從 理 想 到 實 踐　　擘 劃 淨 零 未 來 藍 圖

# VISION TO REALITY

## *A Net Zero Future*



EUROPEAN CHAMBER OF COMMERCE TAIWAN
歐洲在臺商務協會

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# Shape the Future with Confidence

EY is committed to building a better working world – with increased trust and confidence in business, sustainable growth, the development of talent in all its forms, and greater collaboration. EY aspires to build a better working world through actions and by engaging with like-minded organizations and individuals. This is the EY purpose – and why EY exists as an organization. We hope it will inspire innovative thinking and action. We seek to drive more enlightening discussions and more fruitful and ambitious outcomes for EY clients. We want to inspire businesses to look further into the future and entrust us with helping to find the right solutions.

安永致力於建設更美好的商業世界。我們深信透過實踐該理念，將為世界帶來更多正面的影響：信任度增加、資本流動更順暢、投資者進行更明智的決策、企業永續發展、就業增加、消費行為熱絡、政府更有效地投資於民。更美好的商業世界也能激發個人潛能，培養人才發揮優勢，鼓勵更多元的合作。我們期許透過自身的行動，與思維相近的組織和個人共同建設更美好的商業世界。這是安永的宗旨，也是我們身為一家專業服務機構的立基。

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EUROPEAN CHAMBER OF COMMERCE TAIWAN
歐洲在臺商務協會

# Foreword



H. Henry Chang

Chairman, European Chamber of Commerce Taiwan

Taiwan and Europe share the vision and commitment to realise a net zero future. Progress has been made towards this shared vision, but, with only 25 years to go, interim targets have been missed and long-term targets will not be reached without concerted action.

Europeans are the largest investors in Taiwan and by far the largest investors in Taiwan's wind energy sector. As this report illustrates, ECCT members have innovative technology and solutions aimed at achieving net zero emissions by 2050. Several solutions will be pivotal in reaching this target, each contributing uniquely to reducing carbon footprints and promoting environmental sustainability. For example, alternative energy sources, including wind, solar, geothermal, hydropower and ocean energy are fundamental to transitioning from fossil fuels to cleaner, renewable sources. Similarly, alternative feedstocks, such as clean hydrogen and bio-based fuels, offer sustainable solutions for industries like power generation, transport, agriculture, manufacturing, and chemicals, displacing carbon-intensive raw materials.

Financial measures play a crucial role by providing the necessary funding for green technologies and projects. Policies, incentives, and investment in clean energy infrastructure are essential to scaling up solutions and accelerating the shift toward a low-carbon economy. The right financial strategies will ensure that businesses and governments can drive innovation, support energy transition projects, and promote sustainable practices.

Sustainable practices in industry and transportation, including energy-efficient manufacturing processes, the adoption of electric vehicles and smart transport can significantly reduce emissions. These measures can also encourage innovation in green technologies, pushing industries to embrace cleaner alternatives. Furthermore, low-carbon and energy-efficient buildings are essential to minimizing energy consumption and emissions. By integrating advanced insulation, smart technologies, and renewable energy systems, buildings can operate with smaller environmental footprints.

Biotech and natural solutions, such as ecological restoration, biodiversity conservation and smart agriculture offer novel methods to strengthen eco-systems, reduce emissions and enhance carbon sequestration. In addition, the development of zero-emission circular goods, products designed for reuse, recycling, or repurposing, reduce waste and curtail emissions across product lifecycles.

Adopting the solutions outlined in the following chapters would help Taiwan to move faster towards its net zero vision. Doing so in partnership with ECCT members would make the transition even smoother, producing benefits for the economy and the environment, which would in turn boost Taiwan's global image as an effective steward of the environment and champion of net zero initiatives.



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# Foreword



Andrew Fuh

Country Managing Partner, Ernst & Young, Taiwan

## The best way to predict the future is to create a future with confidence

In today's world, climate change is no longer a distant threat but an immediate and formidable challenge we must confront. As a critical hub in the global supply chain, Taiwan not only bears international responsibility but also faces a historic moment to reshape its economy, society, and environment in its journey toward net zero transformation.

Against this backdrop, we are honored to collaborate with the European Chamber of Commerce Taiwan (ECCT) to publish the Net Zero Best Practices Report. This report compiles leading practices and professional insights on net zero strategies, providing actionable guidance for governments and businesses to help Taiwan achieve its 2050 net zero target.

## Taiwan's Role in the Global Perspective

As a leader in the global semiconductor industry and a key player in the supply chains for high-tech and manufacturing sectors, Taiwan enjoys unique advantages and takes on greater responsibilities. Under the global initiative for energy transition and net zero goals, Taiwan must demonstrate leadership in three key areas:

1. **Innovation-driven industrial transformation:** Through technological innovation, Taiwan must guide high-carbon industries toward low-carbon transformation, setting benchmarks for green manufacturing in the global market.
2. **Fundamental changes in energy structure:** Developing renewable energy and achieving energy independence and stability are crucial to Taiwan's net zero success.
3. **Equitable transformation with social inclusion:** While advancing net zero initiatives, Taiwan must ensure vulnerable groups are not marginalized, fostering a more equitable development environment.

## EY's Global Strategy: All In

We also recognize that accountants face three emerging challenges under sustainability and net-zero trends: how to measure the uncertainty in sustainability-related information, how to conduct longer-term and more comprehensive financial assessments, and how to ensure financial statements reflect sustainability-related risks across entire value chains.

As a global professional services organization, EY has embedded sustainable development as its core mission. Today, EY's new global strategy, All In, demonstrates our bold ambition to create value for clients, employees, and stakeholders alike.

All In is not merely a business strategy—it reflects the commitment and diverse experience of EY's 400,000 professionals worldwide. It empowers us to anticipate and navigate in an ever-changing world, enabling governments and businesses to shape the future with confidence.

## Shared Responsibility and Vision

This report brings together the experience of EY and ECCT corporate members, offering insights into global trends, industry transformation cases, and directions for technological innovation. We firmly believe that successful net zero transformation requires the collaborative efforts of governments, businesses, and society.

Achieving net zero is not only about reducing carbon emissions but also about transforming economic structures, enhancing social equity, and safeguarding the future for the next generation. EY will continue to blend global perspectives with local insights, supporting governments and businesses every step of the way in their net zero journey with ECCT.

We hope this report serves as a valuable resource for policymakers and industry leaders, helping Taiwan become a frontrunner in the global race toward net-zero. Together, we can create a sustainable future for Taiwan and the world.



經濟部
Ministry of Economic Affairs

# Foreword



Kuo Jyh-Huei

Minister, Ministry of Economic Affairs (MOEA)

The escalating impacts of climate change have made addressing the climate crisis a shared and urgent challenge for nations worldwide, compelling them to actively implement sustainable action plans and embark on green transitions toward achieving net-zero emissions. The European Union stands as a global trailblazer in the net zero transition, having firmly committed to achieving climate neutrality by 2050. Its landmark initiative, the European Green Deal, spans a comprehensive range of sectors—including energy, economy, construction, transportation, agriculture, ecology, and the environment—serving as a benchmark for Taiwan and other nations to follow.

The European Chamber of Commerce Taiwan (ECCT) has long been a dedicated advocate of and active participant in Taiwan's energy development initiatives. Since establishing the Low Carbon Initiative in 2011, the ECCT has consistently shared Europe's best practices and standards in low-carbon solutions with Taiwan's government and industries. This enduring collaboration has significantly raised Taiwan's awareness of sustainable development while cultivating a strong and fruitful partnership between Taiwan and Europe to promote low-carbon and sustainable growth. The ECCT has become an indispensable partner in Taiwan's journey toward net zero transformation. Through its report Vision to Reality : A Net Zero Future, the ECCT provides an in-depth exploration of the energy transition pathways of Taiwan and Europe, offering insights into EU industrial solutions and practical examples drawn from its energy transition experience. Covering themes such as renewable energy, green finance, sustainable consumption, transportation and infrastructure, and ecological preservation, the report serves as a vital reference for shaping Taiwan's future net zero policies.

Bound by close trade relations, Taiwan and Europe are united in their shared vision for green transition. Since the initiation of Taiwan's energy transition in 2016, Europe has emerged as a key source of green technology and an essential investment partner for Taiwan. Numerous European enterprises have played pivotal roles in Taiwan's energy transition. Taiwan is now embarking on its second phase of energy transition, while ensuring a stable energy supply and enhancing energy independence through diversified renewable energy sources, and comprehensive energy conservation measures. Looking ahead, Taiwan and Europe aspire to deepen their collaboration in emerging energy fields, such as geothermal and ocean energy, further solidifying their partnership.

The 2050 net-zero transition represents an ambitious, cross-generational, interdisciplinary, and transnational endeavor that demands global cooperation and the exchange of expertise. Taiwan, with its globally competitive semiconductor and ICT industries and its well-established technology and traditional industry supply chains possesses unique strengths. Meanwhile, the EU is a global leader in clean energy technologies, such as renewable energy and hydrogen power, as well as in green finance and regulatory frameworks. We look forward to continued collaboration between Taiwan and the EU, jointly advancing research, development, and the commercial application of low/zero-carbon technologies. United in purpose, we can make a profound positive impact on the global journey toward a net zero future.



環境部
Ministry of Environment

# Foreword



Peng Chi-Ming

Minister, Ministry of Environment (MOENV)

As climate change continues to intensify around the globe, achieving net zero emissions has become a key priority for the international community. Taiwan, as an integral part of the global ICT supply chain, is actively working toward its net zero goals while fostering close collaboration with global partners.

