

台電工程月刊937期(9月)目錄

新及再生能源：

NEW AND RENEWABLE ENERGY：

我國電力系統氫基燃料供應鏈成本評估.....張耀仁 等	(1)
<u>Cost Assessment of Hydrogen-Based Fuel Supply Chains for Taiwan's Power System</u>	<u>Chang, Yao-Jen et al. (1)</u>
鹼性膜電解產氫系統開發及特性研究.....丁富彬 等	(22)
<u>Development and Characteristic Study of an Anion Exchange Membrane Electrolyzer System for Hydrogen Production.....</u>	<u>Ting, Fu-Pin et al. (22)</u>
構網型變流器之國際規範盤點與研析.....江文莊 等	(31)
<u>Review and Analysis of International Grid-Forming Inverter Regulations and Specifications</u>	<u>Jiang, Wen-Zhuang et al. . (31)</u>

環境與永續：

ENVIRONMENT AND SUSTAINABILITY：

林口發電廠輸煤皮帶機之可程式控制霧化系統安裝及測試.....顧宏碁 等	(50)
<u>Installation and Commissioning of a Programmable Logic Controlled Fog System for Coal Belt Conveyors at Linkou Power Plant</u>	<u>Ku, Hung-Chi et al. (50)</u>

售電與用戶：

ELECTRICITY RETAILING AND CUSTOMERS：

實現虛擬電廠的多元創新運作機制與經濟效益考量.....蔣佳佑 等	(60)
<u>Innovative Operational Mechanisms and Economic Benefit Considerations for Deploying Diverse Virtual Power Plants.....</u>	<u>Chiang, Jia-Yo et al. (60)</u>

經營管理：

BUSINESS MANAGEMENT：

臺灣近期供電可靠度風險問卷調查.....謝佩穎 等	(80)
<u>Questionnaire Survey on Near-Term Power Supply Reliability Risks in Taiwan</u>	<u>Hsieh, Pei-Ying et al. (80)</u>

其他：

OTHERS：

台中供電區營運處霧峰超高壓變電所南側宿舍區停車空間設置太陽光電 公開標租案經驗分享.....張書銓 等	(96)
<u>Experience Sharing on the Solar Photovoltaic Installation Project via Public Tendering for Leasing in the Southern Dormitory Parking Space of Wufeng Ultra-High Voltage Substation, Taichung Power Supply District Operations Office</u>	<u>Jhang, Shu-Cyuan et al. ... (96)</u>

我國電力系統氫基燃料供應鏈成本評估

Cost Assessment of Hydrogen-Based Fuel Supply Chains for Taiwan's Power System

張耀仁*
Chang, Yao-Jen

石蕙菱*
Shih, Huei-Lin

蕭思恩*
Hsiao, Szu-En

卓金和**
Cho, Chin-Ho

楊宗霖**
Yang, Tsung-Lin

洪育民**
Hung, Yu-Ming

摘 要

本研究提出我國電力系統氫基燃料需求與進口供應鏈成本評估方法論，並設計未來氫基燃料進口供應鏈成本計算流程，完成我國至 2050 年氫基燃料進口供應鏈架構與成本評估，以藍與綠氫作為進口評估選項。評估架構包括：產地氫氣生產、產地運輸、狀態轉換、出口、跨國運輸、到港卸收轉換、島內運輸及電廠發電。研究結果顯示：我國從生產來源國進口取得氫基燃料的成本皆相當高，但從澳洲透過液氨運輸模式的到港價格相對低，且相關技術皆已商業化，是電業未來可優先考慮的氫基燃料進口路徑。對於電力系統氫基燃料應用，本研究建議以燃氣電廠混燒氫氣發電為優先推動項目，而燃煤電廠混氨發電將導致燃料成本大幅增加。若將進口視為氫基燃料取得途徑，本研究建議應盡早洽談氫氣取得管道，確保穩定的氫基燃料取得來源，且須儘快啟動相關基礎建設。

Abstract

This study proposes a methodology for evaluating the demand and import supply chain costs of hydrogen-based fuels for Taiwan's power system. It designs a comprehensive cost calculation framework and assesses the import supply chain structures and costs up to 2050, selecting blue and green hydrogen as the primary import alternatives.

