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具備彈性調度能力之電力決策支援工具整合試驗

Integrated Testing of Power Decision Support Tools with Flexible Dispatch Capabilities

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摘 要

本研究運用整合資源規劃架構與線性規劃建置我國小時層級電力供需規劃模型，並完成一套電業決策支援系統，用於電力系統淨零轉型路徑規劃與相關影響評估。本研究運用模型完成滿足系統供電穩定、具備彈性調度及達成淨零目標的系統情境模擬。電力系統邁向淨零除持續擴大再生能源與低碳發電資源，系統需要額外彈性資源輔助，例如：需求抑抵措施、儲能等，彈性資源可在負載緊張時增加電力供應，或吸納供過於求的電力供應資源，並轉移資源至適宜時間點或轉換成其它載體，有效提升電力系統營運的韌性。根據目前系統淨零資源，電力系統 2050 年達成淨零極具挑戰性，系統應積極開發更多淨零資源。

Abstract

This study develops an hourly power supply and demand planning model for Taiwan using an integrated resource planning (IRP) framework and linear programming methodology, establishing a utility decision support system for the power system's net-zero transition pathway planning and impact assessment. The model was utilized to simulate system scenarios that satisfy power supply stability, flexible dispatch, and net-zero targets. As the power system transitions toward net-zero by continuously expanding renewable energy and low-carbon generation, auxiliary flexible resources, such as demand-side management and energy storage systems, are indispensable. These flexible resources can increase power supply during periods of high load or absorb surplus power during oversupply, shifting energy to optimal timeframes or converting it into alternative energy carriers, thereby effectively enhancing power system resilience. Given the current inventory of net-zero resources, achieving net-zero emissions by 2050 presents a significant challenge, highlighting the urgent need for the power system to actively develop and tap into additional net-zero resources.

關鍵詞(Key Words)： 整合資源規劃(Integrated Resource Planning, IRP)、決策支援系統(Decision Support System)、電力系統(Power System)、淨零(Net Zero)、彈性資源(Flexible Resources)。

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MW 級試驗型混氫發電系統整合規劃

Integrated Planning of a MW-Scale Experimental Hydrogen Co-firing Power Generation System

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摘要

依循國家發展委員會 2050 淨零轉型之 12 項關鍵戰略，氫能被視為達成淨零轉型願景之核心選項，台電公司肩負其中氫能混燒發電應用推動的任務。然而，導入氫能除須克服混燒技術瓶頸外，亦面臨多元產氫來源之差異對發電機組穩定性帶來的挑戰。考量現階段潔淨產氫技術尚處於較高成本且經驗累積階段，本研究規劃建置約 5 MW 規模之混氫氣渦輪發電系統，藉此評估不同氫源與發電系統的整合可行性，為未來大規模潔淨能源應用奠定技術基礎。

Abstract

In alignment with the 12 Key Strategic of the National Development Council's 2050 Net-Zero Transition, hydrogen energy is identified as a pivotal component for achieving the net-zero vision. Taipower is tasked with advancing the application of hydrogen co-firing in power generation. However, integrating hydrogen requires overcoming co-firing technical bottlenecks and addressing the stability challenges posed to generating units by variations in diverse hydrogen sources. Given that clean hydrogen technologies currently entail high costs and remain in the stage of operational experience accumulation, the study proposes the development of a 5 MW-scale hydrogen-blended gas turbine power generation system. This facility aims to evaluate the integration feasibility of various hydrogen sources with power generation systems, thereby establishing a technical foundation for future large-scale clean energy applications.

關鍵詞(Key Words)：氫能(Hydrogen Energy)、混燒(Co-firing)、產氫(Hydrogen Production)、氣渦輪機發電平台(Gas Turbine Power Generation Platform)。

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應用生成式 AI 技術導引新建變電所 AC 電源並整合 太陽能光電系統設置規劃之研究

Application of Generative AI Technology to Guide the AC Power Supply Planning of New Substations and Integrate Solar Photovoltaic Systems

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摘 要

本研究探討新建變電所工程 AC 電源，除了容納相關大項設備，還要將建築物附屬機電設施所需用電納入，惟評估所內用電設備之變壓器容量要能提供變電所全部設備之 AC 電源，因此須規劃所內用電設備之各分路開關規格以供整所負載，以及檢討太陽光電系統是否能併入自用(所內)或市電(外線)，避免後續施工疑義之發生，本文首先分析新建變電所之所內用電設備所需各分路開關規格性與差異性，後續提出創新方法導入生成對抗網路演算法，藉由該演算法協助推算出最佳所內用電設備各分路開關規格及太陽光電併自用或市電之配置，接著利用 Visual Basic 軟體開發人機介面視窗系統，整合開啟 AutoCAD 繪圖軟體，並藉由 AutoCAD 內建程式 AutoLISP 達到自動繪圖之功能，以提升新進人員設計能力，強化新建變電所 AC 電源規劃核心技術。

