

# 台電工程月刊 885 期( 5 月)目錄

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# 國際電業淨零排放發展趨勢及其對台電公司之 策略探討

The Development Trend of Net Zero Emissions of Worldwide Electric Industry and its  
Strategic Implications for Taiwan Power Company

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## 摘要

自巴黎協議簽訂後，各國陸續宣布減碳目標，並推動相關政策法案的擬定與執行，此外COP26會議亦加速全球對於2050的減碳目標等議題之討論。而我國2021年蔡英文總統亦宣布淨零轉型主張，致力達成減排目標，預期未來國內能源政策或將有重大轉變。

對此，本研究團隊主要透過關注全球主要國家推動淨零排放的發展進程與動向，並彙整各國對於電力部門在如：發電端、電網端與需求端等的發展限制與扶植措施，掌握對於電力部門的影響；同時研析七家海外標竿電業的減排推動策略，透過借鏡各國標竿電業因應減碳之發展策略思維，作為台電公司邁向淨零目標與發展路徑之規畫參考，以利針對台電公司的未來發展目標與短中長期之發展策略與相關課題提出建議。

## Abstract

After the signing of the Paris Agreement, many countries have successively declared their carbon reduction targets and turned policies into legislation. The COP26 further accelerated the discussion of 2050 net zero carbon emissions (NZE). Also, President Tsai Ing-wen has announced the net zero emissions goal in 2021, committed to achieving the goal of reducing carbon emissions. Therefore, it is predictable that the energy policies of Taiwan may undergo drastic changes in the future.

In this regard, we put our focus on following up the development trends of carbon reduction in major countries, then integrates the development restrictions and measures adopted in each country's different functional areas of the electricity department, e.g., generation, transmission and distribution, and retailing. By doing so, we grasp the potential impact on electric utilities.

To serve as a reference for TPC to plan its 2050 NZE path, as well as the corporate strategies, 7 global benchmarks were analyzed. And based on their Net Zero transition strategies, we came up with some recommendations for the TPC's future development goals and listed up the issues that should be aware of at each stage.

**關鍵詞(Key Words)**：淨零排放(Net Zero Emissions)、政策(Policy)、國際電業(International Power Industry)、發展策略(Development Strategy)。

# 淨零排放下電力市場發展趨勢與因應策略

The Development Trend and the Coping Strategies of Electricity Market Moving towards Net Zero Emissions

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## 摘要

根據國際能源總署(IEA)表示能源及電力部門排放40%的溫室氣體，為達到其淨零排放之目的，其策略為設置大量再生能源、限縮傳統火力機組運作及創新發電資源導入電力市場。本研究藉由耙梳國際電力市場未來發展之趨勢及衡量我國目前電力市場發展之現況，在電力發展趨勢不變下，我國應儘速規劃包含電能市場之完整電力交易市場，使發電資源達到有效運用。另因應創新發電資源進入市場，電力市場規則需動態調整以因應電力市場環境之改變，最後，導入分散式發電資源及彈性資源，使電力系統能提供彈性及韌性。

## Abstract

As the research of IEA indicated, energy sectors (including power sector) accounts for 40% greenhouse gases emissions. To achieve net zero emissions (NZE), the strategies that power sector may adopt include deploying a large amount of renewable energy, restricting the operation of traditional thermal power plants and recruiting innovative power generation resources. This study aims to analyze the evolving trend of worldwide electricity markets to serve as reference for Taipower and the government to evaluate the status quo of the electricity market in Taiwan. As the results of this study show, Taiwan shall establish a comprehensive electricity trading market to improve the operation efficiency of the existing generation resources ; Next, dynamically adjusting the market rules to respond to the changing market environments, such as the entering of innovative generation resources ; Finally, introducing distributed resource and flexible resources to improve the flexibility and resilience of power system.

