaluate their performance in providing virtual inertia, ancillary services, and voltage support. The results aim to inform the strategic deployment of transmission-level energy storage as a means of ensuring grid stability and facilitating a reliable energy transition.

關鍵詞(Key Words)：電池式儲能系統(Battery Energy Storage System)、電網應用(Grid Application)、低慣量系統(Low Inertia System)、最佳化(Optimization)、再生能源(Renewable Energy)。

---

*國立臺灣科技大學電機工程學系
**台灣電力公司綜合研究所
***國立臺灣科技大學能源永續研究所

發電機定子熔損肇因分析

Root Cause Analysis of Stator Core Melting in Thermal Power Generators

廖佳麒* Liao, Chia-Chyi
石振宇* Shih, Cheng-Yu
陳瑞麒* Chen, Ruey-Chyi
吳憲政* Wu, Hsien-Cheng
鄭伃琁* Cheng, Yu-Hsuan

摘 要

火力電廠發電機組於運轉過程發生定子鐵芯熔損、貫穿螺栓斷裂等嚴重損壞情形，導致機組緊急停機，此類損壞難以短期修復，易造成重大營運損失。研究結合材料分析與有線元素分析方法，判斷起因是定子鐵芯的貫穿螺栓因應力腐蝕龜裂，造成鐵芯的鎖固力偏心，導致矽鋼片間振動加大，微動磨損破壞表面絕緣層，引發短路電流局部加熱，最終熔解鐵芯。

Abstract

Severe damage, including stator core melting and through-bolt fracture, occurred during the operation of a thermal power generator, resulting in an emergency shutdown. Such damage is not easily repairable in the short term and often leads to significant operational and financial losses.

This study identifies the root cause as stress corrosion cracking (SCC) of the stator core's through-bolts, which led to uneven locking forces and misalignment of the stator core. This misalignment intensified vibrations between laminated silicon steel sheets, causing fretting wear that damaged the surface insulation layer. The compromised insulation triggered localized heating due to short-circuit currents, ultimately resulting in stator core melting.

關鍵詞(Key Words)：發電機定子熔解 (Generator Stator Core Melting)、破損分析(Fracture Analysis)、有限元素法(Finite Element Method)、微動磨損(Fretting)。

*台灣電力公司綜合研究所

興達發電廠跨域榮獲環境教育設施場所認證的實踐策略分析研究

Strategic Analysis of Hsinta Power Plant's Cross-Sector Practices Leading to Environmental Education Facility Certification

黃琴扉*
Huang, Chin-Fei

黃錦城**
Huang, Chin-Chen

康敏捷***
Kang, Min-Chieh

摘　要

隸屬台灣電力股份有限公司(台電公司)轄下，地處高雄市的興達發電廠，從 1991 年開始積極推動環境保護工作，並在近年努力推動環境教育，終於在 2024 年通過環境教育設施場所認證，在認證過程中需具備場域現地的環境教育特色盤點與開發、環境教育專業人力配置與培訓、場域相關之環境教育課程方案研發與推廣、場域經營管理規劃說明、環境教育近三年推廣成果分析等，是一項十分龐雜的行動方案。本研究將從興達發電廠逐步規劃與落實環境教育理念，最終榮獲環境教育設施場所認證的實踐策略進行分析研究，並闡述社會貢獻價值的意義，以提供台電公司相關政策參考。

Abstract

Hsinta Power Plant, operated by Taipower and located in Kaohsiung City, has actively engaged in environmental protection initiatives since 1991. In recent years, the plant has intensified its efforts to promote environmental education and successfully obtained certification as an Environmental Education Facility in 2024. This certification entails a comprehensive and multifaceted process, including the identification and development of site-specific environmental education features, the deployment and training of professional educators, the design and dissemination of tailored educational programs, detailed planning for site management and operations, and an evaluation of environmental education outcomes over the past three years.

This study analyzes the strategies employed by Hsinta Power Plant to systematically plan and implement environmental education practices, ultimately achieving formal certification. It further examines the broader societal value of this accomplishment and offers strategic insights to inform relevant policymaking within Taipower.

