# 台電工程月刊 858 期（2 月 號）目錄

## 輸 變 電：



## 配　　電：



## 電力系統：



## 能源與環境：

# 變電設備維護數據收集分析-LoRa 通訊技術之規劃應用

Application of Substation Equipment Maintenance Data Collection and Analysis Planning - LoRa Communication Technology

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## 摘　要

台電公司運用油中氣體分析技術(DGA)已有多年時間，用於監測現場變電設備運轉狀況，TCG 設備早期施作工法皆裝設在現場，未配置通訊線路將變電設備維護數據即時回傳，須藉由維護人員定期至現場下載收集數據。本文利用 LoRa 通訊技術建置一系統，將各變電所現場 TCG 數據回傳至仁武變電所控制室。本系統除提供查詢各所 TCG 數據及分析圖表外，亦可提供數據比對，供維護人員即早發現設備異常進而降低事故發生機率，落實變電設備狀態基準維護(Condition-based Maintenance, CBM)，也可做為點檢排程或汰換設備的依據；本系統若偵測到 TCG 設備故障(依各 TCG 廠牌故障訊息)或 TCG 趨勢異常(變電設備有異狀)將於第一時間回傳示警，可縮短維護查修時程。

## Abstract

Taipower has applied Dissolved Gas Analysis technique to monitor the operation state of substation equipment for years. Since Total Combustible Gases units were installed on site, without communication cables to transmit the real-time data, operation data must be regularly downloaded by maintenance crew on site.

This study explores the establishment of a system transmitting TCG data from each substation back to Ren-Wu Substation Control Center through LoRa communication technique. The aforesaid system provides function of requesting TCG data of each substation and analysis diagrams, and fuction of data comparison, to help for the maintenance crew to identify asset malfunction on site in early stage, reduce possibility of incidents, and substantiate the benefits of CBM.

The system also report alerts immediately when afailure of TCG unit or abnormal trend of TCG reading has been detected, so as to shorten the maintenance schedule and timeline.

**關鍵詞(Key Words)：**LoRa 通訊(Long Range communication)、油中氣體分析(Dissolved Gas Analysis, DGA)、可燃性氣體總量(Total Combustible Gases, TCG)、工業電腦(IPC)、變電設備狀態基準維護(Condition-based Maintenance, CBM)。

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# 抗滑排樁運用於塔基邊坡穩定-以 345kV 核三~大鵬一二路#31 塔基保護工程為例

The Practical Application of Double Row Anti-Slide Piles to Stabilize Slope – A Case Study of Protection to the Potential Slope Landslide of Transmission Tower

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## 摘　要

本案例 345kV 核三~大鵬一二路#31 鐵塔基礎因提報異狀進行定期塔基監測，且經地盤傾斜儀觀測後，發現地表下約 17~18 公尺處有持續緩慢滑動情形，並以邊坡穩定分析軟體分析後，同樣在約 17~18 公尺處有最小的邊坡穩定安全係數。

本文將以 Stedwin 邊坡穩定分析後最小安全係數之滑動面作為抗滑排樁設計標的，依塔基邊坡地質條件，以 Midas 建立數值模型及載重條件，分析其結構行為，得知結構內力及變位資訊，再依規範規定、現場腹地空間、線下施工安全、滑動位移方向及提升抗滑動阻抗力等為抗滑排樁之設計考量，實務上採雙排抗滑樁結合連接梁作應用，增加輸電鐵塔基礎之邊坡穩定性。

## Abstract

Applying inclinometer and slope stability analysis software, we affirmed a 17-18 meters slide regarding a reported abnormal transmission tower, #31 345kV 3rd NPP to Da-Pong 1-2 circuits.

We then applied double row anti-slide piles with linked beam applied to stabilize the potential slope landslide. The structure model of this case was analyzed by Midas, to establish geotechnical report and surcharge loads. By analyzing the structure, the piles bending moment, the shear and deformation, were found and the retaining mechanism of the structure were learned. The slope has been stable after applying double row anti-slide piles structure. Experience of this case is informative to other landslide applications.