**關鍵詞(Key Words)**：淨零排放 (Net Zero Emissions)、電力市場(Electricity Market)、再生能源(Renewables)。

# 2050 淨零碳排下電業的風險與機會

Risks and Opportunities for Electric Industries Moving towards 2050 Net Zero Carbon Emissions

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## 摘要

為因應淨零碳排的需求，大量間歇性再生能源將進入系統中，進而帶來了諸多新的風險。單靠電力供給端之力，已難確保電力的穩定與品質。必須透過一個有效的電力市場，引入更多元的技術(如氫的多聯產)與消費端的參與，才能在經濟可行與安全無虞下，達成淨零碳排之目標。

## Abstract

Along the way moving towards net zero carbon emissions (NZE), a large amount of intermittent renewable energy will enter power systems. When bringing in new risks and opportunities, it is becoming more and more difficult ensuring stable and high quality power supply solely with supply side resources. Nevertheless, by the aid of an efficient electricity market trading platform, we may introduce diverse technologies and demand side participation, and achieve 2050 NZE under the premise of economic efficiency and system security.

**關鍵詞(Key Words)**：淨零碳排(Net Zero Carbon Emissions)、再生能源(Renewable Energy)、多聯產氫(Poly-hydrogen)、電力市場Electricity Market)、消費者參與(Consumer Participation)。

# 因應氣候變遷與大量再生能源併網下之淨負載曲線 變動與挑戰

In Response to the Challenges of Changing Net Load Curves under the Impacts of Climate Change and Large-scale Integration of Renewable Energy Sources

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## 摘要

目前全球正值能源轉型之重要階段，世界主要先進國家的公用電業除面臨再生能源發、售電業者的競爭外，分散式電源、再生能源、儲能設備、電動載具充放電技術與商業模式等顛覆性技術，均將促使電力之供給與需求更具時間與地域上的不確定性。然而籌措各類可調度資源及擬定相關配套措施並非一夕即成，必須將產業發展政策、氣候、人口分布、能源結構等因素納入通盤考量，進行相關規劃。有鑑於此，實有必要建構一套更符合未來情境之長期負載預測模式，提供電網及電源開發計畫及相關因應措施研擬時之參考依據。

## Abstract

At this important moment of global energy transition, electric utilities of developed countries not only have to face the competition of renewable energy generators and retailers, but also disruptive technologies, such as distributed generation, e.g., energy storage system and electric vehicles. These new energy sources have casted uncertainties on electricity supply and demand in the terms of time and geography. However, dispatchable resources and the corresponding measures cannot be accomplished overnight-unless all of the factors, e.g., industrial development policies, climate, population distribution, and energy structure, are taken into consideration. That said, a model of long-term load forecasting is needed to serve as reference for planning and developing electric infrastructure.

**關鍵詞(Key Words)**：能源轉型(Energy Transition)、不確定性(Uncertainty)、長期負載預測(Long-term Load Forecasting)。

# 碳經濟措施對我國中長期電力供需之影響評估

Assessing the Impacts of Carbon Economy Measures on Taiwan's Power Supply and Demand

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## 摘要

本研究運用整合資源規劃模型模擬我國最適電力供需策略，並設計基準情境與碳費課徵情境，評估碳費課徵對我國電力系統的影響。評估結果顯示：基準情境2050年的化石燃料供應比例將高達69.76%，再生能源供應比例約為24.5%，此為無課徵碳費之最適電力供應策略。碳費課徵情境2050化石燃料供電比例為45.24%，再生能源供應比例為38.84%。基準情境2050年電力碳排放將增加至141.87百萬噸，相對2020年約增加14%。碳費課徵情境碳排放量至2050年降至83.99百萬噸，相對2020年約減少32.6%，顯示課徵碳費有助於我國電力系統逐步走向低碳化。碳費課徵情境2050年電力成本增加至4.26元/度，相對2020年約增加57%，且該年電力系統還須要支付高達202億元的碳費。