Europe has long been a global leader in climate policy, excelling in areas such as innovative technology, policy planning, and building societal consensus. Taiwan draws significant inspiration from Europe, with which it actively collaborates to learn from its successful practices, adapting them to local initiatives. With the support of the European Chamber of Commerce Taiwan, bilateral cooperation has been further strengthened, fostering the exchange of technologies and resources while enhancing both economic and environmental values.

Since Taiwan announced 2050 net zero emissions target in 2021, significant progress has been made. A series of policies have been steadily implemented, achieving notable results in energy transition, industrial decarbonization, and sustainable transportation. Specifically, Taiwan reduced its national greenhouse gas emissions by approximately 3% in 2023, with particularly strong outcomes in emission controls within the power and industrial sectors. Additionally, Taiwan has made steady progress in advancing renewable energy. As of mid-2024, solar installation capacity had reached 12 GW, and wind power capacity exceeded 3.01 GW, marking solid steps toward a low-carbon society.

In 2024, Taiwan took a pivotal step on its net zero journey by announcing the formal implementation of the carbon fee system. Over recent months, the Ministry of Environment has worked diligently to draft and enforce carbon fee regulations. Through multiple public hearings and consultations with industries, the system has been tailored to meet the specific needs and characteristics of different sectors, ensuring its feasibility and fairness. The carbon fee system not only lays the foundation for Taiwan's decarbonization efforts but also represents a significant milestone toward a low-carbon economy.

The carbon fee system is based on greenhouse gas emissions and was designed to support innovation and adaptation rather than impose economic penalties. In the first three months of the system's implementation, the government signed emission reduction commitments with over 100 companies and introduced technical support and funding programs to help businesses adapt to the new policies.

The comprehensive implementation of carbon fee regulations is expected to reduce national greenhouse gas emissions, playing a critical role in meeting the 2050 net zero target. The launch of the carbon fee system underscores Taiwan's firm commitment to decarbonization and provides industries with clear policy guidance to accelerate their transition to low-carbon operations.

Taiwan and Europe's collaboration on net-zero initiatives extends beyond policymaking to encompass technological innovation and the green transformation of industrial supply chains. Taiwan's high-tech industries work closely with Europe's advanced technology providers, creating opportunities for joint development in smart grids, energy storage, renewable energy technologies, and electric vehicles. These partnerships not only accelerate Taiwan's internal green transition but also position Taiwan as a key partner for European businesses expanding into the Asia-Pacific region. Through these international collaborations, both sides are addressing the challenges of climate change and promoting sustainable global economic growth.

Taiwan's vision for net zero emissions is both long-term and systematic. Achieving this goal is not just the responsibility of individual nations but a global challenge. Looking ahead, the path to net zero remains filled with challenges, whether in achieving technological breakthroughs or fostering societal consensus. However, through the combined efforts of Taiwan and its global partners, these obstacles can be overcome, climate goals can be reached, and a better future can be created for generations to come.

Chi-Ming Peng

EU ropean Economic & Trade OFFICE 歐洲經貿辦事處

# Foreword



Lutz Güllner

Head of the European Economic and Trade Office

A changing climate threatens not just coral reefs, coastal cities, and millions of livelihoods, but the very nature of the world we inhabit.

The costs of adaptation to a warming beyond 1.5°C will far exceed those of switching to less polluting energy sources before the damage is irreversible, highlighting the need to promptly decarbonise our economies.

In line with its goal of reducing emissions by 55% by 2030 and by 90% before 2040, as well as of reaching climate-neutrality by 2050, the European Union has, in the past years, set out an ambitious policy agenda, the effects of which are now bearing fruit. In 2022, the EU generated more electricity from sun and wind than from gas. And in 2023, renewable energy constituted around a quarter of the total mix, representing a twofold increase over the previous fifteen years. This is part of the EU's continued shift to more sustainable patterns of production and consumption, scaling up and prioritising investment in clean energy infrastructure and technologies in partnership with industry, social partners, and all stakeholders.

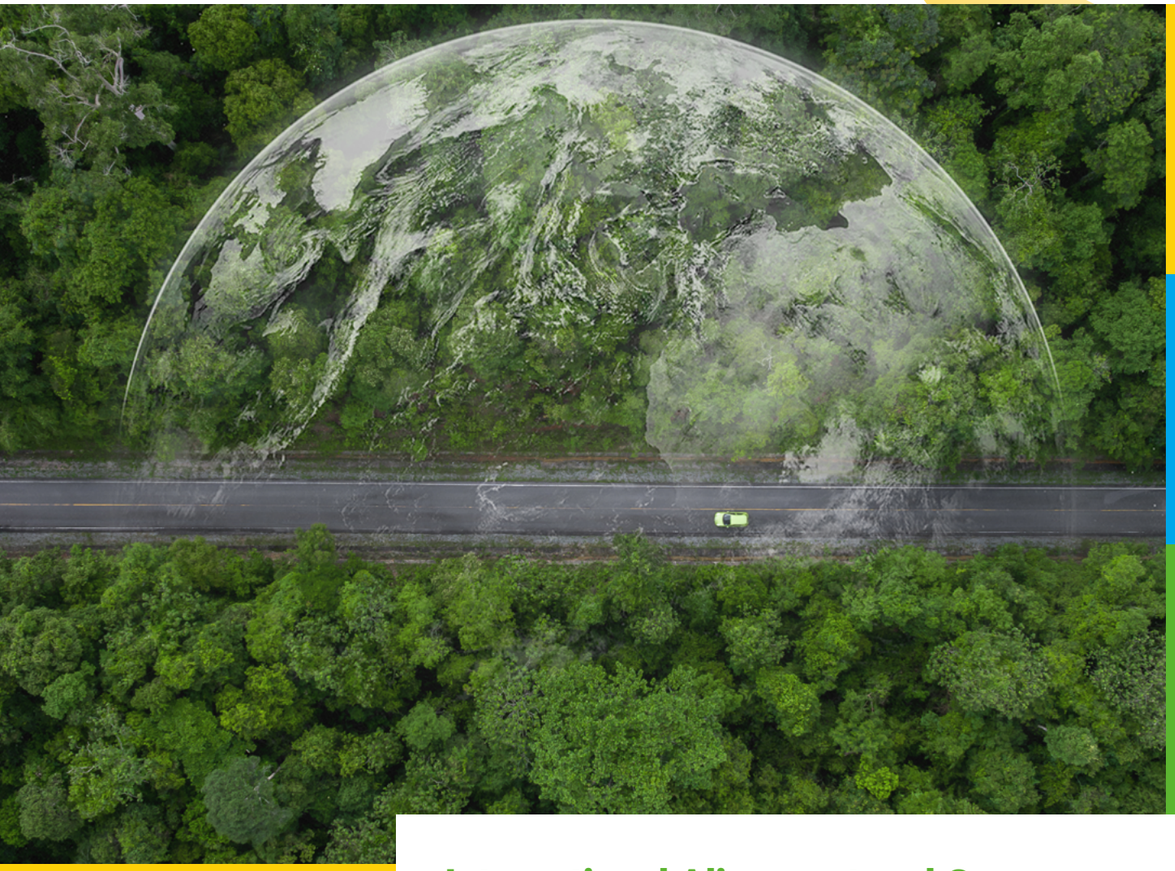
We must acknowledge, however, that, as emitter of less than 10% of the world's $CO_2$, the EU cannot mitigate climate change on its own. As the name implies, global warming is a global problem, and as such it requires global engagement and global solutions. To help bring about said solutions, what the EU can do is show—even lead— the path towards a successful green economy.

By also committing to carbon neutrality before 2050, Taiwan, which is increasingly susceptible to flooding, deadly heat waves, and more frequent and intense typhoons, has chosen to join like-minded partners in one of the most transcendental challenges of our era. The EU would like to strengthen that partnership, whether by encouraging European investment in wind energy off the island's shore or by collaborating on recent EU initiatives on global issues such as methane, carbon pricing, and global targets for renewable energy.

Let us seize the opportunity and work towards a greener and safer future together.



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# International Alignment and Green Growth of Net Zero Technologies in Taiwan

**Roger Tseng**, Climate Change, Sustainability and ESG Advisory Service practice leader & Taiwan CPA, Ernst & Young, Taiwan

**Henry Lin**, Deputy Manager, Climate Change & Sustainability Services, Ernst & Young, Taiwan





Taiwan is committed to achieving net zero emissions by 2050. Guided by the Climate Change Response Act with four transition strategies at its core — energy, industry, lifestyle, and society — the government has implemented the "2023-2026 Plan for Taiwan's Pathway to Net Zero Emissions" (hereafter referred to as the Net Zero Plan). Approved by the Executive Yuan in January 2023, this plan outlines concrete measures to drive energy transition, carbon reduction, and industrial transformation. Focusing on five key sectors such as construction, transportation, industrial, power, and negative emissions technologies, the plan identifies pathways that are critical to reaching the net zero target, and highlights Taiwan's most promising options for energy transition, which include low carbon technologies such as geothermal energy, hydrogen energy, smart grids, offshore wind power and marine energy.

While identifying net zero technologies suitable for domestic development, and examining the potential risks and opportunities associated with low-carbon transition plans, Ernst & Young, Taiwan (EY Taiwan) refers to the "IEA Clean Energy Technology Guide" (hereafter referred to as the ETP Technology Guide) published by the International Energy Agency (IEA), using three metrics to compare and analyze technologies from the Net Zero Plan: "technology readiness level", "carbon reduction potential", and "regulatory standards".

