

台電工程月刊 896 期(4 月)目錄

輸 變 電 :

TRANSMISSION AND TRANSFORMATION :

推進工作井鏡面密閉鋼製止水箱之應用黃勇誠 等(1)

Application of Steel Bulkhead for Tunnel Shaft Mirror FaceHuang, Yung-Chen et al.....(1)

中興製 345kV GIL BG 側 T 相異音查修蕭明順 等(8)

345kV GIL BG-Side T-phase Dissimilar Sound Inspection and RepairSiao, Ming-Shun et al.....(8)

電力系統 :

POWER SYSTEM :

南投地區輸電系統堅實工程規劃檢討林維哲 等(16)

Review of Solid Engineering Planning for Transmission System in Nantou AreaLin, Wei-Che et al.....(16)

國外需量反應納入備用及備轉容量做法對我國之啟示張文奇 等(25)

The Enlightenment of Incorporating Demand Response as Reserve Margin and Operating Reserve in Foreign CountriesChang, Wen-Chi et al.....(25)

化學與材料 :

CHEMISTRY AND MATERIAL :

懸垂聚合礙子斷裂原因分析鄭錦榮(37)

Analysis of the Reasons for the Breakage of Composite Suspension InsulatorsCheng, Jiin-Rong.....(37)

工程技術 :

ENGINEERING TECHNIQUES :

序貫模糊田口法於三相鼠籠式感應馬達之多目標優化設計陳仲村 等(59)

Sequential Fuzzy Taguchi Method for Multi-Objective Optimization Design of Three-Phase Squirrel Cage Induction MotorsChen, Zhong-Cun et al.....(59)

售電與用戶 :

ELECTRICITY RETAILING AND CUSTOMERS :

自動需量反應商業模式研究賈方霽 等(70)

Study on Business Models of Automated Demand ResponseJia, Fang-Pei et al.....(70)

其 他 :

OTHERS :

台電智慧電表應用於家居照護系統可行性評估楊新全 等(89)

Feasibility Assessment of Smart Meter Application in Home Care SystemYang, Hsin-Chuan et al.....(89)

住宅部門家電汰舊換新補助與推動策略研析廖文華 等(95)

Research and Analysis on Subsidies and Promotion Strategies for Retiring and Replacing Household Electrical AppliancesLiao, Wen-Hua et al.....(95)

推進工作井鏡面密閉鋼製止水箱之應用

Application of Steel Bulkhead for Tunnel Shaft Mirror Face

黃勇誠*
Huang, Yung-Chen

熊美如*
Hsiung, Mei-Ju

摘要

以潛盾機做隧道開挖，須在隧道出發點和到達點開挖設置工作井，使潛盾機在出發點工作井中送達預定鑽掘深度組裝，在開挖完成後則可在到達點工作井中拆裝。在潛盾機出發及到達前，隧道預定位置處的工作井擋土壁須以人工方式鑿除，一般稱為破鏡工程。由於鑿除擋土壁後，其後方之土壤及高壓水有湧入的可能，因此破鏡之前須將擋土壁後方之土壤先施作地盤改良以穩固土壤，本文對隧道施工時破鏡之輔助工法予以說明。

Abstract

To excavate a tunnel with a shield machine, a tunnel shaft must be excavated at the starting point and arrival point of the tunnel, so that the shield machine can be delivered to the predetermined drilling depth in the shaft at the starting point for assembly, and be dismantled in the tunnel shaft at the arrival point after the excavation is completed. Before the break in and break out of the shield machine, the retaining wall of the working shaft at the predetermined position of the tunnel must be manually chiseled out, which is generally called the mirror face breaking project. Since the soil behind the high-pressure water may flow in after the retaining wall is cut, the soil behind the retaining wall must be improved before breaking the mirror face to stabilize the soil. This article discusses the auxiliary construction method for mirror face breaking during tunnel construction.

