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# 燃煤電廠輸煤系統積落煤成因普查報告

Census Report on the Causes of Dropped-coal of Coal Conveying Systems of Coal-fired Power Plants

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## 摘要

輸煤系統的積落料清理是每座燃煤電廠必須面對的課題，若清理不完全或異常落料，恐造成積煤悶燒、設備燒損、甚至影響機組供電。造成積落煤的成因有許多直接、間接因素，且彼此間都有因果關係與連鎖效應；本研究試圖由輸煤設備普遍最容易產生積落煤的數個「積煤熱點」切入，接著針對各熱點個別探討其成因並加以分析，同時與設備維護的歷史資料交互比對，期能找出幾個造成落料的關鍵因素，以利於後續的探討與改善。

## Abstract

Coal-fired power plants have to deal with dropped-coal cleaning of coal conveying systems to avoid coal smoldering and equipment burnout, in a worst case negative impact to power supply, caused by incomplete cleaning and abnormal coal deposits.

There are direct and indirect factors that cause coal deposits, and the factors co-related to each other. This study aims to explore the hot spots of coal deposits apt to produce coal deposits-each hot spot been analyzed individually and cross-checked with the equipment's historic maintenance data. By identifying the key factors that cause coal deposit, we look forward that follow-up discussion and improvement may be thus accelerated.

**關鍵詞 (Key Words):** 煤場(Coal Yard)、輸煤系統(Coal Conveying System)、積落煤(Dropped-coal)、裙板(Skirt Board)、清潔器(Cleaner)。

# 台中發電廠空氣品質控制系統改善工程之可行性研究

Feasibility Study of Improving the Air Quality Control System at Taichung Power Plant

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## 摘要

台中電廠是我國最重要的燃煤發電廠之一，該電廠除了提供穩定的電力之外，如何進行空氣污染物減量排放受各界關注。本研究依據「台灣電力股份有限公司新興火力發電機組環保設備規劃準則」進行評估並篩選最佳方案，最終以不考量經費預算但考量工期之情境為最佳方案。方案內容為調整選擇性觸媒還原法(Selective Catalytic Reduction, SCR)相關元件及更換觸媒、更新靜電集塵器(Electrostatic Precipitator, ESP)極線及變壓器系統、新建排煙脫硫吸收塔(Flue-Gas Desulfurisation, FGD)/更新 FGD 內部元件、更換氣對氣加熱系統(Gas Gas Heater, GGH)及新建濕式靜電集塵器(Wet Electrostatic Precipitator, WESP)等。

經本工程改善後，台中發電廠 5~10 號機執行空污改善工程計畫之承諾濃度為  $PM \leq 10 \text{ mg/Nm}^3$ 、 $SO_x \leq 12 \text{ ppm}$  及  $NO_x \leq 22 \text{ ppm}$ 。

## Abstract

The importance of Taichung Power Plant regarding maintaining stable power supply in Taiwan is undoubtful. Nevertheless, since it is coal-fired, how to reduce the plant's air pollutant emissions has also attracted a lot of social attention. To cope with the regulations of "the Environmental Protection Equipment Planning Guidelines Regarding Taipower's New-built Coal Fired Units", we conducted an engineering improvement study, and construction period, instead of budget, turned out to be the primary consideration of the project. The major contents of the study includes: 1) replace Selective Catalytic Reduction (SCR) related components and catalysts, 2) upgrade Electrostatic Precipitator (ESP) discharge electrode and transformer system, 3) rebuild Flue-Gas Desulfurization (FGD) and to upgrade FGD internal components, 4) replace Gas-Gas Heater (GGH) and install a new Wet Electrostatic Precipitator (WESP). After improvement, the manufacturer's committed concentration for units #5 to #10 of Taichung Power Plant are  $PM \leq 10 \text{ mg/Nm}^3$ ,  $SO_x \leq 12 \text{ ppm}$ , and  $NO_x \leq 22 \text{ ppm}$ .