## Abstract

This study uses a model titled TPC-IRP to simulate Taiwan's optimal power supply and demand strategy, based on two scenarios, namely the baseline scenario and the carbon fee scenario, to evaluate the impact of carbon fee on the power system in Taiwan. As the evaluation results of the baseline scenario showed, the generation percentage of fossil fuels in 2050 will be as high as 69.76%, and the percentage of renewable energy 24.5%- the optimal power supply strategy without carbon fees. Regarding the carbon fee scenario in 2050, the generation percentage of fossil fuels is about 45.24%, and renewable energy 38.84%. In the baseline scenario, the carbon emissions derived from electricity generation will increase to 141.87 million tons in 2050, about 14% increase compared to that of 2020. As for the carbon fee scenario, the carbon emissions will drop to 83.99 million tons by 2050, a decrease of about 32.6% compared to that of 2020. In the carbon fee scenario, the electricity cost will increase to 4.26 NT\$/kWh in 2050, an increase of about 57% compared to that of 2020, and the power system needs to pay up to 20.2 billion NT\$ carbon fee in 2050.

**關鍵詞(Key Words)**：碳費(Carbon Fee)、電力部門(Power Sector)、整合資源規劃(Integrated Resource Planning)、碳排放(Carbon Emission)。

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hydrogen energy in energy transition and net-zero emissions issues, as well as its relationship to energy system integration. The paper is divided into five sections: The second, examining the integration of hydrogen energy and energy systems; The third, discussions regarding the technical development path of the hydrogen supply chain system; the fourth, the market opportunities, business models, and strategic planning of hydrogen; Lastly, the conclusion and recommendation.

**關鍵詞(Key Words)：**淨零排放(Net-zero Emission)、氫載體(Hydrogen Carrier)、氫能經濟(Hydrogen Economy)、氫能系統(Hydrogen Energy System)、氫能商業模式(Hydrogen Business Models)、氫能價值鏈(Hydrogen Value Chain)。

# 台灣實現淨零排放與能源轉型的機會與挑戰－氫能 技術發展與策略規劃

The Opportunities and Challenges for Taiwan to Achieve Net Zero Emissions - Technology  
Development and Strategic Planning of Hydrogen Energy

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## 摘要

氣候變遷可能破壞經濟穩定，並威脅全球安全與人類福祉。如果人為導致的溫室氣體排放量持續成長，將加劇全球暖化幅度到數百萬年未見的程度，並對總體經濟的維穩，產生重大衝擊。然而巴黎協定各締約國面對淨零排放目標，所表現的減量企圖心不足，且欠缺具體且積極的減量行動，乃是現行全球因應氣候變遷議題的最大困境與挑戰。而台灣地狹人稠、工業發達，卻又幾乎毫無自產(傳統)能源，如何建構一個穩健可行的淨零碳排放能源供應系統，更是牽動台灣未來能否持續發展、確保產業競爭力的關鍵議題。有鑑於近期的發展所揭示的氫能在潔淨能源推廣應用的機會及潛力，本文的目的，乃在檢視氫能在能源轉型及淨零排放議題中之角色，及其與能源系統整合的關係。本文計分五節，第二節之內容，即在檢視氫能與能源系統的整合；第三節則研提氫能發電供應鏈系統的技術發展路徑規劃；第四節乃以前二節之論述為基礎，討論氫能技術供應鏈的市場商機與策略規劃，第五節為結論與建議。

## Abstract

Climate change could destabilize economies and threaten global security and human well-being. If human-caused greenhouse gas emissions continue to grow, they are expected to exacerbate global warming, raise the average temperature of the Earth's surface to levels not seen in millions of years, and have a major negative impact on overall economic stability. In the face of the net-zero emission target, the parties to the Paris Agreement have shown insufficient reduction ambitions and a lack of specific and active reduction action plans. These are the biggest dilemmas and challenges facing the current global 2050 net-zero emission target. As to Taiwan, featured with small but densely populated island, well-developed industries, but lack of indigenous (traditional) energy, the key issue confronted is to construct a stable and feasible net-zero carbon emission energy supply system that enables Taiwan to sustain its development and at the same time maintain its competitiveness in the future. In view of recent development revealed by the opportunities and potential of hydrogen energy in the promotion of clean energy and low-carbon hydrogen energy technology, the purpose of this paper is to examine the role of