關鍵詞 (Key Words)：潛盾機(Shield Machine)、工作井(Tunnel Shaft)、發進(Break In)、到達(Break Out)、破鏡(Mirror Face Breaking)。

中興製 345kV GIL BG 側 T 相異音查修

345kV GIL BG-Side T-phase Dissimilar Sound Inspection and Repair

蕭明順*
Siao, Ming-Shun

何權恩*
Ho, Chuan-En

陳銘宗*
Chen, Ming-Tzung

摘 要

近期公司因設備汰舊換新、離岸風力加強電力網容量提升或是變電所擴建、改建等計畫，多項工程如火如荼正在進行，每項大項工程施工工期動則數月或是數年期間不等。工程期間該線路停電施工，或又施工時鄰近線路亦須停電，長時間停電對電力調度是一項艱鉅的挑戰，往往又因考量電力電網強度，而必須縮短施工工期，在工期壓縮同時且必須兼具施工前、中、後品質及工作安全則是一項重大考驗，尤其是新設備加入系統後存在一些不穩定因素初期不會馬上顯現出來，如何在設備加入系統後發掘設備潛藏性弱點，則是維護單位重要工作。本篇報告則因本所因應離岸風力加強電力網容量提升工程，於施工期間、加入系統後，發現問題及建議彙整資料提供相關單位參考。

Abstract

Recently, many projects are in full swing due to factors such as replacement of old equipment, strengthening of grid capacity boosted by offshore wind power, or expansion of substations. Construction period of each major project lasts for several months to several years. During this period, the line and its adjacent lines have to be cut off and hence cause difficult challenges for power dispatching. Therefore, the construction period must be shortened without affecting the quality of the project and work safety. That is a major challenge, especially when there is new equipment added to the system and some unstable factors will not immediately appear at the initial stage. How to discover the hidden weaknesses of newly added equipment is an important task for the maintenance unit. This report is based on the problems discovered and suggestions collected during the period of our offshore wind power oriented grid capacity strengthening project to serve as reference for the relevant units.

關鍵詞(Key Words): 超音波(Partial Discharge)、氣體絕緣輸電線路(Gas-Insulated-Line, GIL)、中興電工機械股份有限公司(CHUNG-HSIN ELECTRIC & MACHINERY MFG, C.H.E.M)。

南投地區輸電系統堅實工程規劃檢討

Review of Solid Engineering Planning for Transmission System in Nantou Area

林維哲*
Lin, Wei-Che

姚竺君*
Yao, Chu-Chun

盧銘順*
Lu, Ming-Shun

摘要

台電公司身為國營公用事業，肩負穩定供電之使命，因應多元的用電需求，部分輸電線路需要跨越高山、河川等險峻環境，當面臨颱風、地震等天然災害時，可能會發生超準則之事故，增加區域性停電風險。為確保供電穩定可靠，台電公司進行輸電系統規劃時，除依循輸電系統規劃準則外，已另提出電網規劃新思維。本文針對埔里一次變電所(Primary Substation，以下簡稱 P/S)轄區進行檢討分析，說明系統概況及潛在弱點，進一步說明為提高輸電系統電網韌性，台電公司針對潛在弱點規劃之輸電系統堅實工程，最後針對改善後之輸電系統進行檢討，在符合輸電系統規劃準則之前提下，檢視當埔里 P/S 因事故無法正常供電時，改以鉅工發電廠(Generator Station，以下簡稱 G/S)供電對系統之輸電線路、變壓器等設備之影響，評估堅實工程可提升之電網韌性，以確保電網在安全無虞下，滿足埔里 P/S 轄區之用電需求及供電品質。

Abstract

As a state-owned public utility, Taiwan Power Company (TPC) shoulders the mission of stable power supply. In response to diverse electricity demand, some transmission lines need to go across dangerous environments such as mountains and rivers. When faced with natural disasters such as typhoons and earthquakes, accidents beyond the guidelines may occur and the risks of regional power outages hence increase. To ensure stable and reliable power supply, in addition to following the planning guidelines for the transmission system, TPC has put forward a new thinking for transmission system planning. This article reviews and analyzes the Puli Primary Substation (P/S) jurisdiction, explains the system review and potential weakness, and further explains that in order to improve the resilience of transmission system. TPC has thus planned a solid project for the transmission system aimed at potential weakness. Finally, this article will review the improved transmission system. Under the premise of complying with the guidelines of transmission system planning, when Puli P/S fails to provide normal power supply due to an accident, Ju-Gong Hydro Power Plant will take over to ensure stable power supply of the Puli P/S.