**關鍵詞 (Key Words)**：選擇性觸媒還原法 (Selective Catalytic Reduction, SCR)、靜電集塵器 (Electrostatic Precipitator, ESP)、靜電集塵器(Electrostatic Precipitator, ESP)、排煙脫硫吸收塔 (Flue-Gas Desulfurisation, FGD)、氣-氣加熱系統 (Gas Gas Heater, GGH)、溼式靜電集塵器(Wet Electrostatic Precipitator, WESP)、空氣污染物減量 (Air Pollution Reduction)、空污改善工程 (Air Pollution Improvement)、空氣品質控制系統 (Air Quality Control System)。

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# 地下電纜設計間距與送電容量/溫度之模擬與實測 差異研究

A Study on the Difference between Simulated and Measured Underground Cable Design  
Spacing and Power Transmission Capacity/Temperature

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## 摘要

地下電纜因為埋設於地底下，受限於環境和道路狹隘，使得無法分散埋設，造成散熱效果較差，損失也較大，導致地下電纜的送電電流與容量受到限制。有鑑於此，本文透過國際標準的數學公式與有限元素軟體 ANSYS Workbench 模擬，針對台灣地下電纜設計間距與送電容量/溫度之關係，分析設計間距縮減是否仍能符合足夠供電能力及安全調度需求。並且透過收集實際的地下電纜送電容量/溫度等數據來與數學公式、有限元素模擬比對之間的差異。最後為地下電纜的設計間距、送電容量/溫度之數學公式、模擬結果、實地監測結果等三者差異，向台灣電力公司提出地下電纜設計間距之合理建議。

## Abstract

The distribution of underground cables is subject to the cables' underground environment. When placed closely, the heat accumulated will cause increase of line loss and decrease of available transmission capacity of underground cables. We apply international standards and ANSYS Workbench method to identify the differences among simulated and measured design spacing, power transmission capacity and temperatures, to see whether narrower design spacing can maintain stable power supply and dispatch security. At the end are our suggestions to serve as reference for Taipower.

**關鍵詞(Key Words)**：地下電纜(Underground Cable)、設計間距(Design Spacing)、送電容量(Power Transmission Capacity)、熱容量(Heat Capacity)、有限元素分析(Finite Element Analysis)。

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# 電力系統 GOOSE 保護策略應用建置

Application and Implementation of GOOSE Protection Function

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## 摘要

目前配電系統之設備保護規劃因考量成本及設備條件，因此無法規劃像 69kV 以上輸電線路等有全線段主保護以及後衛保護等保護電驛，而此文內容將探討 IEC61850 之 GOOSE 功能應用於配電系統中，避免保護電驛在兩饋線同時事故中造成越級跳脫而導致停電範圍擴大。此應用不僅可減少投資成本，亦可提升配電系統供電可靠度。而本轄區目前應用 GOOSE 跳脫功能之一次配電變電所已有保定 D/S、龍子 D/S 與加一 D/S，本文也將探討參與保定 D/S 與龍子 D/S 汰換 IEC61850 以及 GOOSE 功能應用於饋線之驗證過程及測試結果。

## Abstract

Restricted by cost and equipment conditions, the planning of facility protection of distribution system (22kV and below) can not apply 87L current differential relay and backup protection, unlike transmission system (69kV and above). In this study, we apply GOOSE function of IEC 61850 onto distribution system to enhance the protection performance between IEDs and prevent outages caused by relay mal-operation. The said application can not only reduce cost of investment, but also help improve reliability of power supply. In this study, GOOSE function of IEC61850 had been applied to Pao-Ting D/S、Lung-Tzu D/S and Chia-Yi D/S to verify the testing results of GOOSE function on substation feeders.

**關鍵詞(Key Words) :** IEC 61850、一般物件導向變電所事件(GOOSE)、協調時間間隔(Coordination Time Internal)。

# 抽蓄儲能水力電廠廠址評估及裝置容量分析

Site Assessment and Installed Capacity Analysis of Pumped Storage Hydro Power Plant