The ETP Technology Guide is a tool designed to help decision-makers, businesses, and researchers understand the status, potential, and application scenarios of clean energy technologies. It belongs to the IEA's Energy Technology Perspectives (ETP) series and comprises of detailed information on various clean energy technologies, such as stage of development, market application, cost trends, and contribution to reducing carbon emissions. The guide includes key technologies for the production, conversion, storage, and usage of energy such as: renewable energy (solar, wind, hydro, geothermal), energy storage (batteries, hydrogen), energy efficiency (building, industrial, and transportation technologies), carbon capture and storage (CCUS), and low-carbon fuels (green hydrogen, synthetic fuels, bioenergy).

## Technology Readiness Level

The ETP Technology Guide categorizes technologies based on their stage of development:

1. Research and Development (R&D): in need of further research and testing.
2. Demonstration: under testing or trial operation.
3. Early Deployment: beginning to be applied in specific markets.
4. Commercialization: widely used and cost competitive.

## Carbon Reduction Potential

This evaluates each technology's contribution to global carbon reduction in 2030 and 2050, as well as the necessary scale of deployment to achieve net zero goals.

## Regulatory Standards

These standards include policies to accelerate the development and adoption of technologies, such as:

1. Government-supported R&D programs.
2. Market incentive mechanisms (e.g., carbon pricing and subsidies).
3. Promotion of international cooperation and technology transfer.

When compared to the ETP Technology Guide, Taiwan has relatively comprehensive improvement plans and specific technological pathways in the energy and transportation sectors. The Net Zero Plan proposes numerous improvement measures for the energy sector, covering areas such as geothermal energy, hydrogen, grids, offshore wind power, and marine energy. Taiwan has adopted approximately 20% of the energy-related technologies outlined in the ETP Technology Guide; however, technologies such as sustainable fuels and methane reforming have yet to be included due to insufficient maturity.

In the transportation sector, the plan extensively discusses electric vehicles, electric motorcycles, and the electrification of public transportation. Taiwan has adopted approximately 10% of the transportation-related technologies in the ETP Technology Guide; however, a clear or specific description on the policy of technologies such as hydrogen or ammonia infrastructure, as well as fuel cells are still missing from the picture.

For Taiwan's industrial and construction sectors, the plan primarily provides policy explanations or regulatory responses, adopting approximately 3% and 1% of technologies from the ETP Technology Guide, respectively. While there are missing proposals regarding technological promotion that are clearly outlined as those demonstrated in the ETP Technology Guide, the industrial sector is focusing instead on Best Available Technologies (BAT), such as low-carbon processes, energy conversion applications, and equipment performance improvements, which are less closely related to net zero technology development. Despite the proposal of individual carbon reduction or 2050 net zero plans from key industries such as steel and cement, the Net Zero Plan does not address related policies, or specify how sustainable finance will provide sufficient funding or investment for industrial transformation. Similarly, the construction sector also focuses on policies and supporting measures without a defined trajectory for Taiwan's future technological advancement. The push for net zero buildings remains in its infancy, with no explicit or detailed policies on topics such as control systems for cooling, thermal efficiency, lighting standards, low-carbon materials, lifecycle extensions or circular economy, near-zero carbon building ventilation, as well as technical standards for building envelope.

Net zero goals should target 2050, not just 2030; therefore, EY teams suggest that Taiwan should broaden its research and draw lessons from the net zero technology blueprints of Europe and international benchmarks. Beyond continuous and comprehensive evaluation of feasibility, the integration of economic and industrial policies with sustainable finance is crucial to the support of green growth. In addition to existing principles from EU Taxonomy Regulation, Taiwan should reference the EU Green Deal by incorporating Transition and Enabling activities. The introduction of foreign net zero technologies, when necessary, can shorten the industrial learning curve, drive capital investments into low-carbon, transitional, and enabling economic activities. Only then can Taiwan's net zero goals truly enhance the overall competitiveness of the nation, businesses, and society.





Disclaimer: The views reflected in this article are the views of the author and do not necessarily reflect the views of the global EY organization or its member firms.



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# Learning from Europe: Accelerating the Development of Taiwan's Renewable Power Trading Market

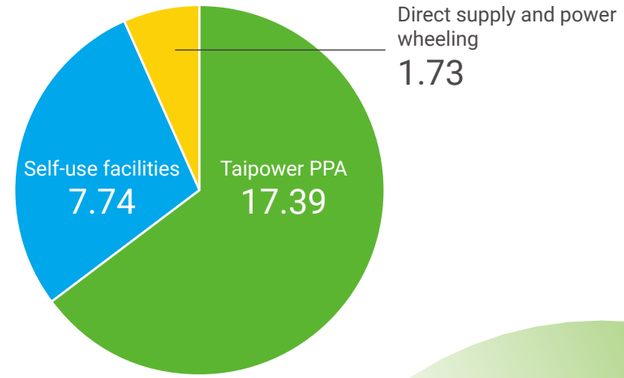
**Aaron Wu**, Managing Director, EY Transaction Advisory Services Inc.

**Vincent Zhu**, Senior, EY Transaction Advisory Services Inc.

## Relaxation of Renewable Energy Policies Boosts Solar Power Supply and Expands the Green Energy Market

According to statistics from Ernst & Young (EY), Taiwan generated 282.1 TWh of electricity in 2023, with 9.5% from renewable energy (approximately 26.86 TWh). Within this renewable portion, Taiwan Power Company (Taipower) purchased 17.39 TWh of renewable energy under its Feed-in-Tariff (FiT) program, while 1.73 TWh was traded in the renewable energy market, either through direct supply or power wheeling, accounting for only 6% of the total renewable energy generated. The remaining 7.747 TWh, came from self-use facilities and was not released into the renewable energy market.

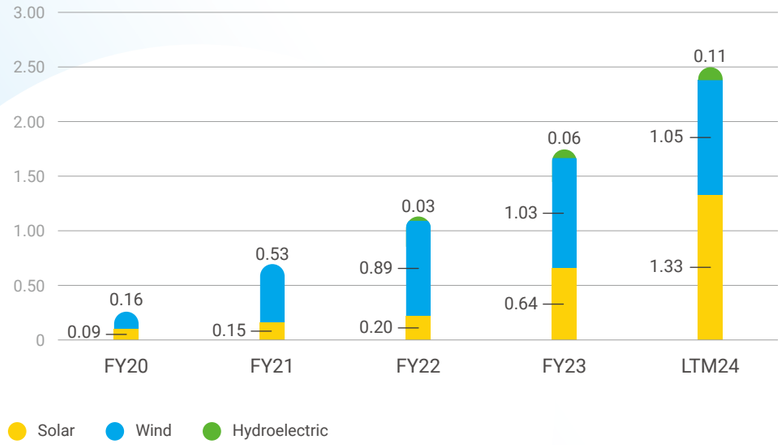
### 2023 Taiwan Renewable Energy Distribution (Unit: TWh)




Additionally, given the increasing domestic demand for green energy, Taiwan's Bureau of Energy under the Ministry of Economic Affairs (MOEA) further relaxed the "Type 3 to Type 1 Conversion" regulations in 2023. This allows renewable energy generated by self-use solar projects (Type 2 and Type 3) to enter the green energy market, to be sold directly to renewable-energy-based electricity retailing enterprises (hereafter "retailing enterprises"). Since Taipower began accepting sales of green energy directly to end-users or via retailing enterprises in May 2020, approximately 5.61 TWh of renewable energy had been traded via Corporate Power Purchase Agreements (CPPAs) by the end of September 2024.

EY statistics show that green electricity traded via CPPA will reach 2.49 TWh in the last 12 months (LTM) of 2024, up by more than 30% compared with 1.73 TWh in 2023. Solar power specifically will increase to 1.33 TWh, over 90% growth compared with 0.64 TWh in 2023. Since the amendment of the Electricity Act on 26 January 2017, enabling green power liberalisation, the renewable energy market in Taiwan has grown at an average annual rate of 50%. The MOEA estimates that approximately 8.6 TWh green electricity from self-use facilities could be traded directly to end-users or sold via retailing enterprises in 2024.

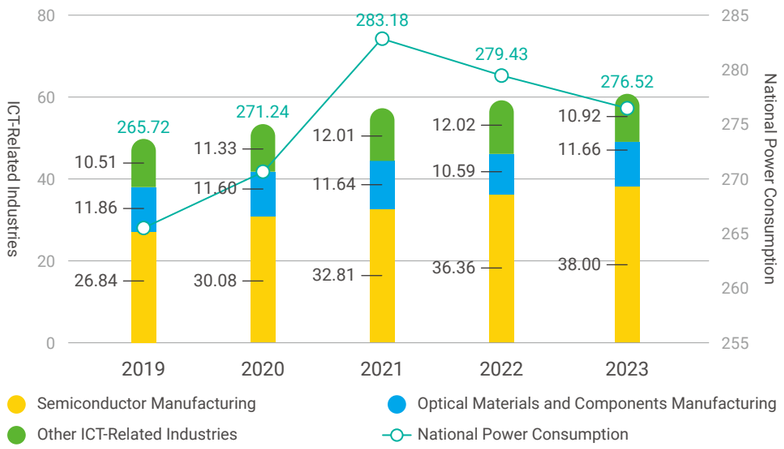
### Taiwan Renewable Energy CPPA 2020-2024 (Unit: TWh)




## Rising Electricity Demand in ICT-Related Industries: Green Energy Still Insufficient

EY highlighted Taiwan's pivotal role in the global AI computing supply chain. Major technology corporations are actively responding to the "2050 Net Zero Emissions" policy and adopting initiatives such as RE100. Consequently, the demand for green energy among technology companies continues to rise. Despite a nationwide reduction of 2.91 TWh in electricity consumption 2023 compared with 2022, the semiconductor manufacturing's electricity usage grew by 1.64 TWh (4.5%). Due to the annual increase in advanced semiconductor manufacturing capacity, it is projected that the electricity consumption of Taiwan's semiconductor industry may grow more than threefold in the future. Furthermore, with the establishment of new AI server and data centres by international corporations from 2024 to 2028, these developments could lead to a substantial increase in electricity demand by 2030.