關鍵詞(Key Words)：興達發電廠 (Hsinta Power Plant)、環境教育(Environmental Education)、實踐策略(Practical Strategies)。

*國立高雄師範大學
**台灣電力公司水火力發電事業部興達發電廠
***磐飛科技股份有限公司

虛擬同步機頻率電壓控制模型參數探討

Investigation of Frequency and Voltage Control Parameters for Virtual Synchronous Machines

賴凱右* 江文莊* 廖清榮*
Lai, Kai-You Jiang, Wen-Zhuang Liao, Ching-Jung

摘 要

本研究針對虛擬同步機(Virtual Synchronous Machine, VSM 或稱 VSG)於低慣量電力系統中之應用進行深入探討，主要內容包括 VSG 控制模型建構、小訊號穩定度分析、動態響應模擬及參數評估策略建立。首先，建立 VSG 之實功–頻率與虛功–電壓控制模型，並分析其與傳統同步機組在孤島與併網運轉模式下之控制行為差異。接著，透過 Matlab 與 DIgSILENT PowerFactory 建構模擬平台，探討不同虛擬慣量、阻尼參數、系統強度與傳輸線阻抗條件下 VSG 對系統動態穩定性的影響。進一步提出一套控制參數與容量大小之評估流程，涵蓋跳機事故後扛載需求、出力過衝與 RoCoF 限制等設計條件。最後，將所建模型與評估方法應用於實際電力系統案例，並研析其在頻率穩定性及電壓支撐方面之效益。本研究內容可作為未來 VSG 控制技術設計、模擬與規劃之基礎，協助推動新型變流器技術於儲能及再生能源系統中之應用與整合。

Abstract

This study conducts an in-depth investigation into the application of Virtual Synchronous Machine (VSM or VSG) technology in low-inertia power systems. The research encompasses the development of VSG control models, small-signal stability analysis, dynamic response simulations, and the establishment of a parameter evaluation strategy.

First, active power–frequency and reactive power–voltage control models for VSGs are constructed. The control behavior of VSGs is then compared with that of traditional synchronous generators under both islanded and grid-connected operation modes. Simulation platforms are developed using MATLAB and DIgSILENT PowerFactory to analyze the impact of virtual inertia, damping parameters, system strength, and transmission line impedance on system dynamic stability.

Furthermore, a comprehensive evaluation framework is proposed to guide the selection of control parameters and capacity sizing. This framework accounts for design considerations such as post-contingency load support, output overshoot limitations, and Rate of Change of Frequency (RoCoF) constraints. Finally, the proposed models and evaluation methodology are applied to a real-world power system case to assess their effectiveness in enhancing frequency stability and voltage support.

The findings of this study provide a foundational reference for the future design, simulation, and planning of VSG control strategies, supporting the integration of advanced converter technologies in energy storage and renewable energy systems.

關鍵詞(Key Words)：虛擬同步機(Virtual Synchronous Machine, VSM)、虛擬慣量(Virtual Inertia)、頻率穩定度(Frequency Stability)、電壓支撐(Voltage Support)、頻率變化率(Rate of Change of Frequency, RoCoF)、電力系統分析軟體(DIgSILENT PowerFactory)。

---

*台灣電力公司綜合研究所

淺談電力系統相位跳變對太陽能變流器之影響

A Preliminary Study on the Impact of Power System Phase Jumps on PV Inverters

江文莊* 謝國聖* 廖清榮*
Jiang, Wen-Zhuang Hsieh, Kuo-Sheng Liao, Ching-Jung

摘 要

隨著併網型變流器(Inverter)在電力系統中的占比逐漸提升，電力系統所引發的擾動對於變流器的影響也變得重要。以太陽能變流器為例，其透過鎖相迴路(Phase Locked-loop, PLL)來對電網的電壓訊號進行相位同步，並對電網注入實功率。然而，電網的電壓會受到如線路故障、負載變化等的影響，不會一直保持在完美的弦波訊號。其中電壓的相位跳變(Phase Jump)為近幾年受到關注的議題。2016 年 10 月 16 日，美國加州發生了一起因為相位跳變讓 1.2GW 的太陽能變流器跳脫的事件。因此，隨著太陽能變流器持續的增加，其穩定性也變得重要，避免因為相位跳變而造成太陽能變流器跳脫成為一個重要的課題。本研究針對併網型太陽能變流器的鎖相迴路在遭受相位跳變時的影響作一概述，並探討國際上針對相位跳變穿越(Phase Jump Ride-through)所制定的規範。

Abstract

With the increasing penetration of grid-connected inverters in power systems, disturbances originating from the grid have become a critical concern for inverter operation. Photovoltaic (PV) inverters, for instance, rely on phase-locked loops (PLLs) to synchronize with the grid voltage phase and to inject active power accordingly. However, grid voltage is often affected by factors such as line faults and load variations, and does not always maintain an ideal sinusoidal waveform. Among these disturbances, voltage phase jumps have drawn considerable attention in recent years. A notable incident occurred on October 16, 2016, in California, where a phase jump caused the disconnection of PV inverters with a total capacity of 1.2 GW. As the deployment of PV inverters continues to expand, ensuring their stability and preventing disconnection due to phase jumps has become an increasingly important issue. This study provides an overview of the behavior of the PLL in grid-connected PV inverters under phase jump conditions and examines relevant international standards regarding phase jump ride-through capability.