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## 摘要

因應地球暖化、極端氣候及提高能源自主率等，再生能源發電乃必然趨勢，亦為政府推動政策之一，經濟部於 105 年 6 月 22 日向立法院經濟委員會提出「綠色能源政策性目標、未來規劃及執行現況」書面報告，全力加速及擴大再生能源，展現政府積極推動再生能源之決心。依據我國目前能源政策，2025 年再生能源發電量占比將提高至 20%，其中太陽光電裝置容量達 20GW、風力發電裝置容量達 6.7GW，合計 26.7GW<sup>[4]</sup>；惟太陽光電及風力屬間歇性再生能源，不受系統調度，如併入電力系統占比過高，對於系統安全、電壓穩定及供電品質將造成衝擊，故必須建置儲能系統。儲能系統主要可分為分散型儲能及系統型儲能等兩種類型，分散型儲能以電池為主<sup>[5]</sup>，系統型儲能目前以抽蓄水力電廠技術較為純熟且具長時效之儲能功能、可在短時間內及時提供電力系統負載需要等優點，除對電力系統具有調頻、調壓功能外，亦有「抽蓄發電、削峰填谷」之作用，提高電力系統調度穩定性。

## Abstract

Renewable energies (RE) are inevitable for worldwide governments to deal with extreme weather accompanied by global warming, and to ensure energy independence. According to a written report, titled the Policy Goals, Future Planning and Current Status of Green Energy, submitted by the Ministry of Economic Affairs (MOEA) to the Economic Committee of the Legislative Yuan on June 22, 2016, Taiwan government is determined to accelerate RE development, and has set a goal of 20% RE generation by 2025, To meet the target, 20GW photovoltaic and 6.7GW wind energy, in total 26.7GW, will have to be installed by the said deadline. Nevertheless, due to RE's intermittent and non-dispatchable attributes, high RE ratio may cast negative impacts to grid operation, e.g. voltage stability, and power quality. To deal with the situations, energy storage system becomes indispensable. There are two types of energy storage systems- the centralized (pumped storage hydro and long duration energy storage) and the decentralized (batteries). Pumped storage hydro power plants have short response time, therefore are capable to provide functions such as frequency/voltage control, peak load clipping and valley filling at off-peak time periods.

**關鍵詞(Key Words)**：抽蓄水力電廠(Pumped Storage Hydro Power Plant)、佈置研究(Layout Study)、水力發電(Hydroelectricity)。

# 高壓AMI之系統負載分析應用案例

## The Application of High Tension AMI System Load Analysis

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### 摘要

102年起，高壓以上用戶已全面布建智慧型電表，透過數據分析技術的應用，可深入探討各契約別及產業別負載型態與對系統負載之影響。運用高壓AMI等資料解析夏月系統尖峰負載組成特性，以及氣溫與負載之關聯，本研究發現與氣溫關聯性較大的低壓用戶用電係造成系統尖峰負載之主要因素，例如：空調用電約占近年尖峰負載之22.7%至24.5%。高壓以上用電部分，學校用戶、電腦、電子產品及光學製品製造業與服務業等用電受氣溫影響較大；系統尖峰日時，以電子零組件製造業、服務業、金屬製品製造業等耗能產業用電占比較高。綜上所述，運用分類技術分析高壓以上用戶用電型態，透過掌握用戶用電特性，可供電價、需量反應負載管理措施修訂與推廣之參考。

### Abstract

High-Tension and Extra-High-Tension customers of Taipower have been comprehensive deployed with smart meters. Through applications of data analysis, it is now possible for us to explore in depth load types of various customers (by contracts or industrials) and their impacts on power system. This paper uses High-tension and Extra-high-tension AMI data to analyze the composition of system peak load and the correlation between temperature and load. It is concluded that the power consumption of Low-Tension customers is not only highly related to temperature, but also the main factor for system peak load- their air-conditioning consumption accounts for 22.7% to 24.5% of system peak load in recent years.

The consumption of High-Tension and Extra-High-Tension customers, such as schools, computer & electronic products & optical product manufacturing industry and service industry, are closely related to temperature. On system peak day, the power consumption of electronic component manufacturing industry, service industry and metal product manufacturing industry are higher than other industries. In addition, classification technologies have also been used to analyze the load patterns of High-Tension and Extra-High-Tension customers. In a word, thorough understanding of customer load pattern may serve as reference for revising and promoting electric utilities' tariffs and DR measures.