### National and ICT-Related Industries Power Consumption 2019-2023 (Unit: TWh)

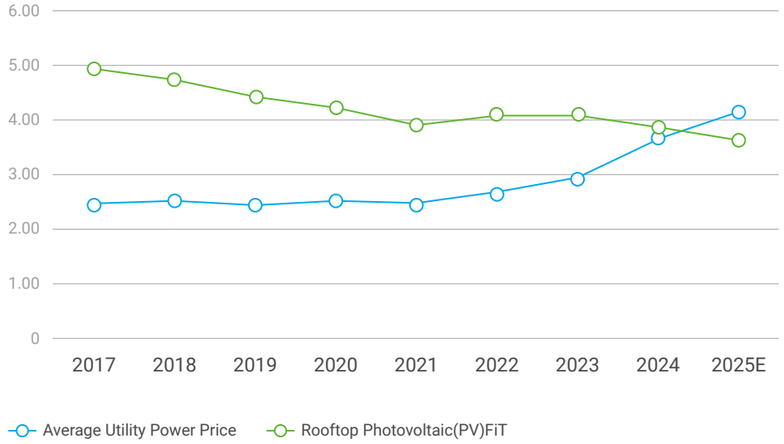



## Declining Feed-in Tariff (FiT) Rates and Rising Electricity Prices Promote Green Energy Trading

As solar development matures, the FiT rate for second-phase rooftop solar projects in Taiwan in 2024 has been capped at NT$4.37/kWh, a 12.2% reduction over eight years. This narrowing profit margin for long-term power purchase agreements (PPAs) with Taipower has highlighted the benefits of trading on the market over direct grid sales.

Taipower's recent announcement of a 12.1% average industrial electricity price hike further underscores this trend. With industrial electricity prices averaging NT$4.27/kWh post-adjustment, forecasts suggest that by 2025, grid buyback prices could fall below industrial electricity rates. This transition marks a critical period for green power trading and the development of the free market.

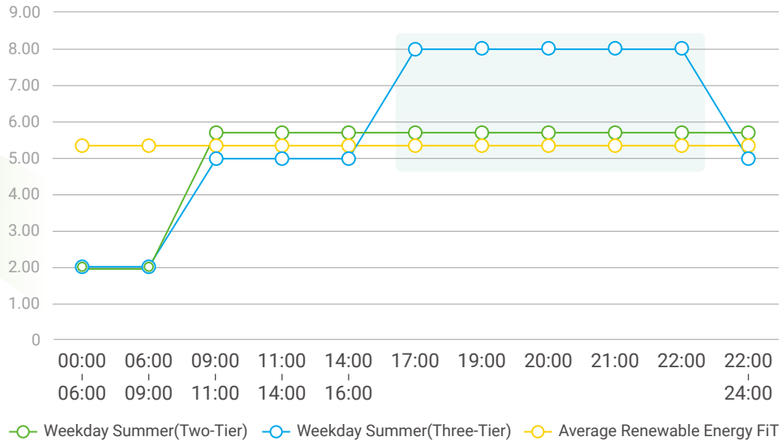
### Rooftop PV FiT vs. Average Industrial Electricity Price (Unit: NT$/kWh)



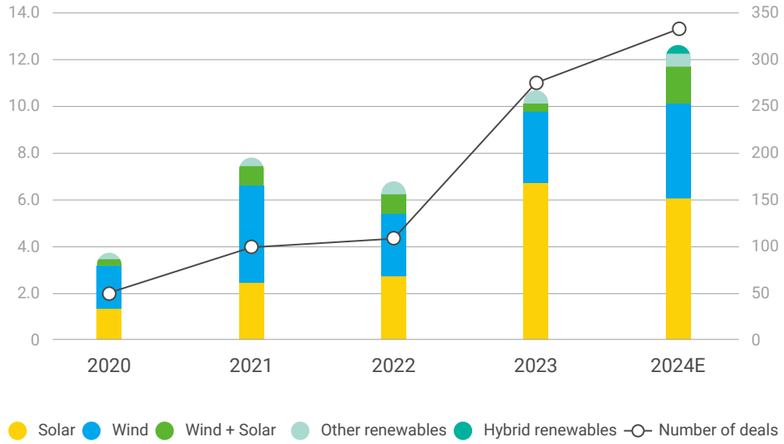

## Time-of-Use Tariffs and Behind-the-Meter Storage Unlock Arbitrage Opportunities

For large corporations, there are many options for signing CPPAs with renewable energy plants or retailing enterprises at fixed rates. However, green energy remains a scarce resource for small and medium enterprises (SMEs) and retail consumers in Taiwan, who are likely to adopt time-of-use tariffs, storing low-cost off-peak electricity for use or sale during peak hours to optimise costs. According to the Bureau of Energy, potential applicants for such systems include 500,000 SMEs, one million small businesses and two million households, yet the current adoption rate is below 3%. EY estimates that if SMEs and retail consumers subsequently adopt time-of-use tariffs, they will need to purchase large amounts of green electricity annually to realize arbitrage. This is expected to drive the development of the behind-the-meter energy storage market.

### 2024 Standard Time-of-Use (TOU) Tariff vs. Average Renewable Energy FiT (Unit: NT$/kWh)



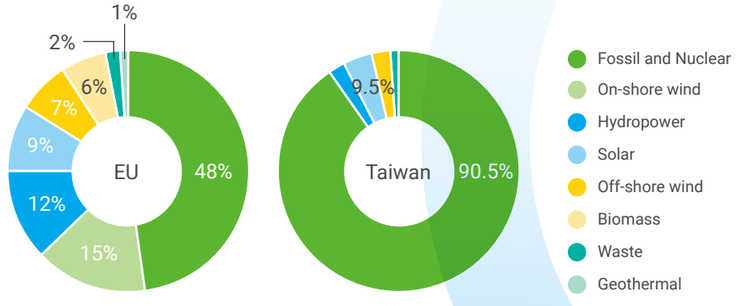

### Contracted PPA Capacity Europe (26 countries incl UK) from 2020-2024E (Unit: GW)




## European Green Power Generation Surpasses 50% in 2023: Growth in CPPA Capacity

The EU is witnessing unprecedented growth in renewable energy. The International Energy Agency (IEA) reports that renewable energy accounted for 51.7% of total energy production in the EU in 2023. In contrast, Taiwan's renewable energy penetration remained low at 9.5%, with significant reliance on imports for hydrogen, natural gas, and bringing in advanced carbon capture technologies. The EU presents itself as a key potential partner and supplier for Taiwan.

### Renewable Energy Generation in EU vs. Taiwan as of 2023



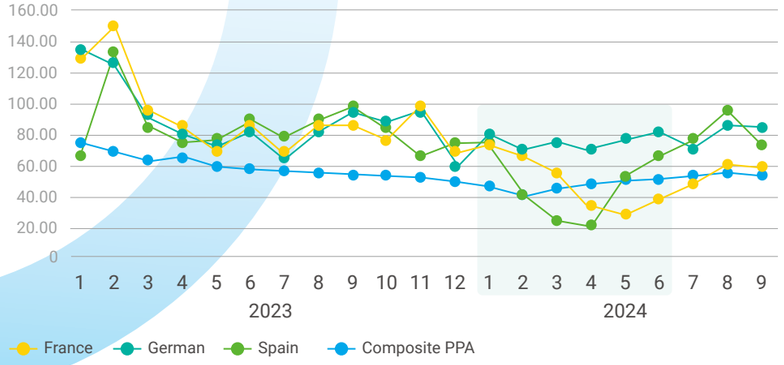

According to statistics from the Brussels-based energy trading platform RE-Source, 145 CPPAs were signed across Europe (including the UK) in the first half of 2024, setting a record for transaction volume. This represents a 54% increase compared with 94 agreements signed during the same period in 2023, equating to 10.6 GW of contracted capacity. Among these, solar energy volumes were double those of both onshore and offshore wind, accounting for approximately 5.9 GW. EY statistics indicate that over the last 12 months in 2024, Europe is expected to reach 323 PPA deals (excluding utility transactions) with a total contracted capacity exceeding 12 GW.

## Intermittent Renewable Surplus and Negative Electricity Prices in Europe

However, rapid expansion of renewable energy sources has led to energy oversupply, resulting in significant negative electricity price occurrences in 2024, with Germany, Spain and France experiencing 142, 160 and 233 hours of negative pricing, respectively. The EU continues to invest in green infrastructure, increasing wind and solar generation by 12.7% in the first half of 2024 compared with the previous year. However, price volatility has raised risks in CPPA agreements.

In contrast, Taiwan's CPPA market remains nascent, facing supply shortages, heavily capital expenditure on the early stage and above-market financing rates. However, the continued volatility of green electricity prices in Europe serves as a warning to the Taiwanese market, as well as highlighting the importance of energy storage in stabilising green electricity prices.

### Average wholesale spot electricity prices vs. Composite PPA 2023–2024 (Unit: EUR/MWh)



## Conclusion

Although Taiwan's renewable energy journey began later than Europe's, industrial development has accelerated the green energy demand. Medium-to-short-term CPPAs are expected to dominate in the face of market fluctuations. At the same time, to compensate for losses caused by low electricity prices, the government raised electricity rates in 2024, is gradually reducing the purchase price of green electricity, and is simultaneously relaxing regulations related to solar energy supply. This will inevitably accelerate the development of business models for behind-the-meter green electricity trading and various energy storage arbitrage opportunities.