**關鍵詞(Key Words)：**輸電鐵塔(Transmission Tower)、地盤傾斜儀觀測(Inclinometer Survey)、抗滑排樁(Anti-Slide Piles)。

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# 放射線攝影檢測技術應用於斷路器內部異狀分析實務 以 ALSTOM 161 kV GIS 遮蔽罩為例

Application of Radiographic Technology to the Internal Analysis of Abnormalities in Circuit Breakers – A Case of ALSTOM 161 kV GIS Corona Shield

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## 摘　要

本次於樹林 D/S 進行 ALSTOM 製 161kV GIS 指標內檢工作時，發現遮蔽罩(Corona Shield)有裂縫的現象，因各區營運處共有 89 檔，依據「變電設備維護手冊」規定所有 GIS 需全面內檢並進行遮蔽罩更換，因遮蔽罩生產需 5.5 個月，對於運轉中斷路器投切操作有一定的風險，為求慎重，針對送電中的同廠牌斷路器先進行伽瑪放射線(Gamma Ray)攝影檢測，並開蓋驗證其準確性。同時要求設備商對有裂縫的遮蔽罩進行成分分析，以釐清破裂的主因。

## Abstract

When executing internal inspection of ALSTOM 161kV GIS at Shulin D/S, abnormal cracks in corona shields were identified. There are 89 switchgears in each district branch and the GISs must be extensively examined and replaced according to the regulation of "Substation Maintenance Manual." Since the manufacturing of corona shield mass usually takes 5.5 months, CB (circuit Breaker) operation must bear certain risks. To be prudent, we take precedence to perform Gamma ray photography on the corona shield of circuit breaker. To verify the accuracy, the lids were kept open. In addition, equipment manufacturers were asked to carry out component analysis up on cracked corona shields to clarify the cause(s) of the cracks.

**關鍵詞 (Key Words)**：遮蔽罩(Corona Shield)、斷路器(Circuit Breaker, CB)、伽瑪放射線攝影(Gamma Ray Photography)、破裂(Crack)、成分分析(Component Analysis)。

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# 一、二次套管不浸油之桿上變壓器研究開發

Study and Development of Pole Transformers with Non-oil-immersed Primary and Secondary Bushings

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## 摘　要

配電系統桿上變壓器發生滲漏油事故，導致民眾安全及財產受影響，嚴重影響電力公司形象。滲漏油原因主要是目前變壓器之一、二次套管均浸於絕緣油中，而相關墊片因老化發生漏油。目前國外已有一、二次套管不浸油型式之油浸式桿上變壓器，惟因各國電壓等級不同無法直接引進使用，故本文藉由變壓器內部構造設計圖面改良，並以電磁場與熱傳模擬軟體建立有限元素模型與分析。以避免類似滲漏油事故再次發生，提升供電可靠度。

## Abstract

Leakage accidents occurred in transformers on distribution poles not only cause negative effect on the safety of the public and loss of property, but also degrade the image of the electric utilities. The main cause of oil leakage is that the primary and secondary casings of transformers are immersed in insulating oil and sometimes the gaskets of the casings may leak due to aging problem. Although , oil-immersed rod-on transformers with casings not immersed in oil type are now available, they cannot be adopted directly due to varied voltage levels in different countries. To avoid oil leakage accidents and to improve power supply reliability, we therefore in this study seek to improve the internal structural design of the transformer, and apply electromagnetic field and heat transfer simulation software to build up finite element model for analysis.

**關鍵詞(Key Words)：**變壓器 (Transformers)、熱傳(Heat Transfer)、有限元素法(Finite Element Method)。

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# 配電系統狀態分析系統之研究

The Research of State Analysis System in Distribution System

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## 摘　要

隨著再生能源蓬勃發展，配電系統不再是單一方向之電源系統，使得配電規劃與運轉調度難度大幅提升。隨著智慧電網的積極建設，藉由線路上量測單元或節點末端負載之記錄資料，發展配電系統狀態分析系統，以協助配電人員掌握饋線運轉動態，進而滿足包含線路無效電力改善、轉供規劃等需求，提升配電系統供電可靠度與運轉效能。本研究發展配電系統狀態分析系統，結合變電所運轉資料、饋線拓樸、歷史量測及自動化開關等資料，利用潮流分析及狀態估計等技術，動態模擬配電系統，評估系統狀態、並提供轉供建議，以視覺化介面呈現即時資訊。所開發之平台，可分析相關記錄資料，視覺化展示線路拓樸結構及潮流動態，並提供無效功率規劃之建議，作為改善規畫之參考。

## Abstract

Renewable energy plays an important role in modern power grids, but intermittency and uncertainty of these resources also form challenges to power system integration. By integrating recorded data from measuring units on power lines or/and end of nodes, state estimation systems in distribution networks therefore provide assistance for the operators to grasp dynamics of feeders meet the needs of reducing reactive power, elevate power factor, manage stable supplying voltage, and offer load transferring strategy to enhance power supply reliability and performance of distribution system.