關鍵詞(Key Words)：電網規劃(System Planning)、電網韌性(Grid Resiliency)、輸電系統堅實工程(Grid Reinforce Project)。

國外需量反應納入備用及備轉容量做法對我國之啟示

The Enlightenment of Incorporating Demand Response as Reserve Margin and Operating Reserve in Foreign Countries

張文奇*
Chang, Wen-Chi

古文潔**
Ku, Wen-Chieh

蔡森洲*
Tsai, Sen-Chou

陳俊瑋*
Chen, Jun-Wei

摘要

為響應節能減碳與提升能源效率，目前世界各國都將需量反應視為重要的電力管理與改善方向。隨著我國能源轉型之發展，再生能源建置容量逐步提升，致使需量反應之方案與制度設計，將導向市場型需量反應措施以及維持系統安全之輔助服務需量反應措施，如何因應當前的趨勢變化，使得電力資源的應用更為多樣化發展成為一項重要的目標及策略。而在電業法第二十七條備用供電容量管理辦法中，已將需量反應納入備用容量，雖然能源局已有初步提出需量反應認定之方法，但目前尚未有明確之規範。另一方面，台電公司現階段已推動多項需量反應措施，惟方案內容仍有調整的空間及彈性。基於以上課題，本文將參考國外推動需量反應的電業，研討國際間需量反應措施納入備用容量的相關準則，並能將需量反應的轉型朝向更進步的發展。

Abstract

To reduce carbon emission and improve energy efficiency, many countries have nowadays treated demand response (DR) as one of the most critical electric management issues. As it is well known, the installed capacity of renewable energy in Taiwan has gradually increased along with the development of the government's energy transition policy. Correspondingly, DR transforms into a market-based ancillary service for the purposes of maintaining system security and resource diversification, as specified in Article 27 of the Electricity, regarding the calculation of reserve margin of power system. The Department of Energy shortly after proposed a preliminary method to incorporate DR into the calculation of reserve margin. Nevertheless, clear specification has not yet been released. Although Taiwan Power Company has promoted a number of DR measures, there is still rooms for adjustment. By referring to foreign cases, this article discusses the relevant criteria to incorporate DR as reserve margin to serve as reference for progressive development of DR.

關鍵詞(Key Words): 需量反應(Demand Response)、備用容量(Reserve Margin)、備轉容量(Operating Reserve)。

*台灣電力公司綜合研究所

**財團法人台灣經濟研究院

懸垂聚合礙子斷裂原因分析

Analysis of the Reasons for the Breakage of Composite Suspension Insulators

鄭錦榮*
Cheng, Jiin-Rong

摘 要

本文將破損耐張聚合礙子四事故案例樣品，分別從材質機械性質分析、材質化學性質分析、表面、斷面缺陷材質結構分析及表面潑水性分析五種方式進行探討分析。經上述各種分析可知，由於絕緣礙子上這些污損物及濕氣分布不均勻，形成不均勻的電場，產生電暈放電，使聚合礙子葉片表面產生規則性的波浪紋，並出現表層電暈無方向性的刮痕及小量的孔洞，表面成不規則碎葉狀結構，引起聚合礙子表面劣化破損。經 EDX 分析在電蝕區域附近含有氯化物等強電解質，強電解質污染物附著，使潑水性消失，小分子混雜體無法浮至表層，導致乾帶電弧電蝕，因乾帶電蝕使空氣中氮氣產生電離，並與濕氣結合形成硝酸，經由破損孔洞延伸進入玻璃纖維礙桿內，構成玻璃纖維局部劣化，在礙桿玻璃纖維撕開處玻璃纖維成片狀分離，積層未能密合，當玻璃纖維礙桿承受應力時則產生沿著桿軸垂直方向平整脆性斷裂，斷裂面清淨，無細玻纖或樹脂顆粒殘留，且在斷裂面末端會因機械斷裂殘留少量玻璃纖維絲。