The evaluation framework encompasses eight distinct stages: hydrogen production source, land transportation at the origin, carrier conversion, export, maritime transport, terminal reception and reconversion, onshore transportation, and power generation. The empirical results indicate that while the total import costs of hydrogen-based fuels remain significantly high, importing liquid ammonia from Australia offers a relatively lower landing price. Given that its underlying technologies are already mature and commercialized, this pathway presents a preferred import route for the power sector.

Regarding applications within the power system, this study recommends prioritizing hydrogen co-firing in gas-fired power plants, as ammonia co-firing in coal-fired power plants would lead to a substantial increase in fuel costs. If Taiwan relies on imports as its primary pathway for securing hydrogen-based fuels, the study suggests initiating negotiations for hydrogen supply channels at an early stage to guarantee stable fuel sources, alongside accelerating the planning and construction assessments of the required infrastructure.

關鍵詞(Key Words)： 氫(Hydrogen)、進口(Import)、供應鏈(Supply Chain)、成本(Cost)。

*工業技術研究院產業科技國際策略發展所

**台灣電力公司綜合研究所

鹼性膜電解產氫系統開發及特性研究

Development and Characteristic Study of an Anion Exchange Membrane Electrolyzer System for Hydrogen Production

丁富彬*
Ting, Fu-Pin

周儷芬*
Chou, Li-Fen

蔡英文**
Tsai, Yin-Wen

陳廣藩**
Chen, Kuang-Fan

賴建銘**
Lai, Chien-Ming

蔡麗端**
Tsai, Li-Duan

摘要

在全球淨零排放與各國潔淨氫政策推動下，具低成本與高效率優勢的鹼性膜電解產氫被視為最具淨零碳排潛力的關鍵技術之一，本研究已就 10 kW 鹼性膜電解產氫系統與國際近似產氫規模競爭技術進行分析，並說明本產氫系統之技術優勢、應用發展與未來挑戰。本研究內容包括：高活性 OER 鎳基觸媒研究、10 kW 高效能電解產氫電堆設計，並透過系統整合技術，完成 10 kW 鹼性膜電解產氫系統技術開發，研究中也同步探討以本系統產氫直接供應 65 kW 微型渦輪燃氣發電機，實場整合驗證本產氫技術作為混氫發電應用之可行性；另外，評估以鹼性膜電解電堆直接結合綠電產氫，其電堆性能及耐受性的影響，相關研究成果，皆可作為擴大規模設計的參考。

Abstract

Driven by global net-zero emissions targets and national clean hydrogen policies, anion exchange membrane (AEM) water electrolysis, characterized by low cost and high efficiency, is recognized as a critical technology with profound potential for achieving net-zero carbon emissions. This study evaluates a 10 kW AEM electrolyzer system alongside competing international technologies of comparable production scales, elucidating the technical advantages, application prospects, and future challenges of the proposed system.

The scope of this research encompasses the development of high-activity nickel-based oxygen evolution reaction (OER) catalysts and the design of a 10 kW high-efficiency electrolysis stack. Through advanced system integration, the technical development of the 10 kW AEM electrolyzer system has been successfully achieved. Furthermore, the feasibility of utilizing the produced hydrogen to directly fuel a 65 kW micro gas turbine generator for hydrogen-blended power generation is investigated through on-site integrated validation. Additionally, this study assesses the impact on stack performance and durability when the AEM stack is directly coupled with renewable electricity for green hydrogen production. The insights and findings obtained from this work serve as a valuable reference for future large-scale designs.

關鍵詞(Key Words)：電解(Electrolysis)、產氫(Hydrogen Production)、淨零碳排(Net-Zero Emissions)、陰離子交換膜(Anion Exchange Membrane, AEM，亦稱鹼性膜)、電解電堆及系統(Electrolysis Stack and System)、燃氣混氫發電(Gas-Hydrogen Combined Power Generation)。

*台灣電力公司綜合研究所

**工業技術研究院，機械與機電系統研究所，智慧綠能關鍵元件及系統整合研究組

構網型變流器之國際規範盤點與研析

Review and Analysis of International Grid-Forming Inverter Regulations and Specifications

