

# 台電工程月刊 886期(6月)目錄

---

## 再生能源：

### RENEWABLE ENERGY：

- 化石燃料電廠淨零轉型策略芻議 ..... 左峻德 等 ..... (1)  
Net Zero Transformation Strategies for Fossil-fueled Power Plants ..... Tso, Chunto et al. .... (1)

## 配電：

### DISTRIBUTION：

- 配電設備警告標線顏色及樣式分析與研究 ..... 蘇偉府 等 ..... (15)  
A Study on Warning Line Color Marking and Style Analysis for Power  
Distribution Equipment ..... Su, Wei-Fu et al. .... (15)  
高效率低噪音非晶質變壓器之研究開發 ..... 陳昭榮 等 ..... (26)  
A Study on Developing High Efficiency and Low Noise Amorphous Metal  
Transformers ..... Chen, Chao-Rong et al. .... (26)  
台電公司電力物聯網通訊系統導入研究及建置成果 ..... 楊仕呈 等 ..... (35)  
A Preliminary Study Results of Introducing Electric Power Internet of Things  
into Taipower ..... Yang, Shih-Cheng et al. .... (35)

## 能源與環境：

### ENERGY AND ENVIRONMENT：

- 評估儲能系統建置之財務模型-以實質選擇權方法為例 ..... 蕭宇喬 等 ..... (46)  
Financial Model of Energy Storage System—A Case Study of Real Option ..... Hsiao, Yu-Chiao et al. .... (46)  
淨零排放對經濟之影響初探 ..... 張桂鳳 等 ..... (62)  
Assessing the Impacts of Net Zero Emissions on Economy: A Literature  
Review ..... Chang, Kuei-Feng et al. .... (62)

## 化學與材料：

### CHEMISTRY AND MATERIAL：

- 鹼性膜電解產氫技術之電池特性研究 ..... 丁富彬 等 ..... (79)  
A Study on Cell Properties of Anion Exchange Membrane Electrolysis for Green  
Hydrogen Production ..... Ting, Fu-Pin et al. .... (79)

## 其他：

### OTHERS：

- 電信機房VRLA電池異常偵測之研究 ..... 張立昇 等 ..... (91)  
A Study on Anomaly Detection for VRLA Batteries of Telecommunication  
Facilitie ..... Chang, Li-Sheng et al. .... (91)

## 核能發電：

### NUCLEAR POWER GENERATION：

- 核三廠鑄造不銹鋼管路熱脆化可能性調查 ..... 郭泰良 等 ..... (101)  
Assessing the Impacts of Carbon Economy Measures on Taiwan's Power  
Supply and Demand ..... Kuo, Tai-Liang et al. .... (101)
-

# 化石燃料電廠淨零轉型策略芻議

Net Zero Transformation Strategies for Fossil-fueled Power Plants

左峻德\*

Tso, Chunto

陳彥豪\*

Chen, Yen-Haw

尤晴韻\*

Yu, Ching-Yun

陳映蓉\*

Chen, Ying-Jung

鄭允勝\*

Cheng, Yeum-Sheng

## 摘要

IEA淨零路徑圖建議2040年前應淘汰未實施減排措施之燃煤電廠。電力部門擁有大量使用年限長且資本密集之資產，臺灣現有火力機組占總裝置容量70.1%，需採取減排措施。CCUS為電力部門淨零轉型有效手段，可提升既有資產效能，亦有助於快速擴大產製低碳氫能。篩選2040年與2050年時經濟壽命期間內之燃煤燃氣機組，分階段導入碳捕捉技術，估計至2050年CCS技術捕捉4.4億噸、DACCS與BECCS捕捉1,437萬噸，可望促成電力部門達至淨零。透過無碳電力憑證機制，可將導入CCUS電廠價值鏈外溫室氣體減量轉換成價值鏈內溫室氣體減量。淨零轉型過程中，需採用包括財政在內之各種政策促成CCUS相關市場，達成化石燃料電廠淨零轉型。同時搭配鼓勵氫能與生質燃料生產、各行業共用二氧化碳輸送與封存基礎設施；並以國家隊規格結合國內外企業實力，促成產業樞紐升級。

