台電工程月刊 859 期（3 號）目錄

離岸風場結合高壓直流傳輸系統之模擬研究

A Simulation Study of Offshore Wind Farms Connecting to High Voltage DC Transmission System

吳元康*
Wu, Yuan-Kang

林志明*
Lin, Zhi-Ming

曾俊傑*
Zeng, Jyun-Jie

摘　要

　　台灣離岸風電的開發是政府既定的政策之一，然而大規模的離岸風電併網勢必對於既有電力系統操作帶來極大的挑戰，其中如何維持電壓穩定是重要的議題之一。本研究探討 2.4GW 與 6.5GW 裝置容量的離岸風場分別於 2024 年與 2025 年併入台灣電力系統後，在不同操作情境下對於系統電壓的影響，並分析採用直流或交流傳輸對於系統電壓控制的差異。本文的模擬已應用電力系統分析軟體 PSS/E 分別完成風場等效模型、高壓交直流傳輸系統模型、以及虛功補償元件模型的建立。藉由本研究的分析，可以凸顯大容量離岸風場併入台電系統後對於電壓控制的重要性、直流傳輸的優勢、以及建立風場等效模型的必要性。

Abstract

Offshore wind power development is top priority energy policy of the ruling government. However, integration of large-scale offshore wind power usually poses great challenge to power system operation. Maintaining voltage stability for example is one among others. This thesis studies the impact of power system voltage under differentiated operation scenarios and analyzes voltage control using VSC-HVDC or HVAC transmission when two offshore wind farms with installed capacity of 2.4 GW and 6.5 GW to be connected to the power system in Taiwan in 2024 and 2025. In this study we apply power system analysis software PSS/E to build up models for/of equivalent wind farm, HVAC and VSC-HVDC transmission systems and reactive power compensation component. The simulation results emphasizes the importance of voltage control, the advantages of HVDC transmission, and the necessity of establishing wind farm equivalent model to cope with issues raised by large scale offshore wind farms integrating with the power system.

關鍵詞(Key Words)：離岸風電 (Offshore Wind Farm)、電壓 (Voltage)、高壓直流傳輸 (HVDC)、風場等效 (Equivalent Wind Farm)、虛功補償 (Reactive Power Compensation)。

＊國立中正大學電機系

電能轉供與併網型直供服務介紹

Introduction of Power Wheeling and Grid-connected Direct Supply Services for Renewable Energy

曾智泓*
Zeng, Jhih-Hong

鄭博文**
Cheng, Bo-Wen

洪永輝*
Hong, Young-Huei

黃張鴻*
Huang, Bill

林柏樺*
Lin, Po-Hua

胡進成*
Hu, Jin-Cheng

摘　要

　　政府推動能源轉型及電業改革，在電力穩定供應的前提下，開放再生能源得採直供、轉供、躉售等多元售電管道，開放用戶購電選擇權，開放再生能源售電業參與電力市場。為達成目標，台電公司訂定「電能轉供及併網型直供營運規章」並建置「電能轉供與併網型直供資訊公開、服務申請與計費系統」。

　　本文分別說明「電能轉供」及「併網型直供」之業務內容、服務費用項目、計費方式與電量解析機制，接著介紹「電能轉供與併網型直供資訊公開、服務申請與計費系統」之建置目的與架構。目的為使讀者能夠瞭解台電公司配合政府政策所推動的此項全新業務。

Abstract

　　To promote energy transition and electricity market reform, the government removed the market entry barrier for renewable energy. Renewable energy now may sell their electricity generation through direct supply, power wheeling, and/or bulk sale to their customers as long as the transactions do no harm to the stability of power supply. On the other hand, retail customers may purchase electricity from any renewable energy licensee with whom they feel like to trade. To execute the aforementioned policy, Taiwan Power Company has formulated "Operation Regulations for Renewable Energy Power Wheeling and Grid-connected Direct Supply" and implemented corresponding information system.

　　This paper aims to elaborate the business contents, items of service, billing methods and power analyzing mechanism and introduce the purpose/structure of the corresponding information system to provide a whole/clear picture of the new services.