關鍵詞(Key Words)：太陽能變流器(PV Inverter)、鎖相迴路(Phase Locked-loop, PLL)、相位跳變(Phase Jump)。

*台灣電力公司綜合研究所

研析國內外碳定價機制及對台電公司之影響

An Analysis of Domestic and International Carbon Pricing Mechanisms and Their Impact on Taipower

郭家妤* Kuo, Jia-Yu
黃薇* Huang, Wei
許聖民* Hsu, Sheng-Ming
郭婷瑋** Kuo, Ting-Wei
曾泓祥** Tseng, Hung-Hsiang

摘 要

歐洲執行委員會為遏止碳洩漏，於 2021 年提出碳邊境調整機制(Carbon Border Adjustment Mechanism, CBAM)並預計 2027 年生效。我國政府為響應國際趨勢，亦通過《氣候變遷因應法》，逐步推動碳定價。身為國內主要排放源之一，台電公司將面臨 CBAM 與國內碳定價的雙重議題。本文將從 CBAM 機制、我國碳定價政策、企業內部碳定價以及碳治理等面向進行深入分析，探討台電公司在淨零目標下所面臨的挑戰與機遇。

Abstract

To mitigate carbon leakage, the European Commission introduced the Carbon Border Adjustment Mechanism (CBAM) in 2021, which is scheduled to take effect in 2027. In alignment with global trends, the Taiwanese government has enacted the Climate Change Response Act and is gradually advancing the implementation of carbon pricing. As one of Taiwan’s primary greenhouse gas emitters, Taipower is poised to confront the dual pressures of the CBAM and the emerging domestic carbon pricing regime. This study offers a comprehensive analysis of the CBAM framework, Taiwan's carbon pricing policies, internal carbon pricing, and broader issues of carbon governance. It further examines the challenges and opportunities that Taipower may encounter in its pursuit of net-zero emissions.

關鍵詞(Key Words)：碳定價(Carbon Pricing)、碳邊境調整機制(Carbon Border Adjustment Mechanism)、碳風險(Carbon Risk)、內部碳定價(Internal Carbon Pricing)。

*台灣綜合研究院
**台灣電力公司綜合研究所

台電導入循環營建之規劃與推動

Taipower's Planning and Promotion of Circular Construction

吳政宏* Wu, Cheng-Hung
林怡美* Lin, Yi-Mei
郭泰均* Kuo, Tai-Chun
陳詩易* Chen, Shih-Yi
黃榮堯** Huang, Rong-Yau
羅文澤** Lo, Wen-Tse

摘　要

在國家推動循環經濟的政策框架下，台電於 108 年發布環境白皮書，並進一步於 109 年擬定「循環經濟策略藍圖」，制定短、中、長期循環經濟推動目標。另鑒於台電擁有大量的電力基礎設施與設備，若能在前期設計採購、施工、營運使用、乃至除役時導入「循環營建」的概念，除可提升能資源的使用效率，亦可減少營建廢棄物的產生，為進一步實踐循環經濟之關鍵。

本研究透過分析導入循環營建之建築案例，汲取國內外推動循環營建之實務做法，彙整內容並凝聚內部共識後，綜整研擬「台電公司循環營建推動指引」，提出循環營建「五大循環面向」與「三大工程階段」之具體落實手法，協助建築工程導入循環營建概念並落實循環永續之理念。

Abstract

Under the national policy framework for advancing the circular economy, Taipower published its Environmental White Paper in 2019, followed by the formulation of a Circular Economy Strategic Blueprint in 2020. This blueprint outlines short-, medium-, and long-term goals for promoting circular economy practices, including the integration of circular construction.

Given Taipower's extensive infrastructure and equipment, incorporating circular construction principles across all project phases (from early-stage design and procurement to construction, operation, and eventual decommissioning) can significantly enhance resource efficiency and reduce construction waste. Such integration is crucial for realizing the objectives of a circular economy.

This study analyzes both domestic and international cases of circular construction to identify practical approaches and implementation strategies. Based on the insights gained and internal consensus, Taipower has developed the Guidelines for the Promotion of Circular Construction, which propose specific methods for applying circular principles across five key dimensions and three major project phases. These guidelines aim to facilitate the adoption of circular construction concepts in infrastructure projects and advance Taipower's commitment to sustainable and circular development.

關鍵詞(Key Words)：循環經濟 (Circular Economy)、循環營建 (Circular Construction)、綠建築 (Green Building)。

*台灣電力公司環境保護處
**財團法人台灣營建研究院