When renewable energy penetration surpassed 50% in Europe, this necessitated the development of stable pricing mechanisms to manage risks. It is also expected that short-term CPPAs will increase. Additionally, Hybrid PPAs combining hydrogen storage with solar or wind power could offer long-term solutions. Taiwan can leverage Europe's experience to refine its green power trading strategies.

Disclaimer: The views reflected in this article are the views of the author and do not necessarily reflect the views of the global EY organization or its member firms.





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# The Tide of Green Finance: Challenges and Opportunities in Renewable Energy Project Financing

**Feng Chih-Wei**, Managing Director, EY Transaction Advisory Services Inc.

**Angus Wang**, Senior Manager, EY Transaction Advisory Services Inc.





The planet is currently witnessing extreme climatic events with alarming frequency and intensity, from heatwaves in Europe to floods in Asia, all signalling that climate change has become a severe challenge facing humanity. Scientists warn that without urgent action, climate change will cause irreversible damage to human societies and ecosystems. To mitigate the impacts of climate change, the international community is united on the need to accelerate the energy transition towards low-carbon, sustainable economic models.

Faced with the imminent climate crisis, countries around the world are turning their attention to energy transformation. Greenhouse gas emissions from traditional fossil fuels are the primary culprits behind climate change, making the shift away from fossil fuel dependency a pressing priority. In this energy revolution, renewable energy is not only valued for its clean, sustainable and distributed generation potential, which can significantly reduce greenhouse gas emissions, but also for its ability to create job opportunities, stimulate economic growth and enhance energy supply stability. With advances in technology and financial investment, the competitiveness of renewable energy is increasing, making it a mainstream source of global energy. Solar panels shining on rooftops and wind turbines spinning across vast plains and seas are gradually changing our traditional perceptions of energy.

## Taiwan and Europe Join Hands for a Green Future

The collaboration between Taiwan and Europe in renewable energy is growing closer. Europe, as a global leader in renewable energy development, offers a wealth of experience, advanced technology and a comprehensive industrial chain, providing valuable insights for Taiwan's energy transition. In pursuit of its 2050 net-zero emissions and carbon neutrality goals, the Taiwanese government is actively accelerating the development of net zero and energy transformation initiatives, contributing to the global green development.

For instance, Denmark is renowned for its wind power technology, and as Taiwan introduces Danish expertise and technology, it is also actively cultivating its local wind power industry chain. With the assistance of European developers, Taiwan has become a leader in offshore wind power development in Asia, with Japan and South Korea coming to learn from its experience. At The Smarter E Europe 2024 – Intersolar Europe solar exhibition in Munich, Taiwanese and European businesses signed MOUs to jointly develop energy storage and photovoltaic solar energy. Through cooperation with Europe, Taiwan not only gains access to advanced technology but also becomes part of the global green supply chain.

## Renewable Energy Project Financing: A Landscape of Challenges and Opportunities

The development of renewable energy projects requires substantial capital investment, and resorting to project financing from banks is a common approach to raise the required capital. However, compared with traditional industry financing, renewable energy project financing faces unique challenges.

- **Project Characteristics:** Renewable energy projects often feature large investments, long construction periods and complex technologies. For example, a large offshore wind farm can require the investment of tens of billions and take several years to construct. Additionally, the generation of renewable energy is highly dependent on natural conditions, lowering its relative revenue stability. These uncertainties increase the risk associated with project financing.
- **Bank Considerations:** When evaluating renewable energy project financing, banks focus on the project's economic benefits as well as considering the following aspects:
  - » **Developer's Strength:** The technical capability, financial condition and previous development experience of the developer are crucial factors for banks. An experienced and financially stable developer is more likely to gain the bank's trust.
  - » **Technical Feasibility:** The project's success will depend on whether the technical solution is mature, the equipment supply is stable, construction is smooth, construction costs are in line with estimates, and the efficiency and quantity of power generation meet expectations.
  - » **Policy Risk:** Government energy policies and subsidy programs can impact the economic benefits of a project. For example, adjustments to feed-in tariffs and changes in tax policies can affect project revenue.
  - » **Market Risk:** Fluctuations in the electricity market could lead to a decline in electricity prices, affecting project revenue. For instance, a significant drop in traditional energy prices could challenge the competitiveness of renewable energy, or a rapid increase in market participants could lead to lower purchase offers.
- **Bank Mitigation Measures:** To address these challenges, banks typically take the following measures:
  - » **Risk Sharing:** Banks share project risks with developers, the government or by seeking syndicated loans from multiple banks. For example, banks may require developers to provide a certain ratio of equity, seek joint financing from several banks or set restrictions on fund utilisation and reserve accounts.
  - » **Financial Feasibility Assessment:** For different project financing plans, banks seek third-party independent institutions like financial advisors to build financial models and examine the project's Debt Service Coverage Ratio (DSCR), Times Interest Earned (TIE) or repayment results under different parameter scenarios. External consultants' financial model simulations can further enhance the bank's grasp of project financing feasibility.
  - » **Credit Enhancement:** Banks require developers to provide credit enhancement measures to improve the project's credit rating. For example, developers can offer collateral or seek joint guarantees from parent companies.

## The Role and Support of the Government

The government plays a crucial role in promoting the development of renewable energy. Supportive policies from the government, such as providing stable feed-in tariffs, financing guarantees and tax incentives, can effectively reduce the investment risk of projects and attract more capital to the renewable energy industry. Additionally, the government can create a favorable business environment for the renewable energy industry by establishing relevant regulations and improving market mechanisms.

## Outlook

As the global demand for green energy continues to grow and governments around the world increase their support for renewable energy, the industry is poised to encounter unprecedented development opportunities:

- **Technological Innovation:** Ongoing technological innovation will reduce the cost of renewable energy and enhance its competitiveness.
- **Financial Innovation:** Financial institutions may develop more financial products suitable for renewable energy projects to meet the required rates of return from different investors.
- **International Cooperation:** International cooperation will facilitate the transfer and sharing of renewable energy technologies, accelerating the pace of the global energy transition.

In this era of green transformation, the collaboration between Taiwan and Europe will bring more opportunities to both sides. Through the exchange of technology and financial cooperation, we believe the renewable energy industry will become a significant engine driving future development.

Disclaimer: The views reflected in this article are the views of the author and do not necessarily reflect the views of the global EY organization or its member firms.




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# The Development of Taiwan's Future Sustainable Green Tax Policies and the Industry's Response Strategies

**Lin Yi-Shian**, Partner, International Tax and Transactions Services, Transfer Pricing and Supply Chain Advisory, Ernst & Young

Green taxes policy is a government's fiscal engine of impacting corporate sustainability strategies in two perspectives: tax incentives and tax costs. Tax incentives are to encourage green investment behavior and innovation in green goods, production processes and technology. Tax costs are based on the polluter pays principle in which pollution costs are borne by the polluter and reflected in the prices of their goods and services. Polluters are penalized and thereby reducing their profitability. A carbon fee or carbon tax is a type of green tax cost. As governments worldwide commit to reducing emissions and environmental impacts, they are increasingly turning to fiscal policies to incentivize progress toward these goals. These taxes policies are designed not only to discourage environmentally harmful practices, but also to generate revenue that can be reinvested into sustainable initiatives and policy objectives.

As governments worldwide have successively pledged to achieve the goal of carbon emission net zero by 2025, how to formulate green tax policies to encourage industries to invest in energy-saving and carbon-reducing technologies and new energy exploitation has become the most important industrial development policy to achieve net zero goal. The target means not only punishing companies with high carbon emissions, but also encouraging companies to invest in energy-saving and carbon-reducing technologies and develop new energy sources. Should the carbon fee or carbon tax be levied based on the government's public carbon price? Or establish an appropriate carbon emissions trading platform to use market mechanisms to determine carbon prices? Even impose carbon tariffs on imported goods with high carbon emissions? These are important issues when designing the green tax policies.

Countries that charge carbon taxes include France, Ireland, Canada, Singapore, Japan, the five Nordic countries, etc. These countries also have carbon emissions trading systems that use market mechanisms to determine carbon prices. They belong to a dual-track system of carbon tax (penalty policy) and carbon credits (incentive policy). The government department responsible for implementing carbon taxes is usually the ministry of finance which collects taxes and distributes fiscal revenue in a nationwide unified manner, including taxation procedure, tax incentives and exemptions, and establishment of various infrastructure funds for energy conservation, carbon reduction and green power development.

Sustainable green tax policies in Taiwan are still developing. The "Climate Change Response Act" was enacted on 15 February 2023 in Taiwan. The most critical policy of the Act is to impose carbon fee on businesses with high carbon emissions. The carbon fee is implemented and levied by the Ministry of Environment. Carbon fees are collected from high-carbon-emitting companies and a climate fund is established to develop energy-saving and carbon-reducing facilities, green energy exploitation, and subsidize industries to transform into low-carbon emission processes.

In addition, the Taiwan Carbon Solution Exchange was established on 7 August 2023, which aims to provide carbon consulting services and a carbon trading platform. The Taiwan government has not completed the mandatory cap and trade regulation to generate carbon credits. However, according to the "Greenhouse Gas Voluntary Emissions Reduction Project Management Measures", companies can apply for carbon credits certification or publish carbon credits trading information on this platform. All carbon credits certified by relevant institutions can be traded on this exchange or offset carbon fee.