This paper aims to develop state analysis system to provide user interface with dynamic state estimations, suggestions, and information of distribution systems by integrating operation data of substations, switch status from distribution feeder automation systems, and power output of renewable energy. Under the said framework, topology and dynamics of distribution network can be analyzed, and recommendations of load transfer can also be provided.

**關鍵詞(Key Words)：**配電系統(Distribution System)、三相潮流(Three-Phase Power Flow)、狀態估計(State Estimation)、再生能源(Renewable Energy)。

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# 應用 IEC 61850 之 GOOSE 功能強化配電系統保護效能

Apply IEC 61850 GOOSE Function to Enhance Protection Performance in Distribution System

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## 摘 要

配電系統之設備保護規劃不若 161kV 以上輸電級配置強健,如:中壓匯流排無配置 87B 匯流排主保護電驛；饋線等設備因放射狀結構無法使用全線段 87L 差電流快速主保護電驛，而僅以過電流電驛做上下游間協調保護，先天上其保護即有較不足處。當發生少數超出原設計規劃之事故時(如：出現兩條饋線同時故障)，將可能發生上游 Main CB 保護電驛越級跳脫導致停電範圍擴大；又如發生中壓匯流排事故，將遷就於既有之 Main CB 與饋線間上下游保護協調關係，而延長了 Main CB 故障隔離時間。本研究內容旨在探討應用 IEC 61850 之 GOOSE 功能於配電系統中，強化其上下游電驛間之保護協調、加速中壓 BUS 故障保護等，可簡化系統設備投資建置、避免電驛越級跳脫，以達到快速、低成本及高可靠度之保護方式。

## Abstract

The planning of power facility protection of Distribution system(22kV and below) is not as robust as the planning of 161kV and above transmission system. For examples, 11/22 kV busbars are not equipped with 87B bus protection relay, and feeders only applied overcurrent protection, but not 87L current differential relay due to radial arrangements. When there are faults occurred on two feeders simultaneously, the original coordination design will be out of function and trigger the tripping of upstream Main CB relay .

The study tries to apply the GOOSE function of IEC 61850 to distribution system protection to enhance the protection performance between IEDs, so as to reduce investment costs, prevent relays from maloperation, and shorten the busbar fault clearing time.

**關鍵詞(Key Words)：**IEC 61850、一般物件導向變電所事件(GOOSE)、發佈(Publish)、訂閱者(Subscribe)、群播(Multicast)、協調時間間隔(Coordination Time Interval)。

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# 台電系統慣性頻率響應估算及再生能源的影響

System Inertial Frequency Response Estimation and Impact of Renewable Resources in Taiwan Power System

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## 摘　要

本文以台灣電力系統的慣性頻率響應，針對再生能源在頻率控制方面的觀察和挑戰進行探討。通常，頻率控制可以根據響應時間分為慣性、初級和次級頻率響應。目前，在台灣電力系統，可以通過採用適當的控制設置來實現初級和次級頻率響應。本文描述的慣性頻率響應是指連接到電網的總同步慣量，包括電機負載和同步發電機。保持最低水平的慣性頻率響應與機組排程，對於確保再生能源的可靠整合至關重要。本文根據台灣電力系統過去七年記錄的頻率事件，觀察到慣性頻率響應在再生能源滲透率增加有下降的趨勢。由於慣性頻率響應決定了電力系統供電需求不匹配而導致的頻率變化，因此在即時操作中保持足夠的系統慣性非常重要。因此，本文利用迴歸分析提供系統慣性頻率響應的估計，以幫助系統調度操作人員維持足夠的系統慣性，避免系統發生 N-1 事件時觸動低頻卸載，確保系統供電可靠度。

## Abstract

This paper aims to explore the challenges to of integrating renewable resources with the power system in Taiwan focusing on inertial Frequency Response, one of three categories of frequency control, namely Inertial, Primary and Secondary Frequency Responses, depending on the response time of the resources.

Primary and secondary frequency response are achieved by deploying adequate control settings. Inertial Frequency Response in this paper refers to the total synchronous mass, which includes motor loads and synchronous generators.

Retaining minimum level of Inertial Frequency Response is crucial for ensuring reliable integration with renewable resources. A trend of declining Inertial Frequency Response level due to increase of renewable resources has been observed by studying the recorded frequency events over the past seven years in Taiwan. Since Inertial Frequency Response dictates the change in frequency due to load imbalance, it is important to maintain adequate system inertia in real-time operation. Therefore, this paper uses regression analysis to provide estimation of system-wide Inertial Frequency Response, looking forward to assisting the System Operators to maintain adequate system inertia.