關鍵詞(Key Words)：併網型直供(Grid-connected Direct Supply)、電力代輸/電力轉供(Power Wheeling)。

＊台灣電力公司輸供電事業部系統規劃處
＊＊台灣電力公司資訊系統處

離岸風力第一期示範風場三維地質建模與海底地形變遷探討

Offshore Windfarm Phase 1 Demonstration Project – Investigation of Three Dimensional Geological Modeling and Seabed Topography Change

黃宣維*`**
Huang, Hsuan-Wei

蕭以晨*
Hsiao, Yi-Chen

黃鐘***
Huang, Chung

游鎮源*
Yu, Chen-Yuan

黃連通*
Hwang, Lian-Tong

摘　要

　　離岸風力發電之場域規劃中，海底地質與海底地形為重要之關鍵因素，目前本公司已完成兩次離岸風場之海底地形掃描及海底淺地層反射震測探勘，未來風場施工即可基於目前資料進行細部設計。本公司過去並無實施離岸風場開發之計畫，故離岸一期風場之地質資料取得方法以遵循國外離岸風場地質探勘與分析方向為主。由於國外主要離岸風場開發商多從油氣探勘業轉型而來，因此在資料之整合與詮釋以海域石油與天然氣探勘之概念進行。

　　本研究以綜研所化環室之油氣探勘地質建模軟體 JewelSuite 為主要工具，建立離岸一期風場之三維地質模型，並藉由建立模型之過程，了解離岸風電開發階段地質探勘時所需注意事項。本研究成果亦可應用於未來離岸風電計畫之地質探勘階段，希望利用本研究獲得之經驗，加強本公司離岸風電地質調查階段之資料品質、資料呈現方式與資料加值等項目，以加速離岸風電之開發進度。

Abstract

Subsea geological properties and seabed topography are two crucial factors influencing offshore windfarm site planning. Taiwan Power Company has so far fulfilled two round offshore windfarm seabed topography and seismic reflection investigation hopefully to provide detail construction design information for the future. However, TPC barely has offshore windfarm developing experience from the past to the present, so the methods obtaining/analyzing geological data of offshore windfarm phase 1 demonstration project adhere to customary engineering geology adopted abroad. Besides, the predecessors of most offshore windfarm developing companies abroad are oil/gas exploration companies, their data integration and interpretation naturally invoke the concepts of oil/gas exploration.

This study uses JewelSuite software as a main tool to construct three-dimensional geological model for Offshore Windfarm Phase 1 Demonstration Project. For readers' reference, JewelSuite is a software for oil exploration and geological construction model and owned by Chemistry and Environmental Research Laboratory of Taiwan Power Research Institute.

The results of this study may apply to offshore windfarm geological investigation in the future, help ensure the quality of offshore windfarm developing, enhance data quality, and add value to the ways of data presenting.

關鍵詞 (Key Words)：圓錐貫入試驗(Cone Penetration Test, CPT)、離岸風場(Offshore Windfarm, OWF)、風力發電機組(Wind Turbine Generator, WTG)、砂波(Sand Wave)、地質模型(Geological Model)。

*台灣電力公司營建處
**臺灣大學地質科學系所
***台灣電力公司綜合研究所

融入深度學習建構變電所工程監控圖資管理系統平台

Study of Applying Deep-Learning Techniques to Substation Engineering Control and Management System Platform

張喜翔*　　　　　李志堂*　　　　　鄭暘辰*　　　　　林正義*
Chang, Hsi-Hsiang　　Li, Chih-Tang　　Cheng, Yang-Chen　　Lin, Cheng-Yi

摘　要

　　為了提升電力品質、可靠性及提高備轉容量，本公司將陸續啟動再生能源加強電力網、區域電網、變電所整所改建計畫及電力設備汰換工程等，惟考量每一類型工程不盡相同，再加上工程面規劃複雜，而導致相關配合工作增多及施工工期延長，無法使工程如質如期加入系統，必須研擬因應對策改善工程延宕之課題，因此導入人工智慧深度學習之演算法，首先收集歷史工程資料，再利用大數據資料進行訓練，經訓練學習後產生深度類神經網路模型，評估不同類型工程之工期，將該模型納入由 Visual Basic 軟體開發人機介面系統中，並結合 Google 地圖服務之功能，以智慧搜尋變電所施工位置及周遭環境，以及該變電所施工圖面、工程內容、工程進度、接收單位等介面資料加以彙整連結，整合一套多功能系統平台架構，能夠快速查詢及管控不同階段工作項目及自動更新工程資料庫，爰此，對變電所工程監控管理提出一種新的創新方法，改革目前作法，藉此提升公司工程品質及施工效率。