江文莊*
Jiang, Wen-Zhuang

謝國聖*
Hsieh, Kuo-Sheng

程泓璋*
Chen, Hung-Wei

摘 要

本研究蒐集國際標準規範涵括歐、美、澳、英國家電業之構網型變流器相關法規及控制技術，並藉由分析各國電力公司對於構網型變流器控制技術標準的訂定與系統驗證方式、電壓和頻率調整架構、模式模擬技術開發與系統再生能源協調的研究，以評估系統遭受干擾或故障時，構網型變流器如何根據電網狀況提供穩定輸出功率與輸出電壓，俾於維持系統穩定持續運轉，同時整理構網型變流器電流限制條件要求、技術性能要求、電廠規範要求，以提供台灣電力公司進行構網型變流器不同控制技術訂定策略時之參考。本研究之執行，包含蒐集上列各國現有法規標準及資料典藏、參考文獻及相關資源，並已進行分析國外電力公司針對構網型變流器面臨電力系統遭受干擾或故障之故障處理能力，同時進行重要相關規範之施行差異比較分析，研究內容可提供本國電力公司研發及制定構網型變流器相關技術要點或施行規範時之參考。

Abstract

This research reviews international standards and regulations concerning grid-forming (GFM) inverter technologies and control requirements across Europe, the United States, Australia, and the United Kingdom. By analyzing the technical standards, system verification methods, voltage and frequency regulation architectures, simulation model development, and renewable energy coordination strategies established by global utilities, this study evaluates how GFM converters provide stable output power and voltage during system disturbances or faults to maintain continuous grid stability. Furthermore, the study compiles requirements for current limiting conditions, technical performance benchmarks, and power plant codes to serve as a strategic reference for Taiwan Power Company in formulating control technology policies.

The execution of this research encompasses the collection of existing international regulatory standards, literature, and archival resources, alongside a detailed assessment of fault-handling capabilities under system disturbances. Additionally, a comparative analysis highlighting the implementation differences among key regulations is performed. The findings of this research provide a foundational framework for domestic utilities in developing and formulating technical guidelines or implementation specifications for grid-forming converters.

關鍵詞(Key Words)：構網型(Grid Forming)、變流器(Inverter)、國際標準(International Standard)。

林口發電廠輸煤皮帶機之可程式控制霧化系統安裝及測試

Installation and Commissioning of a Programmable Logic Controlled Fog System for Coal Belt Conveyors at Linkou Power Plant

顧宏基*
Ku, Hung-Chi

郭岱鑫*
Kuo, Tai-Hsin

陳孟杭*
Chen, Meng-Hang

高坤榮*
Gao, Kun-Rong

張天豪*
Chang, Tien-Hao

洪福隆**
Hung, Fu-Long

摘 要

霧化系統(Fog System, FS)為電廠、水泥、煉鋼廠、紙廠等工廠控制粉塵排放最主要的設備之一^[1]。面對環保意識抬頭和法規日趨嚴格，燃煤於輸送過程中產生之煤塵逸散問題，應提早因應，擬定防範對策，建立友善環境。

本文就林口火力電廠 TR10 轉運塔輸煤皮帶機安裝可程式霧化系統(PLC Fog System, PFS)進行討論。該系統利用噴嘴把高壓水霧化產生 5-20 μm 細小水霧顆粒方式，使水霧顆粒與粉塵顆粒充分碰撞凝聚，提高接觸效率和結合後重量，達到抑制粉塵濃度和溫度，從而大大降低粉塵爆炸機率，經測試分析，顯示該系統能有效抑制轉運塔內的粉塵逸散，達到環保要求。

Abstract

The fog system (FS) is one of the primary technologies used to control fugitive dust emission in industrial facilities, including power stations, cement plants, steel mills, and pulp and paper mills^[1]. Driven by rising environmental awareness and increasingly stringent regulatory frameworks, proactive measures must be implemented to mitigate coal dust dispersion during transport, thereby ensuring regulatory compliance and environmental sustainability.

This study evaluates the installation of a Programmable Logic Controlled Fog System (PFS) at the TR10 transfer tower coal belt conveyor within the Linkou Power Plant. Utilizing high-pressure nozzles, the system generates fine atomized water mist particles (5–20 μm) that collide and agglomerate with airborne dust particles. This mechanism enhances contact efficiency and increases the combined mass of the particles, suppressing dust concentration and lowering ambient temperatures, which significantly mitigates dust explosion risks. Experimental testing and analysis demonstrate that the PFS effectively suppresses fugitive dust emission within the transfer tower, successfully satisfying environmental standards.