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## 燃煤機組減碳之曙光：氨的混燒

Silver Linings of Carbon Reduction in Coal-fired Units: Ammonia Co-firing

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### 摘要

火力機組在我國的減碳路徑規劃中，雖然發電配比將會逐年降低，惟仍肩負2050年淨零排放過渡期間本公司穩定供電的角色，在此期間如何將火力機組減排亦為重要的減碳策略之一，其中又以燃煤機組的碳排放較多，因此，一種新興的減碳技術-氨混燒於燃煤機組逐漸受到重視，該技術是燃煤機組在減碳路徑可能的生存契機，由於氨在燃燒時不會產生二氧化碳，且具有便於運輸的特色，如能發展順利，預期將可減少滿可觀的碳排放，本文進行燃煤混氨燃燒技術之彙整與研析，將有助於宣導本公司邁向電力淨零排放可能採取的策略選項。

### Abstract

According to the planning of Taiwan's carbon reduction path, the ratio of thermal power generation will decrease year by year, but thermal units still have to play an important role to maintain generation and load balance along the way to 2050 net zero emissions (NZE). As we all know, reducing carbon emissions of thermal generators is important and coal-fired units have more carbon emissions than the other fossil fueled generation technologies. Therefore, ammonia co-firing of coal-fired units receives more and more attention. As a survival opportunity for coal-fired units, ammonia does not yield carbon dioxide during combustion and is easy to transport. When properly developed, this new generation technology may significantly reduce the carbon emissions of coal-fired units. The results of this study regarding the discussion and integration of ammonia co-firing technology may serve as a reference for the company to draft useful strategic options to tackle the issues originated from 2050 NZE.

**關鍵詞(Key Words)**：火力機組(Thermal Unit)、淨零排放(Net Zero Emissions)、燃煤機組(Coal-fired Unit)、氨(Ammonia)、混燒(Co-firing)。

# 2050 年淨零碳排電業轉型之機會與挑戰

Opportunities and Challenges for Electric Industry towards 2050 Net Zero Carbon Emissions

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## 摘要

隨著第26屆聯合國氣候變遷大會(COP26)結束，淨零碳排已蔚為國際的趨勢，各參與國紛紛承諾減少化石燃料的使用，以達到減少碳排放的目標，我國為因應世界潮流即將公布相關的減碳路徑，其中就能源部門的發展策略主要涉及減排、零碳電力、電氣化及碳捕捉，在此策略之下，位於供給方的電業產業將首當其衝，對於未來的發展也會有深遠的影響，因此本文先就國際上針對淨零碳排所訂定之策略與作為進行蒐集，並針對國內現行在能源轉型對於減碳的相關政策與作為進行盤點，後參考國際經驗針對我國電業未來發展的方向與挑戰提出看法。

## Abstract

Accompanied with the opening-and-closure of the 26th United Nations Conference on Climate Change (COP26), net zero carbon emissions (NZE) has become a roaring global trend. Most countries participating COP26 have pledged to reduce the use of fossil fuels to achieve the goal of 2050 NZE. In response to the aforesaid global trend, the Executive Yuan is scheduled to disclose Taiwan's carbon reduction path together with the strategies of energy sector, from the perspectives of carbon reduction, zero carbon power resources, electrification and carbon capture. Electric industry, the main sector of carbon emissions, unavoidably will be significantly affected in all respects. In this study, we utilize the strategies and measures collected from worldwide NZE cases to compare with the domestic policies and measures under discussion to serve as reference for Taipower and the government.

**關鍵詞(Key Words)**：淨零碳排(Net Zero)、再生能源 (Renewable)、儲能(Energy Storage)、智慧電網(Smart Grid)。