Abstract

This study explores the AC power supply planning for new substation projects, which must accommodate major equipment as well as the electricity required for building-associated electromechanical facilities. To ensure that the station service transformer capacity can supply the entire substation, it is necessary to determine the branch circuit switch specifications for the overall load and evaluate whether the solar photovoltaic (PV) system should be integrated for self-use (station service) or utility power mode to prevent subsequent construction ambiguities. This paper first analyzes the specifications and variations of branch circuit switches required for new substations. Subsequently, it proposes an innovative method incorporating a Generative Adversarial Network (GAN) algorithm to determine the optimal branch circuit switch specifications and PV integration configurations. Furthermore, a human-machine interface (HMI) window system was developed using Visual Basic, which integrates and launches AutoCAD while utilizing its built-in AutoLISP program to achieve automated drafting. This approach aims to enhance the design proficiency of junior personnel and strengthen the core technologies involved in AC power planning for new substations.

關鍵詞(Key Words)：所內用電設備(AC Power Equipment In The Substation)、人工智慧(Artificial Intelligence)、生成對抗網路(Generative Adversarial Networks)、市電模式(Utility Power Mode)。

全興 E/S #1DTR 熱縮型電纜終端接頭復舊處理及故障分析

Fault Analysis and Restoration of Heat-Shrinkable Cable Terminations for #1DTR at Chuan-Hsing E/S

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摘 要

本文將探討全興 E/S #1DTR 電力變壓器之熱縮型電纜終端接頭故障案例。隨著裝甲開關箱(MCSG)汰換為氣封開關設備(CGIS)之工程推進，電力電纜及其終端接頭之可靠度成為電力變壓器穩定運轉的關鍵。鑑於該案例於加入系統後短期內即發生故障，為釐清事故主因，本文透過會同電纜原製造商進行解剖試驗，並委託綜合研究所進行材料分析，同時對照施工說明書進行品質複查。經由「製造面」與「施工面」之雙重維度評估，完整解析其故障機制，期能作為後續同類工程之技術參考與預防依據。

Abstract

This paper investigates a fault case involving the heat-shrinkable cable terminations for #1DTR power transformer at Chuan-Hsing Extra-High Voltage Substation (E/S). With the ongoing replacement of Metal-Clad Switchgear (MCSG) by Cubicle-type Gas-Insulated Switchgear (CGIS), the reliability of power cables and their terminations has become a critical factor for the stable operation of power transformers. Given that the fault occurred shortly after energization, this study aims to clarify the root cause through a collaborative anatomical inspection with the original cable manufacturer, material analysis commissioned by the Taiwan Power Research Institute (TPRI), and a quality review against the construction manual. By evaluating both manufacturing and construction dimensions, this paper thoroughly analyzes the fault mechanism, serving as a technical reference and preventive measure for similar future projects.

關鍵詞(Key Words)：熱縮型電纜接頭(Heat-Shrinkable Tubing Connector)、故障分析(Fault Analysis)、箱型氣封開關設備(Cubicle-type Gas-Insulated Switchgear, CGIS)、電力變壓器(Power Transformer)、施工品質管理(Construction Quality Management)。

整合電業規章之大型語言模型應用

Application of Large Language Models to the Integration of Electrical Regulations

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摘要

為提升本公司再生能源發電設備與儲能系統併網規章查詢效率，提供完整且即時的法令導引服務，有效減少人工查閱時間，並確保資訊傳遞之準確性，本計畫建置「再生能源與儲能併網法規智慧諮詢平台」。

本計畫彙整「再生能源發電設備併聯技術要點」、作業須知及「儲能系統併聯審查要點」等多項核心規章，利用大型語言模型與檢索增強生成(Retrieval-Augmented Generation, RAG)技術，建立智慧化詢答界面，供申請人及公司同仁使用。

本計畫導入之 RAG 架構，解決傳統模型易產生幻覺之限制，並具備更新機制，當電業規章變動調整時，僅需更新知識庫即可確保回饋資訊與最新章則一致，無須重新訓練模型。

主要工作包括規章資料庫建置與向量化、RAG 檢索架構開發、智慧語義詢答界面設計及系統準確度驗證。藉由本案，不僅強化了公司數位轉型之形象，更能顯著降低行政溝通成本，達成擷節人力與節能減碳之目標。

Abstract

To enhance the query efficiency of grid connection regulations for renewable energy generation and energy storage systems and to provide comprehensive, real-time regulatory guidance that reduces manual search time and ensures information accuracy, this project established the “Intelligent Consultation Platform for Grid Connection Regulations.” The platform aggregates core regulations, including the “Technical Guidelines for Renewable Energy Power Generation Systems” and the “Review Key Points for Energy Storage System Interconnection.” By integrating Large Language Models (LLMs) with Retrieval-Augmented Generation (RAG) technology, an intelligent Q&A interface has been established for both applicants and internal personnel.