The Ministry of Environment convened a carbon fee review committee on 7 October 2024, and set the carbon price per ton at NTD 300, which will be gradually increased in stages in the future. Enterprises that meet the "Autonomous Reduction Plan" can apply preferential rates for Case A of NTD 50 or Case B of NTD 100. According to Article 3 of the "Regulations Governing the Collection of Carbon Fees": the emission sources subject to the carbon fee collection are "direct emissions from the entire site" (Scope 1) and "indirect emissions from using electricity" (Scope 2). The initial collection targets will cover the power industry, gas supply industry and manufacturing industry with annual emissions exceeding 25,000 metric tons of CO2 equivalent. Enterprises subject to the carbon fee will formally declare in May 2026 to pay the carbon fee for carbon emissions in 2025, but companies must accrue provisions for carbon emissions liabilities every month starting from 2025, so the profitability of their financial statements will begin to be affected from the beginning of 2025.

The Taiwan government's regulations on tax incentives are formulated in the "Statute for Industrial Innovation". The investment credit outlined in Article 10-1 will expire on 31 December 2024. In order to facilitate the industry to respond to the global net zero emission trend, promote investment in start-up businesses, and strengthen the company's key technologies, the Industrial Development Administration of the Ministry of Economic Affairs has announced a draft amendment to certain provisions of the Statute for Industrial Innovation on 5 October 2024. In order to comply with the global carbon reduction trend and year 2050 net zero emission goal, energy-saving and carbon-reduction items were included in Article 10-1 to promote active investment in green industries with tax incentives. The current upper limit of applicable investment expenditures has been increased from NTD 1 billion to NTD 1.8 billion, expecting more investment in energy-saving and carbon-reducing equipment to accelerate the dual-axis digital and net zero transformation. The implementation period will be extended to 31 December 2029. This draft amendment has not yet passed by the Congress (Legislative Yuan) at the end of 2024.

The landscape of sustainable green tax policies is both diverse and rapidly evolving, reflecting the unique environmental priorities and economic conditions of each jurisdiction. This diversity presents a significant challenge for businesses operating across multiple regions, as they must navigate a complex and ever-changing array of tax incentives, penalties, and reporting obligations. Therefore, the scope of the Taiwan government's formulation of green tax policies should not be limited to carbon pricing mechanisms, such as carbon fees, carbon taxes, carbon rights, and carbon emissions trading systems, or only provide investment tax credit for capital expenditure. It is necessary to design a wider range of "green tax measures" and "green tax incentives".

Green taxes measures refer to governments using green taxation as a source of fiscal revenue, and also as an instrumental policy. Taxes are imposed on a variety of products, services and processes to encourage or discourage consumption. Simultaneously, governments offer exemptions of such taxes for certain qualifying product, uses or taxpayers, as in the following examples:

- Energy – conventional electricity, fossil fuels and nature gas taxation
- Water source – consumption and discharge taxation
- Pollution – air, chemical, soil and wastewater taxation
- Plastic and packaging – extended producer's obligation of taxation
- Circular economy – provide landfill, recycling and returns of electronics waste with tax exemptions or refunds

Green tax incentives are important government programs to promote sustainable green industrial investment. In general, the programs can be divided into the following 3 categories. Many programs contain multiple elements and are a mix of the 3 categories, for example tax credits, cash grants and green loans, which are frequently used measures.

1. Reduction of energy consumption – invest in energy-efficient manufacturing equipment and green buildings
2. Usage of alternative or renewable resources – invest in sustainability R&D, electric vehicles (EVs) and charging infrastructure, carbon capture and storage
3. Encouragement of technology innovation – invest in new technology, emission reduction, and energy conservation

As the green tax policy landscape continues to expand and evolve, corporate tax functions closely collaborated with the stakeholders in other functions such as finance, legal counsel, procurement, supply chain and others to play a crucial role in ensuring that their companies not only comply with new regulations but also leverage those regulations to advance their sustainability goals and achieve net-zero emissions and other environmental targets.

Under the multiple pressures of domestic carbon fee and foreign carbon tariffs and various green tax systems, Taiwanese multinational companies are advised to establish the following 8 response strategies:

### 1. Information collection

The initial information collected includes carbon prices in various countries' markets, product carbon embedded emission, product weight, and customs information (country of origin, tariff classification, and custom valuation).

### 2. Internal and external stakeholder engagement

Stakeholders within the company's internal organization should cooperate, such as tax, finance, legal, procurement, customs affair and sustainability departments, and the scope of collaboration needs to cover diverse external suppliers and clients.

### 3. Organization and process transformation

Companies must re-establish departments and functions as well as related operating procedures, and each is responsible for collecting and exchanging information that should be implemented. All departments of a company should actively communicate with the environment protection authorities, tax authorities and import/export custom authorities.

### 4. Manufacturing costs and product pricing

Additional green tax costs must be considered when negotiating purchase and sales prices with vendors and clients. The costs of carbon fees and carbon tariffs will seriously affect the supply chain structure, business activities and investment decision.

### 5. Contract formulation incorporating compliance issues

In order to process declarations and payments of carbon fees and carbon tariffs, information provision and additional costs for data collection will face big challenges, and the terms of commercial contracts with suppliers and clients must be renegotiated.

### 6. Risk management

It is expected that extensive and huge carbon fees and carbon tariffs will cause traders in the supply chain to take risks to engage in under-reporting and evading carbon fees or carbon tariffs. Companies must improve the level of risk management and conduct due diligence on vendors and clients.

### 7. Adjustment of corporate operating models

The corporate operating models will be affected by additional issues that should be considered, such as EU CBAM, deforestation, export control and international transportation security, therefore the current business models must be modified to adapt to changing supply chains.

### 8. Accuracy of declaration information

Companies that are subject to carbon fees or carbon tariffs or various green taxes must correctly declare relevant information in compliance with regulations, and obtain correct emissions information from trusted suppliers to report declarations and pay carbon tariffs, such as: country of origin, tariff classification, carbon embedded emissions, value and weight of products, and carbon tax amount paid by the vendors in the other jurisdictions.

Facing the advent of the net zero carbon emissions era, if the above eight response strategies can be well planned and implemented, companies will be able to maintain competitiveness and develop sustainably amidst the rapid changes in global supply chain.

Disclaimer: The views reflected in this article are the views of the author and do not necessarily reflect the views of the global EY organization or its member firms.



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# Who's Fit for 55?

# How EU Policies Drive Renewable Energy Development

European Economic and Trade Office

As the world faces unprecedented warming, with devastating consequences for biodiversity, human health, and economic activity, the European Union has made the green transition one of its core priorities, aiming to achieve climate neutrality before any other continent. To ensure it emits less greenhouse gases (GHG) than it is able to absorb by 2050, a number of policy measures have been deployed under the umbrella of the European Green Deal, approved in 2020. It is through these policies that the EU has stood out as one of the indisputable leaders in the global green transition.

In an effort to further strengthen the EU's environmental commitments, the European Parliament and Council passed the "Fit for 55" legislative package (55 refers to the EU's target of reducing net greenhouse gas emissions by at least 55% by 2030) in 2023. This package not only enshrines higher emission reductions into law, but does so specifying axes of action: reforming the EU emissions trading system (ETS), targeting the transport and construction sectors to reduce emissions, improving land use and forestry sector goals, addressing emissions outside the EU through the Carbon Border Adjustment Mechanism (CBAM), helping those most vulnerable to the transition through a social climate fund, increasing the uptake of greener fuels in aviation and maritime transport, regulating methane emissions reduction, toughening $CO_2$ emissions standards for private vehicles, revising energy taxation, improving overall energy efficiency, and providing sector-specific targets for renewable energy use.

"Fit for 55" is expected to boost the deployment and development of renewable energy in Europe and beyond. The lines below attempt to give a picture of how this might take place across the main elements of the package.

## 1. ETS

The EU emissions trading system (ETS), introduced in 2005, is a cap-and-trade-based carbon market as well as the bloc's main tool in reducing emissions. By setting a limit on the total amount of GHGs that can be emitted by all participants in the economy and by annually decreasing the cap, the EU can control and mitigate its contributions to climate change. Companies receive or buy emission allowances, which they can trade freely. Prices are stabilised through a Market Stability Reserve, which deals with issues of oversupply or over demand by introducing or retrieving allowances from the market as needed. "Fit for 55" not only further decreases the cap for years ahead—directly reducing emissions, but also phases out free allowances to some agents and extends the ETS to emissions from other sectors, such as maritime, road, and air transport. A strengthening of ETS renders emitting carbon more costly, lowering the relative price of renewables, and thus incentivising their adoption.

## 2. SCF

Although the EU's Social Climate Fund (SCF) is primarily aimed at addressing the social impacts of the green transition for the most vulnerable households, micro-enterprises, and transport users, it indirectly contributes to the development and deployment of renewable energy by lowering the barriers to their integration into daily life. Indeed, member states are encouraged to use the funds to invest in energy efficiency and building renovation projects for those most affected, which directly translates into the adoption of clean heating and cooling and of low-emission mobility solutions, most often powered by renewable energy.

## 3. CBAM

The carbon border adjustment mechanism (CBAM) aims to ensure that the emissions reduction efforts of the EU are not offset by increasing emissions outside its borders, either through the relocation of production to non-EU countries (where policies applied to fight climate change are less ambitious than those of the EU) or through increased imports of carbon-intensive products. CBAM is an effective way to get producers to invest in the transition to renewables instead of relocating, as well as to encourage foreign exporters to the EU to adopt low-carbon forms of production. Perhaps most importantly, CBAM can lead non-EU countries to adopt policies geared towards renewables to help their industries avoid CBAM charges.