**關鍵詞(Key Words)**：用電分析(Electricity Consumption Analysis)、系統負載(System Load)、智慧型電表(AMI)。

# 變電所巡檢機器人之開發與應用

The Development and Applications of Substation Inspection Robot

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## 摘要

變電所巡檢作業為維護電網可靠運行的重要工作，近來因機器人相關技術快速發展，如能讓機器人執行巡檢、遠端監控、紅外線熱點偵測、異常警報通知等功能，將可大幅提升巡檢的效能。

本計畫根據國內外案例與現地勘查，決定定位導航以 3D LiDAR 為主，在影像巡檢元件設計上，是採用可視光與熱影像兩種視覺影像感測模組，音訊部分使用麥克風陣列設計，最後則是選擇以較具代表性的萬華二次變電所作為後續驗證場域。針對功能開發與系統整合的部分，進行地圖建置、自走功能及任務排程等功能的開發，也完成了中控端軟體介面的開發，並且建置了充電小屋。

巡檢機器人硬體開發及系統整合完成後，進行長時間場域驗證與測試。讓機器人在不同時間、天候條件下運行的驗證測試，與台電相關人員進行多次會議，以此提出改進設計，以掌握未來商轉時，可以快速建置與廣泛使用。

## Abstract

Substation inspection is essential for maintaining reliable power grid operation. Rapid development of robot-related technologies has made robots possible to perform some functions such as inspection, remote monitoring, infrared hot spot detection, abnormal alarm notification, and greatly improve the efficiency of substation inspection. This contents of this research are as follows: 1) survey state-of-the-art technologies and their complexity, 2) implement navigation algorithm based on 3D LiDAR, 3) apply dual vision image sensing module, 4) present microphone array for audio recognition, 5) Wanhua secondary substation is elected to verify the functions of user interface, system integration, and some other tasks like scheduling, localization, and navigation. By the way, a charging cabin had been designed and constructed.

The evaluation tests were undertaken under critical weather conditions and many discussion meeting had been held with Taipower to improve the functions of the robot to ensure stable operation of the system.

**關鍵詞 (Key Words)**：變電所巡檢機器人(Substation Inspection Robot)、自主移動與定位導航(Autonomous Moving and Positioning Navigation)、智慧巡檢(Intelligent Inspection)、紅外線熱點偵測(Infrared Hot Spot Detection)。

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# 配電器材之 OCR 文字識別程式測試

Testing of Distribution System Equipment Based Optical Character Recognition Program

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## 摘要

光學字元辨識(Optical Character Recognition, OCR)為針對文字型態之圖像進行分析辨識，取得文字資訊及版面資訊的過程，其技術對於圖像降噪、傾斜校正技術相當著重。現今在應用 OCR 技術逐漸普及，若可實際應用於範圍廣泛的配電系統中，將可以快速管理系統線上設備位置、裝置時間及裝置名稱等。

目前區處材料部門於各項器材的採購及進料/出料皆有系統管控，承商及員工施工領退料、裝設現場亦以相關系統管理，惟器材現場裝設後(如：變壓器、電表、電纜或開關等之編號、製造日期、製造商等基本資料)至電腦建檔，皆以人工填寫或 KEY IN 電腦建檔，易造成資料人工填寫及建檔錯誤，錯誤資料可能造成器材設備未按時汰換遭罰款(如電表檢定年限到達未換)，或用戶因不預警停電損失要求賠償(如事故器材設備因使用週期到達未汰換造成故障停電)，故器材現場裝設後至電腦建檔，如改以智慧工具掃描匯入，可避免人為作業錯誤產生，並且可以確認各個物料實際裝置的位置、地點及時間。

## Abstract

Optical character recognition (OCR) has been developed to analyze and recognize text-based images. OCR is indispensable for reducing the image noises and tilt correction for text information obtaining. The application of OCR technology is more and more popular, and widely applied to power distribution systems in terms of prompt management of the locations of online equipment, installation time, and device names. When installing an equipment such as transformer, cable or switch, the related information of the equipment, e.g. equipment number, manufacturing date, manufacturer and so on, we have to manually create a data file for the equipment and stored the information in a computer, and human errors sometimes happen. On the contrary, when the information are scanned into a computer with smart tools, the errors can be avoided and after-installation reconfirmation easily done.