**關鍵詞(Key Words)：**頻率響應(Frequency Response)、再生能源(Renewable Energy)、慣性頻率響應(Inertial Frequency Response)、間歇性資源(Intermittent Resources)。

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# 智慧校園成本效益分析與營運模式之研究
# –以〇〇大學為例

Cost Benefit Analysis and Operation Models of Smart Campus
– A Case Study of ○○ University

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## 摘　要

本研究旨在探討智慧校園的核心價值與成本效益分析研究，蒐集智慧校園相關文獻，探討其定義及內涵，彙整先進國家與國內之智慧校園發展現況及應用案例，並針對「〇〇大學—多元智能永續校園建置計畫」進行個案研究，分析其後續營運模式與營運模式畫布。

為了達成以上目的，本研究採用個案研究法與成本效益分析法，針對五大創新提案中的三大提案:「智慧照明管理」、「智慧用電管理」、「智慧場域服務」進行描述性(Descriptive)個案研究，說明各項提案實行前的現況基礎及重要性，詳述個案建置成果，並進行成本效益分析，以〇〇大學觀點與整體社會觀點的不同面向，評估其執行成效，最終歸納其作為示範計畫之效益。

## Abstract

This study aims to explore the core values and engage in cost-benefit analysis of smart campus. The contents of this study therewith includes clarifying the definition and connotation of smart campus through literature review, collecting current application cases of smart campus both domestic and oversea, and conducting a case study titled "○○ University - Multiple Intelligences Sustainable Campus Construction Project" to elicit subsequent Business Model Canvas.

To achieve the said purposes, this study applies case studies and cost-benefit analysis, focusing on three out of five innovative proposals, namely "smart lighting management", "smart power management" and "smart field service", by conducting a descriptive case study to illustrate the current situation and importance of each of the three proposals before putting into practication, and preliminary cost-benefit analysis to assess the effectiveness from the perspectives of ○○ University and the whole society as well.

**關鍵詞(Key Words)：**智慧校園(Smart Campus)、物聯網(Internet of Things)、大數據(Big Data)、永續智慧社區創新實證示範計畫(Sustainable Smart Community Innovation Demonstration Project)、營運模式(Operation Model)。

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# 福島事故後續環境輻射、民眾劑量與健康效應長期變化趨勢分析

Long-term Trend of the Environment Radiation Level, Public Dose and Health Effect after the Fukushima Daiichi Nuclear Power Plant Accident

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## 摘　要

2011 年福島核子事故之後，日本等各國政府以及許多跨國際權威組織與研究單位，如：世界衛生組織(WHO)、聯合國原子輻射效應科學委員會(UNSCEAR)等，針對福島核子事故進行的專業研究與評估報告指出，福島核災放射性物質外釋所造成的民眾劑量、健康效應及對後續環境輻射的影響，遠比想像中輕微。本計畫執行成果提供社會大眾獲知福島事故後續環境輻射、民眾劑量與健康效應長期變化趨勢的全貌，以利未來進行輻射相關議題的理性決策。

本計畫工作項目共分為六大項，包含：(1)福島事故肇因與後果；(2)日本全國及福島周邊民眾劑量與民眾健康調查或評估；(3)福島事故期間民眾與救災人員各項輻射防護措施與資源整備；(4)福島周邊地區環境輻射劑量率；(5)福島周邊地區除污進度與效果評估；(6)福島核子事故與車諾比核子事故之民眾健康效應等，期能多方搜集客觀正確與國際專業評估資料，提供相關正確資訊了解嚴重核子事故造成環境與健康的長期效應。

## Abstract

After the Fukushima Daiichi Nuclear Power Plant accident in 2011, the government of Japan and some international organizations, e.g., World Health Organization (WHO) and United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), had published numerous research reports. These reports concluded that the impact of the radiation dose of the Fukushima accident upon the health of the public and the environment was slighter than what we expected.

The results of this study can serve as useful information for the public's right to know and rational decision.

The contents of this study includes (1) causation and impacts of the Fukushima accident, (2) results of related investigation/assessment of public dose and its effect upon the health of the residents within/outside of Fukushima, (3) radiation protection procedures and backup resources provided to/available for the public and the disaster relief workers, (4) radiation level of the surrounding area of Fukushima, (5) assessment of the progress and effect of decontamination in the surrounding area of Fukushima, and (6) health effect comparison of the Fukushima accident and the Chernobyl accident.

By collecting and presenting objective/correct information of the Fukushima accident disclosed by professional international institutes, this study thus provides useful long-term information of severe nuclear accidents to the public.

**關鍵詞(Key Words)：**福島事故(Fukushima Daiichi Accident)、民眾劑量(Public Dose)、健康效應(Health Effect)。

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