## 4. LULUCF

The land use, land-use change and forestry (LULUCF) regulation sets a binding commitment for the EU to reduce emissions and increase removals in the land use and forestry sectors. This commitment is strengthened and enlarged with the "Fit for 55" package. While renewable energy sources are deployed to reduce emissions, LULUCF focuses on increasing carbon sequestration in natural ecosystems. By encouraging sustainable forestry practices, however, LULUCF also has the potential to enhance the production of biomass, a sustainable energy source, without depleting carbon stocks. LULUCF also guarantees areas with high carbon sequestration potential are protected, thus promoting the deployment of renewables in land where the environmental impact is lower.

## 5. Cars and vans

Road vehicles account for 71% of the EU's transport-related emissions. New regulation introduces progressive EU-wide emissions reduction targets for cars and vans for 2030 and beyond, including a 100% reduction target for new cars and vans by 2035. When combined with the requirement to install recharging stations every 60 kilometres on Europe's main roads, this piece of legislation is guaranteed to drive demand for renewable-energy-powered vehicles.

## 6. Methane

19% of methane emissions (which in mass are second only to carbon) come from the energy sector, specifically from the burning of fossil fuels. As of May 2024 new EU rules in the context of "Fit for 55" require the measuring and reporting of methane emissions in the energy sector, their verification by independent parties, as well as their immediate reduction through mandatory leak detection and mitigation. These policies directly increase the costs of running fossil-fuel-powered plants, both in the present and in the future, thus incentivising the switch to renewables.

## 7. ReFuelEU

Aviation and maritime transport account for 14.4% and 13.5% of EU transport emissions respectively. ReFuelEU regulation will oblige aircraft fuel suppliers at EU airports to gradually increase the share of sustainable fuels that they distribute (to 6% by 2030 all the way to a minimum of 70% by 2050). It will also require EU airports to guarantee the necessary infrastructure to deliver, store, and refuel with sustainable fuels. Moreover, it mandates that vessels above 5,000 gross tonnes calling at European ports reduce the GHG intensity of the energy used on boards by 2% next year, by 31% before 2040, and by 80% before 2050. ReFuelEU regulation will also guarantee ships' connection to onshore power supply while moored at the quayside. On top of providing more eco-responsible transport for EU citizens, these measures will increase innovation and investment as well as production and uptake of sustainable fuels, which include renewable fuels.

## 8. ETD

"Fit for 55" prompted an ongoing revision of the energy taxation directive (ETD), which aims to ensure that the taxation of different energy products reflects their impact on the environment, encouraging businesses to switch to renewable sources.

## 9. Greener buildings

Buildings account for 36% of the bloc's energy-related GHG emissions. In order to increase their sustainability, the EU mandates that both residential and non-residential buildings reduce their primary energy use by at least 20% before 2035. New legislation also requires that solar energy be installed in all buildings when suitable and feasible, and that charging points be added across the built environment. This entails a major boost to renewable energy, most notably solar.

## Opportunities for EU-Taiwan Collaboration

The European Union's "Fit for 55" not only facilitates the deployment and development of renewable energy indirectly through all the avenues described in the previous pages, but also directly mandates that the amount of renewables in the EU's energy mix be increased to 42.5% of the total by 2030. This is to be achieved by fast tracking the permitting process of renewable energy projects, which will henceforth be considered of "overriding public interest" by the EU, whether they be in biofuels, heat pumps, solar, hydro, wind, tidal, or geothermal power. Indeed, the bloc sees the transition to cleaner forms of energy as a prerequisite for climate neutrality, which is indispensable to mitigating the potentially catastrophic consequences of global warming.

Taiwan is an indispensable partner in this effort. Just like the EU, it acknowledges the need for urgent action and is actively implementing policy to make its climate pledges a reality. At a time when the European Union represents the largest share of foreign direct investment in Taiwan, and a time when most of said investment is flowing into the offshore wind sector, the potential for further collaboration on renewable energy between these two like-minded partners could not be higher. By seizing the opportunity and strengthening joint efforts on the adoption of renewable energy and on emissions reduction at large, Taiwan and the EU stand to improve not only their close relationship but the entirety of our fast-warming planet.









## Author

**Lutz Güllner**

**Head of the European Economic and Trade Office**

Lutz Güllner was appointed Head of the European Economic and Trade Office in Taiwan as of 1 September 2024. He is a senior career diplomat in the European External Action Service (EEAS), the EU's diplomatic service. He specialises in economic and trade relations, as well as security issues.

Prior to his current posting, Mr Güllner served as the Head of Division for Information Integrity and Countering Foreign Information Manipulation and Interference at the EEAS, where he was lead on issues related to disinformation and foreign information manipulation and interference (FIMI).

From 2003 to 2017, he served in different functions in the European Commission's Directorate General for Trade, where he worked on bilateral relations with the United States and Russia, communications, as well as trade strategy and planning.

In 2009 and 2010, Mr Güllner was spokesperson for the High Representative of the European Union for Foreign Affairs and Security Policy, Catherine Ashton.

Before joining the European Commission in 2003, he worked as public affairs consultant in Brussels.

Mr Güllner studied political science and international relations at the Free University of Berlin and the Institut d'Etudes Politiques (Sciences Po) in Paris. He teaches EU foreign affairs at several universities, including the College of Europe in Bruges and Tokyo University.

He was born in Munich/Germany in 1971 and is married with three children.



## Setting the Standard for Offshore Wind in Taiwan

## Assuring Future Renewable Energy Systems Through Certification

**Offshore wind is a critical component of Taiwan's energy transition. But challenges, both unique to the region and within the wider sector, are emphasizing the need for third-party verification.**

**Mark Richmond**, Taiwan Area Manager, DNV

Certification is a crucial milestone in the development of any new technology or industry, and renewable energy is no exception. As the low-carbon energy sector rapidly expands, the need for independent verification becomes even more important. Certification ensures that equipment, whether operating independently or as part of a larger system, complies with established requirements, enhancing safety and reinforcing confidence across the entire supply chain. In an industry where reliability, safety, and performance are paramount, independent certification provides a strong foundation for building trust and credibility.

DNV, as a leading authority in risk management and assurance, plays a pivotal role in shaping global industry standards and benchmarks. By setting these recognized standards, DNV helps safeguard life, property, and the environment – our reason for being - while ensuring that renewable energy systems perform efficiently and safely. Whether it's onshore turbines, solar panels, or offshore wind structures, DNV's certification process rigorously evaluates each component and system, ensuring that they meet the required technical and safety criteria. This not only protects stakeholders but also supports the long-term sustainability of the renewable energy sector.

In Taiwan, our departments include Business Assurance, Renewables Advisory, Renewables Certification, Maritime and Oil & Gas. By working together, these divisions, through independent certification, help in the creation of robust energy systems, with those focused on renewables ensuring that offshore wind developments meet the high standards that are expected.

Taiwan has an overarching aim of delivering net zero by 2050, and independent project certification will go a long way in allowing initiatives to move forward while encouraging local developers to scale the application of their technologies.

By involving a third-party certification body like DNV, Taiwanese companies can add an extra layer of trust in their ability to operate in line with customer expectations and industry requirements. Our wind farm project certification, outlined in DNV-SE-0190[1], covers all the critical phases of a wind plant project, from development through construction to operation.

## At the Forefront of Emerging Industries

DNV is at the cutting edge of establishing industry-defining projects and technologies, having assisted customers with the evolution of technology from the very beginning. Most notably, we write and define new standards rather than just following them, having published more than 40 service documents (including service specifications, standards and recommended practices) which cover offshore wind, onshore wind, wave & tidal and solar.

Offshore wind's enormous energy potential, combined with the requirements for new, low carbon energy sources, sets the scene for a rapid development of the renewables industry in Taiwan, and across Asia Pacific more widely. This growth requires extended risk management through certification. In an era where sustainability and ethical business practices are becoming increasingly important to consumers and investors, certification can enhance reputation, making it a valuable asset in competitive markets.

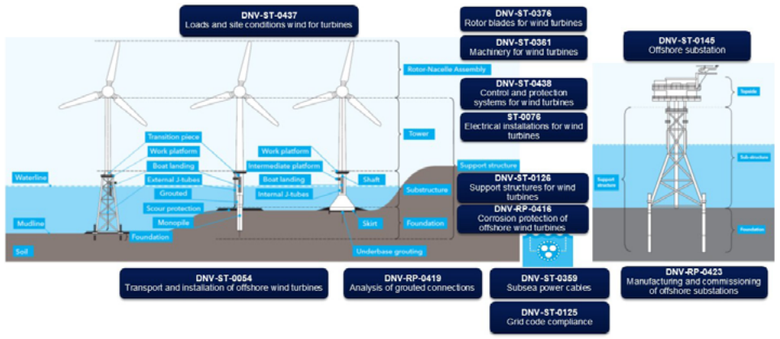
Often, companies initially view certification as a necessary administrative step to gain access to certain markets or contracts, but the certification process offers much more than just a compliance check.

Through rigorous evaluation, companies gain a deeper understanding of their own operations, systems, and processes. Certification acts as a mirror, revealing areas where improvements can be made, inefficiencies can be reduced, and risks can be mitigated.



In Taiwan, one of the most prevalent areas where DNV supports the development of offshore wind farms is with project certification. This comprises a range of specific technical reviews and verifications, including:

- Site-specific environmental conditions verification
- Design basis certification
- Design verification of integrated structural systems
- Manufacturing surveillance of support structures, substations, power cables and wind turbines
- Transport and installation surveillance
- Commissioning witnessing




DNV's standards and recommended practices for bottom fixed power plants

Ultimately, certification is not just about meeting industry standards; it's about building a culture of excellence, accountability, and trust. It's a proactive step that reflects an organization's commitment to quality, safety, and sustainability. For renewable energy companies looking to lead the way in a fast-evolving market, certification is a vital tool that helps them prove their capability, gain stakeholder confidence, and pave the way for future growth.