Abstract

In this paper, the samples of four accident cases of damaged composite suspension insulators are discussed and analyzed from five methods: material mechanical property analysis, material chemical property analysis, surface and cross-section defect material structure analysis and surface water repellency analysis. Through these analyses, it can be seen that due to the uneven distribution of these contaminants and moisture on the insulating surface, an uneven electric field is formed and corona discharge is generated, causing regular wavy lines and surface electricity. Halo non-directional scratches and a small amount of holes, the surface has an irregular leaf-like structure, causing deterioration and damages to the surface of the composite suspension insulators. According to EDX analysis, there are strong electrolytes such as chloride in the vicinity of the electric corrosion area. The attachment of strong electrolyte pollutants makes the water repellency disappear, and small molecule hybrids cannot float to the surface, resulting in dry-band arcing fracture. Due to the phenomenon, nitrogen in the air is ionized and combined with moisture to form nitric acid, which extends through damaged pores into the glass fiber surface and causes local deterioration of the broken glass fiber. The glass fiber is separated into flakes at the part where the glass fiber of the surface is torn, and the laminate is not tightly bonded. When the glass fiber surface is subjected to stress on the rod, a flat brittle fracture occurs along the vertical direction of the rod axis, the fracture surface is clean and there is no fine glass fiber or resin particles remain, and a small amount of glass fiber strands remain at the end of the fracture surface due to mechanical fracture.

關鍵詞 (Key Words)：耐張聚合物礙子 (Composite Suspension Insulators)、潑水性 (Hydrophobicity)、強化玻璃纖維桿 (FRP Rod)、脆性破斷 (Brittle Fracture)。

序貫模糊田口法於三相鼠籠式感應馬達之多目標優化設計

Sequential Fuzzy Taguchi Method for Multi-Objective Optimization Design of Three-Phase Squirrel Cage Induction Motors

陳仲村*
Chen, Zhong-Cun

謝振中*
Shieh, Jenn-Jong

梁育瑞*
Luang, Yu-Jui

摘要

本論文針對一三相鼠籠式感應馬達，於模糊田口法中加入序貫規則與層次規則並藉由有限元素法，提出一兼具多目標優化設計之三相鼠籠式感應馬達結構。本論文除以一電動車用三相37.15HP 鼠籠式感應馬達為例說明所提之優化設計方法外，並與田口法、模糊田口法優化設計之輸出轉矩、效率、轉矩漣波、起動轉矩與最大轉矩等5項重要性能同時比較，以驗證所提設計方法之正確性與有效性。

Abstract

Aiming at a three-phase squirrel cage induction motor, this paper adds sequential and hierarchical rules to the fuzzy Taguchi method and uses the finite element method to propose a three-phase squirrel-cage induction motor structure with multi-objective optimization design. In addition to using a three-phase 37.15HP squirrel-cage induction motor for an electric vehicle as an example to illustrate the optimal design method, this paper also compares five important properties including output torque, efficiency, torque ripple, maximum torque, starting torque and maximum torque of induction motors to verify the correctness and effectiveness of the proposed design method.

關鍵詞(Key Words): 鼠籠式感應馬達(Squirrel Cage Induction Motor)、田口法(Taguchi Method)、模糊 (Fuzzy)、序貫(Sequential)。

自動需量反應商業模式研究

Study on Business Models of Automated Demand Response

賈方霽*	楊新全*	張文贏**	陳俊宇**
Jia, Fang-Pei	Yang, Shin-Chuan	Chang, Wen-Ying	Chen, Chun-Yu
陳暉祁**	鄒玉萍**	古文潔***	施恩****
Chen, Wei-Chi	Tsou, Yu-Ping	Ku, Wen-Chieh	Shih, En

摘要

本研究藉由蒐集研析國外住商用戶參與自動需量反應(ADR)之發展與實施案例，結合我國智慧家電相關通訊協定標準(如：CNS 16014)，以及智慧遠端遙控等業界設備與技術發展，研擬提出適用我國之低壓住商 ADR 方案內容，並建立低壓住商用戶自動需量反應系統試驗平台環境，招募 200 用戶進行至少 35 次 ADR 事件，以研析低壓住商 ADR 之可行商業模式，並透過參加用戶之所在縣市區域等申請資料及氣溫，搭配抑低執行結果進行執行成效分析。最後配合問卷調查資料，進一步分析目標用戶特徵，以作為未來台電公司研擬低壓用戶需量反應方案目標用戶招募之參考。