關鍵詞(Key Words)：可程式霧化系統(Programmable Logic Controlled Fog System, PFS)、輸煤皮帶機(Coal Conveyor)、煤塵(Coal Dust)、塵爆(Dust Explosion)。

*台灣電力公司水火力發電事業部林口發電廠

**駿維實業股份有限公司

實現虛擬電廠的多元創新運作機制與經濟效益考量

Innovative Operational Mechanisms and Economic Benefit Considerations for Deploying Diverse Virtual Power Plants

蔣佳佑*
Chiang, Jia-Yo

許涵甄**
Hsu, Han-Chen

呂昭麟***
Lu, Chao-Lin

黃奕儒****
Huang, Yi-Ju

林筱翊****
Lin, Hsiao-Yi

摘 要

在各國積極採用再生能源的趨勢，雖然再生能源有助於降低碳排，但其發電並不穩定，往往迫使電力系統必須為可靠度配置更多備用容量。此外，綠能增加調度的複雜性，加上極端氣候日益頻繁，使得短暫缺電漸成常態。為強化電網韌性、降低系統成本並加速綠能轉型，分散型電源(Distributed Energy Resources, DER)日益受到重視。建置發電源於用電端，不僅可降低輸配電損耗與電網負擔，亦能賦予社區更多的能源選擇權，進而有效的降低老舊電力設施影響供電穩定性的風險。因此，虛擬電廠(Virtual Power Plant, VPP)已成為提升電網可靠性與降低供電成本的策略。然而，推動 VPP 仍面臨運作機制複雜與經濟效益不確定等挑戰。本文將分析國外虛擬電廠不同發展階段的創新應用模式，探討其如何彈性導入電業、電網或兩者之多層面運作模式，並進一步說明經由替代成本(Avoided Costs)的定價規範，對各類型電源提供適當補償。最後也將建議適合台灣的突破性運作模式，作為國內發展虛擬電廠的借鏡。

Abstract

The global proliferation of renewable energy has significantly reduced carbon emissions; however, the intermittent nature of these sources increasingly forces power systems to allocate costly reserve capacity to maintain grid reliability. Moreover, the integration of green energy escalates dispatch complexity, which, compounded by the rising frequency of extreme weather events, has made transient power shortages a recurrent norm. To enhance grid resilience, reduce system costs, and accelerate the clean energy transition, Distributed Energy Resources (DERs) have gained significant attention. Deploying generation sources directly at the consumer side not only minimizes transmission and distribution losses but also empowers communities with greater energy autonomy, thereby effectively mitigating the risks that aging power infrastructure poses to supply stability. Consequently, Virtual Power Plants (VPPs) have emerged as a strategic solution to enhance grid reliability and lower supply costs. Nevertheless, deploying VPPs still faces critical challenges, including complex operational mechanisms and uncertain economic benefits.

This study analyzes the multi-phased innovative application models of VPPs internationally, exploring how they flexibly integrate into electricity markets, grids, or multi-level operational frameworks. Furthermore, it elucidates how appropriate compensation can be provided to various resource types through pricing regulations based on avoided costs. Finally, this study proposes breakthrough operational models tailored for Taiwan, serving as a benchmark for domestic VPP deployment.

關鍵詞(Key Words)： 虛擬電廠(Virtual Power Plants, VPPs)、分散型電源(Distributed Energy Resources, DERs)、替代成本(Avoided Costs)、聚合商(Aggregator)、備用容量(Reserve Capacity)。

*艾能有限公司電力市場顧問服務

**昇旺能源科技股份有限公司

***工業技術研究院產業科技國際策略發展所

****工業技術研究院綠能與環境研究所

臺灣近期供電可靠度風險問卷調查

Questionnaire Survey on Near-Term Power Supply Reliability Risks in Taiwan

謝佩穎*
Hsieh, Pei-Ying

盧展南*
Lu, Chan-Nan

摘要

本研究透過專家問卷調查，針對五大面向、12 項核心供電可靠度風險進行系統性評估，以因應電網轉型、極端氣候與地緣政治挑戰。結果顯示，專家認為最嚴重的風險依序為「關鍵節點高度集中」、「能源政策不一致」及「跨系統關鍵基礎設施相互依存與供應鏈中斷」。研究亦發現不同利害關係人間存在值得注意的認知差異，國營電力公司在職人員對風險的嚴重性與急迫性程度評估，普遍低於退休人員、產業界及學界專家。