## Abstract

IEA recommends phasing out all unabated power plants by 2040. Fossil-fueled power plants account for 70.1% of the total installed generation capacities in Taiwan. CCUS is an effective means to achieve net-zero transformation of the power sector by improving the performance of existing assets and expanding the production of low-carbon hydrogen. As the estimates of this study shows, CCUS may make a significant contribution to net zero emissions (NZE) of the power sector in Taiwan; besides, a mechanism titled carbon-free power certificate mechanism may convert the GHG reductions outside the value chain of power plants into GHG reductions within the value chain. Along the way to NZE, various policies, such as follows, need to be adopted to facilitate CCUS related markets: fiscal measures, sharing CO<sub>2</sub> transmission and storage infrastructure among industries, and get together domestic and foreign enterprises to realize industrial transformation/upgrading.

**關鍵詞(Key Words)**：淨零排放(Net Zero Emissions)、碳捕捉、再利用及封存(Carbon Capture, Utilization and Storage)、負碳技術(Negative Emission Technologies)、二氧化碳從大氣中去除(Carbon Dioxide Removal)、均化發電成本(Levelized Cost of Electricity)、無碳電力憑證(Carbon Free Power Certificates)。

# 配電設備警告標線顏色及樣式分析與研究

A Study on Warning Line Color Marking and Style Analysis for Power Distribution Equipment

蘇偉府\*  
Su, Wei-Fu

張文曜\*\*  
Chang, Wen-Yao

黃世杰\*\*\*  
Huang, Shyh-Jier

廖昱信\*\*\*  
Liao, Yu-Hsin

陳柏融\*\*\*  
Chen, Po-Jung

陳秉寬\*\*\*  
Chen, Ping-Kuan

## 摘要

本研究針對配電級電桿與亭置式設備之警告標示資料進行分析，同時經由蒐集日韓各國之電力公司資料，綜合瞭解目前國際電力工程之配電級電桿與亭置式設備警告標線及加貼反光片的執行經驗，研提各種標線設置及加貼反光片之材料規範與實際執行方法，同時由國內外實務運作角度及經驗，審慎評估配電級電桿與亭置式設備地點、警告標線、反光片設置規劃，進而研析各種可能方案，妥以規劃周延可行之推動策略與配套措施，俾以提供台電公司作為配電級電桿與亭置式設備警告標線及反光片設置參考。

本研究於執行上，除搜尋國內外現有的法規標準及資料典藏及相關資源外，並已與台電公司區營業處討論警告標線及反光片設置方式之確實可行作法，實際瞭解警告標線及反光片設置方式相關準則訂定之實用性，同時詳細分析我國電力公司與國外電力公司警告標線及反光片設置方式之差異性。

## Abstract

The purpose of this paper is to collect information regarding warning line color-marking, e.g., standards for power distribution poles and pole-mounted equipment among others out of prevailing cases in Japan and Korea. The results of this study may serve as reference for electric utilities-for example, Taipower's distribution system. In execution, we first reviewed related literatures, when necessary, discussed with field engineers and visited district offices to gain intensive understanding of the said study goal.

**關鍵詞(Key Words)**：告標線(Color-marking of Warning-line)、配電設備(Distribution Equipment)、亭置式設備(Pole-mounted Equipment)、電桿(Electric Pole)。

\*崑山科技大學電機工程系

\*\*台灣電力公司綜合研究所

\*\*\*國立成功大學電機工程學系

# 高效率低噪音非晶質變壓器之研究開發

A Study on Developing High Efficiency and Low Noise Amorphous Metal Transformers

陳昭榮\*  
Chen, Chao-Rong

周至如\*  
Chou, Chih-Ju

洪穎怡\*\*  
Hong, Ying-Yi

陳柏江\*\*\*  
Chen, Bo-Jiang

## 摘要

隨著地球氣候變遷劇烈及台灣夏季電力供應經常警示紅燈，減少電力傳送損耗被日益關切。其中，將配電變壓器之鐵心由非晶質鐵心來取代傳統矽鋼片鐵心為一有效之方案。非晶質鐵心變壓器可以降低電力損失，在夏季時更可減少電力不足之疑慮，實為節能的一大利器。本文研發並製造亭置式單相167kVA之非晶質鐵心變壓器具有下列四大特性：(1)外觀尺寸符合矽鋼型C001材料標準，(2)鐵損僅為矽鋼型之31%，(3)無載噪音為45.8dB，滿足矽鋼型C001材規之46dB。(4)其餘出廠檢測之特性包括溫升皆滿足Y066及C001之規定。尤其是溫升部分，因體積縮小使絕緣油減少，降溫效果減少。