Abstract

This study collects and analyzes the development and implementation cases of foreign low-voltage residential and commercial customers participating in Automated Demand Response (ADR) program, combined with smart home related standards, such as CNS 16014, and remote-control technology in Taiwan to propose the contents of ADR programs applicable to low voltage R&C customers of Taipower. In this study, we also establish a test ADR platform for R&C customers and recruit 200 customers to conduct at least 35 ADR event tests to study and analyze feasible ADR business models for low-voltage customers. Through the application data and temperature of the participating customers' locations, combined with the execution results of the load clipping, the implementation effect analysis is carried out. Finally, in conjunction with the questionnaire survey data, further analysis of the characteristics of the target customers will serve as a reference for Taipower to recruit target DR customers in the future.

關鍵詞(Key Words)：自動需量反應(Automated Demand Response)、智慧家電(Smart Appliance)、低壓用戶(Low-voltage Users)、用戶群代表(Aggregator)、商業模式(Business Model)。

*台灣電力公司綜合研究所

**工業技術研究院綠能與環境研究所

***財團法人台灣經濟研究院

****晨曦能源有限公司

台電智慧電表應用於家居照護系統可行性評估

Feasibility Assessment of Smart Meter Application in Home Care System

楊新全*
Yang, Hsin-Chuan

陳玉芬*
Chen, Yu-Fen

何牧潔**
Ho, Mu-Chieh

徐業良**
Hsu, Yeh-Liang

蔡宗霖***
Tsai, Tsung-Lin

蔡宗成***
Tsai, Tsung-Cheng

摘要

智慧電表分析技術是管理家庭能源消耗與提高用電效率的有效方法，並可提供用戶用電行為的有用資訊。本研究目的是針對台電智慧電表應用於家居照護系統的可行性進行評估，發展智慧電表大數據分析技術應用於高齡者日常活動能力分析方法，以低取樣頻率(每 15 分鐘 1 筆)用電資訊，非監督式學習演算法，分析用戶使用電器進行 IADL「活躍/非活躍」辨識。在台電高雄鳳山實驗屋測試，有良好準確性。本研究並從智慧電表布建區內招募 30 戶示範用戶，並提供完整智慧照護系統，實際研析「活躍/非活躍」演算法在真實情境中的效果，並訂定「活躍分數」作為用戶使用電器進行 IADL 之指標。分析示範用戶長期數據，發現有些用戶的活躍分數變化甚鉅，可能代表用戶的日常生活模式有極大變化，系統從而應發送警示通知，給予適當介入或關注。本研究並提出(1)基礎模式：以訂閱方式直接提供台電公司用戶加值資訊，以及(2)整合模式：與照護系統廠商/服務提供商整合二種商業模式可行方向之建議，提供台電公司參考。

Abstract

Smart meter analysis technology is an effective way to manage household energy consumption, improve electricity efficiency, and provide useful information regarding users' electricity consumption behaviors. The purpose of this research is to evaluate the feasibility of Taipower smart meter applications in home care systems, develop an smart meter big data analysis technology and apply it to the daily activity analysis method of the elderly, and use low sampling frequency (every 15 minutes) electricity consumption information and unsupervised learning algorithm to analyze the use of electrical appliances for IADL "active/inactive" identification. The tests at Taipower Kaohsiung Fengshan Laboratory House proved that it has good accuracy. In this study, 30 demonstration users were recruited from the smart meter deployment area, and a complete smart care system was provided to actually analyze the effect of the "active/inactive" algorithm in real situations, and set the "active score" as the use of electrical appliances to conduct IADL indicators. As the long-term data of the demonstration users shows, the activity scores of some users have changed drastically, which may represent a great change in the user's daily life pattern. In view of

*台灣電力公司綜合研究所

**元智大學老人福祉科技研究中心

***工業技術研究院

this situation, the system should send a warning notification, intervene appropriately or provide attention. This research also puts forward two business models to serve as reference for Taipower: (1) basic model: direct provision of value-added information of Taipower users in the form of subscription, and (2) integration model: integration with care system manufacturers/service providers.