問卷回應者建議包括：(1)建立獨立、透明且以技術為核心的監管機制，降低政治干預並完善市場治理；(2)將電力規劃由傳統容量導向轉向整合資源規劃，以因應再生能源發電與 AI 資料中心用電成長；(3)改善電力公司財務壓力與人才流失問題，強化技術傳承、事故應變能力及電網韌性投資；(4)落實供電風險資訊揭露與社會溝通，建立雙向風險溝通機制，避免技術問題演變為社會信任危機。

Abstract

This study employs an expert questionnaire survey to systematically assess 12 core power supply reliability risks across five major dimensions in response to challenges arising from power grid transformation, extreme climate, and geopolitical uncertainties in Taiwan. The empirical results indicate that the three most emergent risks perceived by experts are: (1) high concentration at critical nodes of the grid, (2) inconsistency in energy policies, and (3) interdependencies among critical infrastructures and supply chain disruptions. Furthermore, this study reveals noteworthy differences in risk perception among stakeholder groups; specifically, respondents currently employed by the state-owned utility generally evaluate both the severity and urgency of these risks lower than retired utility professionals, industry experts, and academic researchers.

Based on the survey findings, respondents propose the following key recommendations: (1) establishing an independent, transparent, and technology-driven regulatory framework to reduce political interference and strengthen electricity market governance; (2) shifting power system planning from a traditional capacity-based approach to Integrated Resource Planning (IRP) to effectively accommodate renewable energy penetration and rapidly growing electricity demand from AI data centers; (3) alleviating the utility's financial constraints and talent attrition to strengthen knowledge transfer, emergency response capabilities, and resilience investments; and (4) promoting the disclosure of power supply reliability risks and social communication to establish a two-way risk communication mechanism, thereby preventing technical issues from escalating into social trust crises.

關鍵詞(Key Words)：電網韌性(Grid Resilience)、風險評估(Risk Assessment)、典範轉移(Paradigm Shift)。

台中供電區營運處霧峰超高壓變電所南側宿舍區停車 空間設置太陽光電公開標租案經驗分享

Experience Sharing on the Solar Photovoltaic Installation Project via Public Tendering for Leasing in
the Southern Dormitory Parking Space of Wufeng Ultra-High Voltage Substation, Taichung Power
Supply District Operations Office

張書鈐*
Jhang, Shu-Cyuan

吳亮毅*
Wu, Liang-Yi

何權恩*
Ho, Chuan-En

巫昇峯*
Wu, Sheng-Fong

摘 要

為配合公司推動綠能發展政策及有效利用土地，本處選定霧峰超高壓變電所南側宿舍區停車空間辦理公開標租，提供業者設置太陽光電設備，本案係供電系統以素地出租設置「車棚式」太陽光電發電設備之首次案例，除突破既有設置於房舍屋頂或土地之活化模式外，亦為公司創造額外收益，惟後續因市政府認定該地號位於車籠埔斷層地帶不得興建任何立體建築物而未准予建置。本文詳細說明本案 規劃與設計重點、標租流程及決標後向相關主管機關申請設置經驗分享，提供本公司其他單位辦理土地出租供業者設置「車棚式」太陽光電設備之參考。

Abstract

To align with the company's green energy development policy and optimize land utilization, the Taichung Power Supply District Operations Office selected the southern dormitory parking space of Wufeng Ultra-High Voltage Substation for public leasing, enabling private operators to install solar photovoltaic (PV) equipment. This project represents the first instance within the power supply system where undeveloped land was leased for carport-style solar PV power generation. Beyond expanding past asset revitalization models restricted to rooftops or open land, this initiative generated auxiliary revenue for Taiwan Power Company. However, the subsequent construction was disapproved because the municipal government determined that the designated land parcel is situated within the Chelungpu fault zone, where the erection of any above-ground structures is prohibited.

This article details the key planning and design aspects, tendering processes, and post-award regulatory application experiences, serving as a reference for other company units engaging in land leasing for carport-style solar PV installations.

關鍵詞(Key Words)：再生能源(Renewable Energy)、太陽光電發電(Solar Photovoltaic Power Generation)、停車空間(Parking Space)。