## Abstract

As climate changes intensify and power supply in summer remains tight, the topic of reducing power transmission loss is gaining attention. To achieve the goal, an effective solution is to replace traditional silicon steel core of distribution transformers with amorphous iron core. Amorphous metal transformers (AMT) can reduce power loss and as well public doubts regarding tight power supply in summer-therefore, make itself a great tool for energy saving. This paper aims to design and manufacture a new type single-phase 167kVA AMT embedded with the following characteristics: (1) the size, meets the silicon steel transformer C001 standard; (2) merely 31% iron loss, compared to silicon steel transformers; (3) no-load noise 45.8 dB, in compliance with the specified 46dB of silicon steel type C001; (4) all other characteristics (including temperature rise) of factory inspection, in compliance with the specifications of Y066 and C001. Worth to mention, downsizing reduces the amount of insulating oil and correspondingly the cooling effect.

**關鍵詞(Key Words)**：非晶質變壓器(Amorphous Metal Transformer, AMT)、配電變壓器(Distribution Transformer)、噪音(Noise)、材料標準(Material Standard)。

---

\*國立臺北科技大學

\*\*中原大學

\*\*\*台灣電力公司綜合研究所

# 台電公司電力物聯網通訊系統導入研究及建置成果

A Preliminary Study Results of Introducing Electric Power Internet of Things into Taipower

楊仕呈\*

Yang, Shih-Cheng

楊偉正\*

Yang, Wei-Cheng

陳騰聲\*

Chen, Jackson

楊藹齡\*

Yang, Ai-Lin

陳建成\*

Chen, Jian-Cheng

## 摘要

本案為期兩年於台灣及金門離島進行智慧電網通信示範場域，建置應用包含常見的台電智慧電表、台電電箱之故障指示器、發電廠所監控之餘氯偵測器、氣壓表等，這些應用裝置原先需高度仰賴有線網路基礎建置，而透過本案建置及試營運後，台電可毋須進行基礎有線網路架設，輕易在任何地方、隨時隨地建立各項電力設備偵測需求，快速建立台電應用所需的物聯網環境。本研究計畫分為網路規劃與技術/效益評估、系統建置/運轉測試、示範應用系統驗證等步驟，並分成三階段進行。第一階段工作主要為電力物聯網專網建置與導入的流程，並以金門場域建置及金門展示測試為例，提供台電階段性評估內容與初步結果。第二階段進行開發之終端設備擴大連通並進行物聯網運轉之網路功能相關測試。第三階段則進行台電示範應用場域建置，進行示範應用系統驗證及連通應用相關測試。透過三階段的實際規劃、佈建及開發產品、功能之驗證、測試以取得場域量測數據，進行電力物聯網使用於台電各種應用之可行性分析，並提供綜合結論做為台電因應未來電力調度、電網維運、自動化控制的智慧通信網路建置方向之參考。

## Abstract

This two-year project aims to implement smart grid communication demonstration fields in Taiwan and Kinmen Island-by three phases, including applications of smart meters, fault indicators for TPC power boxes, residual chlorine detectors monitored by power plants, barometers, etc. The major contents of this project consist of network planning, technology and benefit evaluation, system construction and operation test, demonstration application system verification, among others, and the work items for each phase: the 1<sup>st</sup> phase-implementation and introduction of electric power Internet of Things, and taking Kinmen demonstration field as an example to provide Taipower interim evaluation and preliminary results; the 2<sup>nd</sup> phase-expanding the connection of the terminal equipment already developed and conducting network function tests of the Internet of Things; the 3<sup>rd</sup> phase-implementing demonstration field and verification and connection

tests of the application systems. After the accomplishment of the said three-phase work items, and planning, feasibility analysis, and various applications of Electric Power Internet of Things, we then put forward comprehensive conclusions, expectedly to serve as reference for the planning of Taipower's power system communication network for the years to come.