關鍵詞(Key Words)：智慧電表(Smart Meter)、非侵入式設備負載監視(Non-Intrusive Appliance Load Monitoring)、用電解析(Load Disaggregation)、高齡者家居照護(Elderly Home Care)、工具性日常生活活動(Instrumental Activities of Daily Living)。

住宅部門家電汰舊換新補助與推動策略研析

Research and Analysis on Subsidies and Promotion Strategies for Retiring and Replacing Household Electrical Appliances

廖文華*
Liao, Wen-Hua

陳奕宏*
Chen, Yi-Hung

廖如閔*
Liao, Ju -Min

林鈺璇*
Lin, Yu-Hsuan

孫廷瑞*
Sun, Ting-Jui

蘇娟儀*
Su, Chuan-Yi

摘要

為達成 2050 淨零目標，各國政府均將電器設備能源效率提升視為關鍵，透過「稅收抵免」、「金額補貼」、「積點換購」、「折抵退款」等方式提升設備效率，並對不同對象提供獎勵，我國大多以「金額補貼」為主，2018 年首度納入「貨物稅」減免。根據工研院 2021 年調查資料顯示，冷氣及冰箱年用電量超過 4 成，其中冷氣及冰箱老舊比例仍有 3 成 5，其中以定頻機為大宗。另發現租賃宅老舊電器(冷氣、冰箱及熱水器)比例高於自有宅，租賃宅 1 級能效產品比例低於自有宅，且租賃宅夏月電費支出約為自有宅 1.1 倍，顯示租賃住宅老舊家電高、節能產品低及夏月電費高等問題。我國目前除透過源頭管理推動能源效率措施外，更透過家電補助及貨物稅減免等誘因加速汰換舊家電，補助條件則搭配環保署廢四機政策全面將舊家電回收。未來針對租賃宅，建議可結合內政部「包租代管」政策，將節能產品(1 級能效產品)納入修繕補助範圍，或透過「建築能源效率評等」資訊揭露，全面提升住宅用電效率，減少用電負擔。

Abstract

To achieve the 2050 Net Zero goal, the governments of various countries regard the improvement of energy efficiency of electrical appliances as the key, and provide incentives for different objects, such as “tax credit”, “subsidy”, “point redemption” and “rebate”. In Taiwan, the incentive is mainly based on “subsidy”. In 2018, Taiwan government introduced “commodity tax reduction” for the first time.

According to the 2021 survey data by the Industrial Technology Research Institute (ITRI), the annual electricity consumption of air conditioners and refrigerators exceeds 40%, and the proportion of old air conditioners and refrigerators is still up to 35%, of which fix-frequency appliances are the bulk. It is also found that the proportion of old electrical appliances (air conditioners, refrigerators and water heaters) in leased houses is higher than that in self-owned houses, the proportion of first grade energy efficiency appliances in leased houses is lower than that in self-owned houses, and the summer monthly electricity bill of leased houses is about 1.1 times that of self-owned houses, showing that there are problems such as high old household

appliances in leased houses, low energy saving appliances and high electricity bill in summer.

At present, in addition to promoting energy efficiency measures through source management, Taiwan also accelerates the replacement of old household appliances through incentives such as household appliance subsidies and commodity tax reduction, subsidy conditions see the Environmental Protection Agency's waste four appliances policy to comprehensively recycle old household appliances. For rental housing in the future, it is suggested that energy-saving appliances (first grade energy efficiency) be included in the scope of repair subsidies in conjunction with the Ministry of Interior's "chartered escrow" policy, or through the information disclosure of "building energy efficiency rating" to comprehensively improve residential customers' energy efficiency and their electricity bill burden.

關鍵詞 (Key Words)：家電補助 (Appliance Subsidy)、汰舊換新 (Inefficient Appliance Replacement)、家電設備 (Household Appliance)、能源效率 (Energy Efficiency)、入戶調查 (In-house Visit)。