**關鍵詞 (Key Words)**：光學字元辨識(Optical Character Recognition, OCR)、物料管理(Objective Management)、配電器材(Distribution System Equipment)。

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# 台電公司導入才能評鑑發展中心模式回顧與展望

The Review and Outlook of Taipower's Developmental Assessment Center System

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## 摘 要

本文旨在回顧台灣電力公司 105 年導入「評鑑中心法(AC)」，至 109 年歷經 4 年的中階主管才能評鑑，先介紹「才能評鑑發展中心」前置作業的職能模型建構開始，接著說明才能評鑑發展中心體系的設計及執行，針對產出結果分析目前高階職能發展的強弱項，並針對群組差異分析提供發現與建議，後續再對受評者進行諮商面談的安排及個人發展計畫的進行方式。文末根據實務經驗提供台電繼續推動才能評鑑發展中心的展望及建議。

## Abstract

This paper reviews the benefits of Taipower's "Assessment Center Method (AC)", encompassing the mid-level executive competency assessments from 2016 to 2020. We first introduce the construction of the functional model of the preliminary work of the Assessment and Development Center, and then introduce the design and implementation of the AC system. Based on the assessment results, the competencies of high-level candidates, strengths and weakness, and group differences are analyzed to serve as reference for subsequent consultation interviews of individual development program (IDP). At the end is the outlook and our suggestions for the subsequent AC development of Taipower.

**關鍵詞(Key Words)**：管理職能模型(Management Competency Model)、才能評鑑發展中心(Developmental Assessment Center)、個人發展計畫 (Individual Development Program)、台灣電力公司(Taiwan Power Company)。

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# 核能發電廠輻射偵檢與工程資訊視覺化作法

Visualization of NPP Radiation Dose Data and Engineering-related Information Applying Building Information Modeling and Serious Game Platforms

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## 摘要

我國首座除役的台電第一核能發電廠，因現場作業具高風險，事前詳細規劃、多次演練為成功的不二法門。本研究基於核一廠既有輻射偵檢除役資料庫，與各式建築、組件與管線的數位模型與工程參數資料，以建築資訊模型與嚴肅遊戲等工程視覺化技術，建構擬真場景，讓使用者可在 3D 虛擬世界漫遊核一廠區、綜覽各處偵檢點的輻射劑量與鄰近汙染源、查閱組件與管線屬性，及模擬拆除樣態等。瞭解現場輻射劑量分布與汙染源位置可謂除役工程首要工作，本研究參考國際電業、核能產業施工、運轉和除役等運用工程視覺化的文獻，設計適用於核一廠之互動視覺場景資訊平台，供廠區及各資料掌管部門運用。考量後續擴充性，平台結合現行除役資料庫輻射偵檢資訊，數位化紙本或不同格式圖檔之偵檢點位，在統一的 3D 座標虛擬世界呈現各式功能，期望協助決策者進行現場工作規劃，達到縮短工期、提高效率，並降低工作人員的工安風險。

## Abstract

On-site operations of nuclear power plants (NPPs) are exposed to high risks, and therefore require detailed planning and training beforehand. This research is based on the radiation survey data currently stored in the decommissioning database of Taipower's First Nuclear Power Plant along with digital models and engineering parameter data of various buildings, components and pipelines of the plant. We utilize building information modeling tools and serious game platforms with the following functions to construct realistic scenes : 1) allow users to roam around the nuclear power plant, overview the radiation dose data and nearby sources, 3) check the attributes of components and pipelines, and simulate their dismantling status. This study, by reviewing documents of international electric and nuclear power plant industries, aims to introduce the construction, operations and decommissioning of NPPs by using engineering visualization techniques to design an interactive visualization platform suitable for the First Nuclear Power Plant of Taipower. Taking subsequent extensions into consideration, the proposed platform may be used to integrate the location data of radiation survey points with the current decommissioning database. We look forward that this study may provide assistance for the company's on-site work planning to shorten the decommissioning period, improve efficiency, and ensure work safety.

**關鍵詞(Key Words)：**核電廠除役(Nuclear Decommissioning)、工程資訊視覺化(Engineering Visualization)、數位孿生(Digital Twin)、建築資訊模型(Building Information Modeling)、嚴肅遊戲平台(Serious Game)。

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