**關鍵詞(Key Words)**：智慧電網 (Smart Grid)、電力物聯網 (Electric Power Internet of Things)、專網(Private Network)。

# 評估儲能系統建置之財務模型-以實質選擇權方法 為例

Financial Model of Energy Storage System-A Case Study of Real Option

蕭宇喬\*  
Hsiao, Yu-Chiao

郭婷瑋\*\*  
Kuo, Ting-Wei

曾泓祥\*\*  
Tsang, Hong-Xiang

高銘淞\*\*\*  
Kao, Ming-Sung

賴靜仙\*  
Lai, Ching-Hsien

陳瑾葵\*  
Chen, Chin-Kuei

## 摘要

本文旨在透過實質選擇權方法評估儲能系統建置之財務模型。電池型儲能設備之優越的性能表現，使其成為大量再生能源加入電力系統下之新寵兒，在邁向淨零排放的路上，更是不可或缺的一項資源。根據國際上的經驗，儲能設備的投資與否與市場價格息息相關，市場價格的波動直接影響了投資的決策。實質選擇權方法可提供決策者在不確定性環境下，可呈現動態管理之分析結果。本研究以鋰電池儲能設備參與調頻備轉容量為假設，並以二項式定價法結合遞延選擇權法為例計算其經濟效益。研究結果顯示在目前電力交易平台之價格訊號下，越早投入市場，越具有投資效益。

## Abstract

This article aims to evaluate the financial model of the installation of energy storage systems (ESSs) through the approach of real option. The superior performance of battery ESSs has made themselves a popular and indispensable alternative as a large amount of renewable energy (RE) generation is added to the power systems to realize 2050 net-zero emissions. According to international experiences, whether to invest in ESSs is closely related to the market prices, and fluctuations of market prices directly affect the decision-making of investment. The approach of real option may provide decision-makers with analytical results mapping dynamic management in an uncertain environment. This study assumes that lithium-ion battery ESSs may serve as an ancillary service of frequency regulation and uses the binomial pricing model combined with the method of deferral option as an example to calculate the economic benefits. As the results of this study show, early entrants of the energy trading platform may have higher investment return under the current market price signals.

**關鍵詞(Key Words)**：再生能源(Renewable Energy)、儲能(Energy Storage)、實質選擇權(Real Option)。

\*台灣綜合研究院

\*\*台灣電力公司綜合研究所

\*\*\*輔仁大學金融與國際企業學系



# 淨零排放對經濟之影響初探

Assessing the Impacts of Net Zero Emissions on Economy: A Literature Review

張桂鳳\*  
Chang, Kuei-Feng

林晉勗\*\*  
Lin, Jin-Xu

林師模\*\*\*  
Lin, Shih-Mo

顏妤珊\*\*\*\*  
Yen, Yu-Shan

## 摘要

因應氣候變遷壓力與挑戰，全球處於能源轉型的關鍵世代，各國陸續宣示淨零排放的目標，台灣也喊出往2050年淨零排放目標邁進。但在彰顯面對氣候變遷之決心外，如何確保能兼顧經濟發展與環境永續，仍是許多國家重要的課題。本研究透過文獻回顧的方式，整理出淨零目標下在全球層級與國家層級之影響評估，並提出未來研究之展望與建議，供政府作為制定減排相關政策之參考。

## Abstract

To cope with the challenges of climate change, the whole world is on the path toward energy transition. With no exception, Taiwan has committed to the goal of net-zero emissions by 2050 (2050 NZE). However, the importance of ensuring economic development and maintaining environmental sustainability remains. In this research, we review the relevant literatures regarding the impacts of 2050 NZE global and on the national level, and bring forward some recommendations. The results of this research may serve as reference for the government to formulate emission reduction policies.