Abstract

　　To improve reliability/quality of power supply and increase the level of operating reserve, Taiwan Power Company has embarked on engineering projects including system-wide/regional power grids reinforcement, substation renovation and power equipment replacement. Since difference and complexity among/of engineering project result in increase of coordination work and prolonging construction time, countermeasures need be developed to correct the drawbacks. Arithmetic method utilizing deep learning/artificial intelligence is thus introduced. We first collect historical engineering data and uses the big data for training purposes. A deep neural network model is generated to evaluate the required construction time of differentiated projects and incorporated into the human-machine interface system developed by Visual Basic software. Banding with Google Map different functions such as smart search for location and surrounding environment of substations, interface information organization, i.e. substation construction maps, content of engineering projects, schedules and receiving unit etc., have been integrated into one platform architecture to provide quick querying, managing work items at different stages and automatic engineering databases updating.

　　Conclusively the platform provides an innovative method to improve the engineering quality and construction efficiency of substation project management.

關鍵詞(Key Words)：再生能源(Renewable Energy)、區域電網(Regional Power Grid)、深度學習(Deep Learning)、Google 地圖(Google Maps)。

---

*台灣電力公司輸供電事業部輸變電工程處南區施工處

高煤灰摻量應用在無加勁鋼筋混凝土技術介紹

Introduction of Applying High Content Coal Ash in Concrete Technology with Unreinforced Structure

林茂容*　　　　　　　　　朱炳垣**　　　　　　　　　張獻文**
Lin, Mao-Lung　　　　　　Ju, Bing-Yuan　　　　　　Chang, Hsien-Wen

摘　要

　　台電燃煤電廠產出煤灰的最大工程用途，目前仍以飛灰(FA)摻用於混凝土工程為主，而且飛灰取代混凝土水泥用量最高比率仍建議置換重量為 25%，本篇介紹以一定規格的底灰(CBA)替代細砂應用於無加勁鋼筋的混凝土結構，同時配合採用更高置換比率的 F 級飛灰，可提高整體煤灰應用的比例，以消波塊設計需求為例，採用 144kg/m^3 飛灰用量取代水泥量 36%比率，整體可提高 1 立方混凝土的煤灰(飛灰+底灰)用量約 700kg/m^3 以上。本篇介紹利用底灰以體積法取代 20%、40%、60%、100%比例的砂細粒料，並配合採用高比例飛灰，發現混凝土硬固強度的發展可符合結構設計需求，在膠結料用量、水膠比不變的條件下，分別以不同比重的底灰替代混凝土的砂細粒料，並比較不含底灰的混凝土抗壓強度、耐硫酸塩能力，以及其他工程性質，試驗證明此種組合材料製成無結構鋼筋的混凝土塊體，具有實際的可行性，結果表明適量與一定規格的底灰礦物摻入混凝土是屬可行的應用。

Abstract

　　Civil concrete engineering is the major application field for fly ash, by-product of coal-fired power plants. So far the recommended highest replacement ratio of concrete cement/fly ash is 25wt%.

　　This article introduces the application substituting coal bottom ash for fine sand of particular specification concrete structures with unreinforced steel. It is found that the proportion of coal ash/fine sand can be escalated with the use of higher replacement ratio fly ash.

　　The main findings of this study include: 1. When applying coal bottom ash to substitute 20%、40%、60%、100% fine sand respectively by volume method, the development of compressive strength of concrete continuingly complies with design requirements, 2. When using same quantity binder power and same water-to-binder ratio to substitute sand granules by coal bottom ash of different gravity and compare their different properties, e.g. compressive strength, barium sulfate resistance and other engineering properties of concrete without coal bottom ash, the results confirm that the said composite material is feasible in engineering practices.

關鍵詞(Key Words)：飛灰(Fly Ash, FA)、底灰(Coal Bottom Ash, CBA)、化學摻劑(Chemical Admixture)、水膠比(Water-Binder ratio)。

---

*台灣電力公司綜合研究所
**台灣電力公司綜合施工處

協和發電廠三年改善靜電集塵器效率達到粒狀物個位數排放專案

A Project Study for Electrostatic Precipitator Efficiency Improvement of Hsieh-Ho Power Plant