The introduced RAG architecture mitigates the limitation of traditional models prone to hallucinations and features an update mechanism; when regulations change, only the knowledge base needs to be updated to ensure that feedback remains aligned with the latest rules without retraining the model. Key tasks include regulatory database construction and vectorization, RAG retrieval architecture development, intelligent semantic Q&A interface design, and system accuracy verification. This project not only reinforces the company's digital transformation image but also significantly reduces administrative communication costs, thereby achieving the goals of labor conservation and energy saving/carbon reduction.

關鍵詞(Key Words)：大語言模型(Large Language Models, LLM)、檢索增強生成(Retrieval-Augmented Generation, RAG)、再生能源並網(Renewable Energy Grid Connection)、儲能系統規章(Energy Storage Regulations)、數位轉型(Digital Transformation)。

運轉中變電所控制室移設-以翁子 P/S 為例

Relocation of an Operating Substation Control Room : A Case Study of Wengzi Primary Substation

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摘 要

翁子 P/S 為屋外式變電所，一期改建工程已完成 161kV 開關設備之屋內化。目前中區施工處正辦理二期 69kV 開關場改建工程規劃，待二期完工後，將可達成全屋內式變電所之目標。因本次改建範圍涵蓋運轉中之控制室，本處須先行將控制室內各項設備移設並完成場域清空，方能交由中區施工處進場施作。本案採設置貨櫃式臨時控制室作為過渡措施，惟控制室移設作業涉及變電、電驛、資控及通訊等不同部門且涉及大用戶，事先的溝通整合、停電規劃及工程施工順序細節皆須納入考量，整合難度甚高。

本文旨在說明工程施工前，如何妥善規劃運轉中控制室之搬遷及場域清空作業流程，並詳實紀錄施工執行細節，以提供本公司其他單位辦理類似變電所改建工程之參考。

Abstract

Wengzi Primary Substation (P/S) is an outdoor substation, where the first phase of the reconstruction project has successfully converted the 161 kV switchgear into an indoor installation. Currently, the Central Region Construction Office is planning Phase II to reconstruct the 69 kV switchyard, which will ultimately transform the facility into a fully indoor substation. Because the scope of this reconstruction encompasses an operating control room, all equipment within the room must be relocated and the site cleared before handing it over to the construction team.

A containerized temporary control room is adopted as an interim solution. However, the relocation work involves multiple disciplines, including substation systems, protection relays, SCADA, and telecommunications, and also affects large-scale industrial customers. Consequently, comprehensive prior coordination, outage planning, and meticulous construction sequencing are required, presenting significant integration challenges. This paper aims to illustrate how to properly plan the relocation and site clearance processes for an in-service control room prior to construction and documents the detailed execution procedures, serving as a technical reference for other units undertaking similar substation reconstruction projects.

關鍵詞(Key Words)：一次變電所(Primary Substation, P/S)、開關場(Switchyard)、遠端終端裝置(Remote Terminal Unit, RTU)、匯流排保護電驛(Bus Protection Relay, Bus RY)。

AI 代理程式輔助燃煤機組廠內用電特性之大數據分析

Big Data Analysis of Auxiliary Power Consumption Characteristics in Coal-Fired Units

Assisted by AI Agents

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摘要

本文以火力發電廠既有運轉資料為基礎，結合 PI 系統資料擷取、Excel 結構化整理及公司內部 AI 工具，建立符合資安規範且可由工程人員檢核之資料分析流程。本次分析彙整 1 至 4 號機近 3 年、逾 600 萬筆運轉資料，篩選 250~550MW 負載區間，觀察機組本體廠內用電、主要輔機及 FGD 用電特性。結果顯示，廠內用電除受負載影響外，亦與輔機運轉方式、燃燒條件及脫硫系統控制邏輯有關；跨機組比較亦可看出相同負載下之用電差異。本文成果可作為後續機組運轉判讀、效能比較及智慧電廠發展之參考。

Abstract

Based on historical operating data from a thermal power plant, this study integrates PI system data extraction, structured Excel-based processing, and internal corporate AI tools to establish a secure, engineer-verifiable data analysis workflow compliant with information security requirements. Over 6 million operating records from Units 1 to 4 spanning nearly three years were compiled and filtered within the 250–550 MW load range to examine the power consumption characteristics of the main units, major auxiliary equipment, and the flue gas desulfurization (FGD) system. The results demonstrate that auxiliary power consumption is influenced not only by unit load but also by auxiliary operation modes, combustion conditions, and FGD control logic. Furthermore, cross-unit comparisons reveal variations in power consumption under identical load conditions. These findings serve as a technical reference for subsequent unit operation evaluation, performance benchmarking, and the development of smart power plants.

關鍵詞(Key Words)： AI 數據分析(AI-Driven Data Analytics)、火力發電廠(Thermal Power Plant)、廠內用電(Auxiliary Power Consumption)、智慧電廠(Smart Power Plant)。