**關鍵詞(Key Words)**：淨零排放(Net Zero Emissions)、溫室氣體(Greenhouse Gases)、影響評估(Impact Assessment)。

## 壹、前言

為了實現《巴黎協定》所規範於 2100 年將全球平均升溫控制在 2°C，甚至 1.5°C 之內，各國政府紛紛提出碳中和或淨零排放相關之目標及應對政策，以落實減碳。

不論是透過擴大再生能源發電、發展氫氣產業鏈或負排放技術，都有助於對發電結構作出調整，改變國內能源配比，控制能源部門的排放，達成淨零排放目標。然而，各種前瞻減碳技術通常不易達到成熟階段，在未達到規模經濟前，產品價格不具

\*中原大學應用經濟模型研究中心

\*\*國立台北大學自然資源與環境管理研究所

\*\*\*中原大學國際經營與貿易學系、中原大學應用經濟模型研究中心

\*\*\*\*台灣電力公司綜合研究所



# 鹼性膜電解產氫技術之電池特性研究

A Study on Cell Properties of Anion Exchange Membrane Electrolysis for Green Hydrogen Production

丁富彬\*  
Ting, Fu-Pin

周儷芬\*  
Chou, Li-Fen

林國興\*\*  
Lin, Kuo-Hsin

黃筱君\*\*  
Huang, Hsiao-Chun

賴建銘\*\*  
Lai, Chien-Ming

蔡麗端\*\*  
Tsai, Li-Duan

## 摘要

本研究已就新型鹼性膜電解產氫技術與國際相關技術進行分析，並說明鹼性膜電解產氫技術之發展優勢與未來挑戰。在本研究中，鹼性膜電解產氫技術之產氫與產氧觸媒研究現況調查、反應之質傳影響與膜電極組效能現況均已探討，此外，在國際大力推動淨零碳排的發展路徑下，對於電解水產製綠氫的需求亦已進行客觀分析。依目前國際發展趨勢而言，未來無論電力、石化、鋼鐵等產業，皆有應用綠氫技術之契機，我國正處能源轉型之階段，發展電解水生產綠氫技術有助於落實再生能源轉型與加速2050淨零碳排之目標。

## Abstract

In this study, we analyze the current status of advanced anion exchange membrane electrolysis technology for green hydrogen production, and the opportunities and challenges for its future applications. The contents of this study consist of the development of electrochemical catalysts, the effects of reaction mass transfer and the performance of membrane electrode assembly of anion exchange membrane electrolysis. Green hydrogen has been considered as one of the most important technologies achieving the target of 2050 net zero emission (2050 NZE), and has great potential in the industries of electric power generation, petrochemical and iron steel. Because Taiwan is in the stage of energy transition, developing technologies of green hydrogen may contribute to the realization of the targets of 2025 energy transition and 2050 NZE.

**關鍵詞(Key Words)**：電解(Electrolysis)、產氫(Hydrogen Production)、淨零碳排(Net-zero)、陰離子交換膜(Anion Exchange Membrane)、膜電極組(Membrane Electrode Assembly)。

\*台灣電力公司綜合研究所

\*\*工業技術研究院材料與化工研究所電子材料及元件研究組

# 電信機房 VRLA 電池異常偵測之研究

A Study on Anomaly Detection for VRLA Batteries of Telecommunication Facilities

張立昇\*  
Chang, Li-Sheng

林信宏\*  
Lin, Hsing-Hung

## 摘要

不斷電系統(Uninterruptible Power Supply, UPS)蓄電池故障會嚴重影響電信機房數據中心的穩定性，故偵測蓄電池即將故障並提早採取因應措施，成為電信機房一項重要工作。過去的研究主要著重在運用統計分析與機器學習建模的方式進行電池的異常偵測，對於自動標註與資料不平衡問題處理的文獻相對較少。本研究以資通信機房自2018年至2020年蓄電池放電數據分析建模。本研究的貢獻有三，首先，針對放電階段具異常電壓現象的單電池，自動化建立異常標籤，次之，以原始數據擴展特徵，應用SMOTE法產製較平衡數據供模型訓練使用，最後運用機器學習二元分類演算法建立預測模型，預測判斷蓄電池屬正常狀態或即將故障。本預測模型可自動化定期提供電池檢測名單，縮短人工檢測時間並縮小具潛在問題的電池範圍，節降機房維運人力成本及提升維運品質。