簡大舜*
Chien, Ta-Shun

王銘揚**
Wang, Ming-Yang

蔡進賜**
Tsai, Chin-Tzu

謝翔帆**
Hsieh, Hsiang-Fan

徐榮彬***
Hsu, Jung-Pin

梁達嵐***
Liang, Da-Lan

摘　要

本專案透過更新機械零件及高頻變壓器，並且透過規劃多階段式的工程，提升協和電廠之靜電集塵器(ESP)之效率，出口濃度達到「固定汙染源最佳可行技術」規範的粒狀物排放濃度(≤ 10 mg/Nm³)。協和電廠具有維持台灣北部電力穩定供應的重責大任，不允許長時間的停機維修。若要完成 ESP 內部全部機械件更新，須至少兩個月工期，因此電廠規劃多階段工程進行，利用 2016 至 2018 年的停機時間，將 ESP 機械部件分段更新，提升運轉可靠度；第一階段將出口排放回復至原始設計集塵效率，第二階段則進一步更新三號機靜電集塵器與四號 ESP 的電源系統，將原有之傳統變壓器全數更新為高頻變壓器。藉由高頻變壓器本身具有之低漣波率之特性，降低火花發生率並提高輸出之功率，進而達到提升靜電集塵器除塵效率以及降低煙囪排放之效果，最終達到粒狀物排放濃度為個位數之排放目標。

Abstract

Hsieh-Ho Power Plant, with generation capacity of 2,000 MW, plays a critical role in electricity supply in the Northern part of Taiwan. Equipped with 4 oil-fired power boilers, Hsieh-Ho began its operation in 1977. In order to cope with the public calls to reduce particulate emission, Hsieh-Ho had executed several project phases of retrofit and upgrade during the 3-year period from 2016 to 2018. As a result, particulate emission had been successfully reduced from 30 mg/Nm³ to below 10 mg/Nm³, which accounted for almost 60% reduction. Most importantly, it had been proven by this project that electrostatic precipitator can be upgraded and contribute to the capturing of PM₂.₅ in a volume of 60% or above.

關鍵詞(Key Words)：靜電集塵器(Electrostatic Precipitator)、細懸浮微粒(PM2.5)、粒狀物排放(Particulate Emission)、高頻變壓器(High Frequency Transformer and Rectifier)。

*台灣電力公司水火力發電事業部發電處
**台灣電力公司水火力發電事業部協和發電廠
***昇台工程股份有限公司

台電公司對電業自由化之策略、因應及執行規劃研究—以管控模式與轉型規劃原則為中心

Study of Business Strategies, Countermeasures and Action Plan to Cope with the Liberalization Policy - Focusing on Control Mode and Planning Principles of TPC Re-organization

林唐裕*
Lin, Tang-Yu

陳建璋*
Chen, Chien-Chang

吳志剛*
Wu, Chih-Kang

黃春霖*
Huang, Chun-Lin

左重慶**
Tso, Chung-Ching

徐守正***
Hsu, Shou-Chen

摘　要

　　為順應國際能源轉型趨勢，大力發展再生能源，政府自民國 105 年起加速推動《電業法》修法，該法於 106 年 1 月 11 日完成三讀，同月 26 日公布施行。新修正通過之《電業法》第 6 條第 5 項規定：「為達成穩定供電目標，台灣電力股份有限公司之發電業及輸配電業專業分工後，轉型為控股母公司，其下成立發電及輸配售電公司。」，惟該項規定僅規範台電公司必須轉型為控股母子公司，至於控股關係如何成立、控股母公司對發電與輸配售電兩家子公司之管控模式、及台電控股集團之轉型規劃原則等重要議題，則未作具體之規範。

　　面對電力市場環境之變化，台電公司如何順利轉型控股集團，以確保穩定供電與供電義務之達成。本文爰以《電業法》之相關規範，參酌主要國家廠網分離之案例，針對台電轉型控股公司之最佳管控模式、組織設計之規劃原則與配套措施等，研提規劃構想供台電公司參考運用。

Abstract

To comply with global energy transition trend and progressively develop domestic renewable energy, the government accelerated the amendment of the Electricity Act in 2016 and accomplished the amendment in January 2017. According to the newly amended Act, Taiwan Power Company shall transform from one vertically integrated electric utility into one holding company and two subsidiaries, one GenCo and one GridCo, to ensure stable power supply. Nevertheless the Act does not specify the hows to accomplish the transformation and issues such as governance mechanism between the holding company and two subsidiaries.

Through surveying/analyzing on unbundling cases abroad and regulations of the Electricity Act, this study comes up with valuable/feasible planning ideas such as the optimal governance mechanism, planning principles and supporting measures for the reference of TPC reorganization.

---

*財團法人台灣綜合研究院
**台灣電力公司企劃處
***台灣電力公司綜合研究所