## Abstract

Battery failures of Uninterruptible Power Supply (UPS) usually come together with severe impact on the stability of data centers of telecommunication facilities. Therefore, it is vital to take precautions aiming at potentially faulty batteries. Related studies in previous literatures mainly focus on anomaly detection of batteries applying statistical or machine learning methods; studies on automatic labelling and/or imbalanced data however is relatively insufficient. This study employs the discharging data sets of the batteries in the Information and Communication Technology Facilities from the years of 2018 to 2020 to build analytical models. The contribution of this study is threefold. Firstly, we propose an automatic labelling method of abnormal discharging voltage of battery cells. Secondly, we expand features from source data and produce more balanced data by applying the Synthetic Minority Over-sampling Technique (SMOTE) for data training. Thirdly, we build anomaly detection models by binary classification of machine learning to predict whether a battery cell is normal or potentially faulty. The aforesaid predictive model may automatically/periodically offer a checklist of batteries. In conclusion, the model can help shorten manual testing time, narrow down the battery list of potential problems, reduce facility maintenance and operating costs, and improve maintenance quality.

**關鍵詞(Key Words)**：機器學習(Machine Learning)、閥調式鉛酸蓄電池(VRLA)、增生小類別樣本技術(Synthetic Minority Over-sampling Technique, SMOTE)、決策樹(Decision Tree)。

# 核三廠鑄造不銹鋼管路熱脆化可能性調查

An Investigation on Thermal Embrittlement of Cast Austenitic Stainless Steel Piping at  
Maanshan Nuclear Power Plant

郭泰良\*

Kuo, Tai-Liang

何明原\*

Ho, Ming-Yuan

范政文\*

Fan, Cheng-Wen

謝楊正\*\*

Hsieh, Yang-Cheng

張漢洲\*\*

Chang, Han-Jou

## 摘要

鑄造沃斯田鐵不銹鋼(CASS)於環境溫度大於482°F(250°C)時，有可能發生熱脆化情形，需要用其他參數進一步評估是否有熱脆化疑慮。由於核三廠滿載時反應爐冷、熱端管路之冷卻水溫度分別約為620°F(323°C)、558°F(293°C)，因此反應爐冷卻水壓力邊界迴路之CASS管路組件將有熱脆化之顧慮。本論文調查找出核三廠材質為CASS的管路組件，並篩選出有熱脆化可能性者，而後更進一步評估該些管路組件在預期運轉期間可能產生的材料破裂韌性下降程度，以確認是否的確發生熱脆化。此研究成果可協助台電公司核三廠得以盡早掌握廠內重要CASS管路組件的可能劣化行為，具備必要的技術資訊以因應日後緊急需求時的安全評估使用。

## Abstract

Thermal embrittlement of Cast Austenitic Stainless Steel (CASS) may happen when the environment temperature is over 482°F (250°C). The coolant water temperatures in hot leg and cold leg piping systems at Maanshan Nuclear Power Plant's are 620°F(323°C) and 558°F(293°C) respectively. Therefore, thermal embrittlement is a matter of concern in this case. This paper investigates the reactor coolant pressure boundary (RCPB) piping made by CASS at Maanshan NPP, and finds out the potential piping liable to thermal embrittlement. Furthermore, this paper evaluates the degradation of fracture toughness of the potential piping to preclude ensure if the thermal embrittlement occurs during its expected service period. Based on the aforementioned results, Maanshan NPP may foresee the degradation of CASS piping and take appropriate precautionary measures.

**關鍵詞(Key Words)**：鑄造沃斯田鐵不銹鋼(Cast Austenitic Stainless Steel, CASS)、熱脆化(Thermal Embrittlement, TE)、反應爐冷卻水壓力邊界(Reactor Coolant Pressure Boundary, RCPB)。

\*工業技術研究院材料與化工研究所

\*\*台灣電力公司核能發電事業部核能安全處