## The Road to Certification

As an independent third-party certification body, DNV's services help customers to demonstrate risk awareness for the materials involved in offshore wind projects, including wind turbines, support structures, substations, power cables and control stations, ensuring every piece of equipment reflects international standards.

Having this certification in place not only showcases an awareness of relevant risks but highlights the willingness of developers to address the challenges impacting their projects, helping to lead the way in the development of future energy systems.

The goal of renewable energy developers is clear: they want to ensure their projects can consistently produce sustainable power, which requires reliable quality, stable operation and proper risk management, and DNV's project certification teams offer the very means to help achieve this.

## Taiwan – A Growing Market for Offshore Wind

In 2020, DNV inked an agreement to enter the Taiwan Offshore Wind Project Certification Alliance (TOWPCA), initiated by the Taiwanese government to promote the localization of its offshore wind sector.

Together with the Bureau of Standards, Metrology and Inspection (BSMI), the administrative agency of the Ministry of Economic Affairs (MOEA), DNV launched TOWPCA, alongside a variety of other partners, including the Metal Industries Research and Development Centre (MIRDC), CR Classification Society, Ship and Ocean Industries R&D Center (SOIC) and the Taiwan Electric Research and Testing Center (TERTEC).

And in 2023 it was announced that DNV would provide quality assurance and quality control, as well as related technical support to turbine jacket fabricator Intercontinental Wind Energy (IWE), for offshore wind projects in the region. DNV's work scope is a key steppingstone in IWE securing Tier-1 supplier status for offshore wind in Taiwan and the contract builds on similar work designed to accelerate the uptake of offshore wind off the coast of the island.

In several countries, certification is not just a recommended practice, but a legal necessity. Taiwan is one such place after certification for renewables projects was mandated by the BSMI.

According to DNV's 2023 Energy Transition Outlook[2], installed wind capacity across the globe is expected to soar from 950 GW in 2022, to 6,500 GW by mid-century. This is underpinned by local government's respective targets to increase installed capacity in their jurisdictions – in Taiwan the goal is to install approximately 5.6 GW of wind-powered generating capacity by 2025, and 20.6 GW by 2035.

But if offshore wind is to scale around the world, we must ensure that the technology is designed, constructed, installed and operated as effectively and safely as feasibly possible.

DNV is intrinsically linked to offshore wind in Taiwan, having been involved in the certification of almost all of its offshore wind farms, and we are actively working with local developers to achieve local targets.

As its burgeoning renewables market expands, Taiwan faces challenges that are different to those faced by European nations. Extreme weather events, transport issues, and local content requirements are all major considerations when it comes to designing and installing projects – DNV is uniquely positioned to help companies to overcome these challenges.

## The Winds of Change

In recent years the offshore wind power sector has faced significant challenges. Cost inflation has had a significant knock-on effect on the levelized cost of energy (LCOE), though we expect cost reductions to return to historic learning curve rates by 2028.

Meanwhile supply-chain disruptions, concerns about turbine and rotor quality, and shrinking profit margins for original equipment manufacturers (OEMs) all combined to cause what many described as a perfect storm. Two recent examples of this coming to a head are the failures of wind power auctions in the North Sea in the United Kingdom (Reed, 2023) and in the Gulf of Mexico in the United States (Noor, 2023).

Our long-term projections remain optimistic for wind power though, fueled largely by regional commitments to decarbonize and increase the attractiveness of fostering emerging wind technology industries.

Onshore wind currently dominates the global market, but, by 2050, the landscape is expected to shift: while onshore wind will still lead with 70%, fixed offshore will rise to cover 25%, and floating wind turbines in deeper waters, a major growth opportunity for Taiwan, will contribute 5% to the total wind electricity.

Several factors are fueling this rapid expansion, with the primary driver being the growing global demand for electricity. Additionally, the economic viability of wind energy is becoming more apparent in many regions. While the initial costs can be high, the long-term financial benefits, coupled with the urgent need to lower carbon emissions, make wind energy an increasingly appealing solution.

Furthermore, regions like Europe and Asia Pacific are strengthening wind energy plans as a strategic move towards bolstering their energy security. By investing in domestic energy production through wind, these regions are reducing their reliance on imported energy sources. In terms of regional contributions to on-grid wind electricity, Europe is anticipated to lead the pack with 43%, boasting an equal split between onshore and fixed offshore sources. Trailing close behind are Asia Pacific at 37% and North America at 35%.

As of last year, Taiwan had over 2 GW of offshore wind capacity hooked into the grid, almost 700 MW of which was commissioned in 2023 alone, according to research by the Global Wind Energy Council, all of which will be key to hitting the nation's various renewables targets, which include reaching net zero emissions by 2050 and adding 15 GW of offshore wind installed capacity between 2026 and 2035.

## Weathering the Storm

Taiwan is a new market with environmental, supply chain, and other present risks that are markedly different from other parts of the world. While Taiwan's day-to-day conditions are generally more benign than those found in the North Sea, the region occasionally faces severe weather events, particularly the emergence of typhoons, which pose a significant threat to offshore infrastructure.

Typhoons in Taiwan bring extreme winds and waves, amplifying the risks during installation and operation phases of projects. Furthermore, Taiwan's geological conditions add another layer of complexity. The soil is often loose, making it susceptible to scouring, which can lead to instability of offshore structures, and there is a high risk of pile runs during foundation installation.

These challenges are compounded by Taiwan's seismic activity - regular earthquakes add to the risk profile, as evidenced by the 7.2 magnitude earthquake on April 3, 2024, which caused loss of life and widespread disruption across the country.

Taiwan's government also has the difficult task of deciding the appropriate levels of relaxation for its localization policies. Projects are challenged by local content requirements which can, in some cases, create project timeline risks – impacting installation vessel availability for the projects. But at the same time, there is still a clear desire to support local industry and avoid making projects in the early stages seem undesirable when compared to projects at further stages of development.

In addition to this, a limited supply of those vessels that can install large turbines and components adds to the difficulties of meeting tight project schedules. The availability of these specialized ships is even further constrained by the narrow weather windows for offshore work, as frequent storms can disrupt operations and delay project progress.

These complexities underline the critical importance of robust project certification and of independent verification partners, like DNV, that can provide support and guidance throughout the lifecycle of a project.

Following an extensive industry collaboration project, DNV published a new Technical Note (TN), providing principles for determining site extreme wind speeds for wind farms caused by tropical cyclones, and last year a new joint industry project (JIP) was formed to increase certainty in the design process for wind farms challenged by earthquakes.

Similarly, a new model developed by DNV has helped to significantly improve the predictability around how wind turbines behave during extreme weather, reducing uncertainty and risk for modern flexible turbines.

Navigating these uncertainties is never easy alone - especially when it's new territory for most - and certification bodies are on hand to help light the way.

## Guiding Hands

Since 2020, DNV has played a pivotal role in supporting the development of the 1.2 GW Hai Long Offshore Wind Project, a large-scale endeavor located in the Taiwan Strait. DNV's team of experts have been actively involved at various critical stages of the project, starting from the initial design basis phase and continuing through the manufacturing process. Currently, DNV's specialists are significantly contributing to the complex phase of offshore transport and installation, where precise planning and execution are essential to ensure the project's success.

Throughout the project, DNV's involvement in verifying numerous aspects has proven instrumental in overcoming a series of technical, logistical, and regulatory hurdles that threatened to slow down or stall progress. By providing rigorous, independent verification, DNV helped ensure that the project met all necessary safety, performance, and regulatory standards. This meticulous attention to detail was crucial in enabling the developers to reach financial close, a key milestone in securing funding and moving forward with construction. The financial close of the Hai Long project marked a major achievement, giving investors the confidence that the wind farm would be delivered on time, within budget, and in accordance with the highest industry standards.

In addition to its work on the Hai Long project, DNV is also currently deeply involved in supporting Synera Renewable Energy's (SRE) Formosa 4 project, located off the coast of Miaoli in Taiwan.

DNV's role in the under-development Formosa 4 project began during the design basis and design review stages, where the company's expertise was leveraged to ensure the project's foundation was solid and compliant with both local and international standards. DNV's thorough review of the design helped SRE address any potential risks or engineering challenges early in the development process, setting the project up for long-term success.

As the Formosa 4 project moves forward, DNV is continuing to offer its expertise and support across the various stages of development, ensuring that every aspect of the wind farm is optimized for performance, safety, and efficiency. Given that the turbines for this wind farm will be positioned in relatively deep waters, this presents additional engineering challenges that require careful consideration. DNV is actively working with SRE to manage these challenges, focusing on areas such as foundation design, turbine suitability, and cable laying in complex seabed conditions. DNV's global experience with deep-water projects equips it with the specialized knowledge needed to help SRE navigate these complexities and ensure that the Formosa 4 project is completed successfully.





DNV AS

## Shop Approval

Moreover, DNV is working with Taiwan-based suppliers to improve the quality of outputs through its DNV-SE-0436[3] 'Shop approval in renewable energy' standard, ultimately supporting the government's targets for localization and supply chain development.

First introduced in 2018, the internationally recognized certification can significantly boost the visibility and competitiveness of local manufacturers, in addition to enhancing confidence in the functionality of outputs.

The main value of the service is to provide a prequalification statement to suppliers which can be used with stakeholders to demonstrate the capabilities needed to produce respective components for wind turbine support structures and power plants.

This service of shop approval certifies that a workshop operates with approved production facilities, working procedures, quality management system, methods and qualified staff. DNV assesses and verifies the customer's capability to manufacture wind turbine components in compliance with national and international standards and guidelines or acknowledged methods.

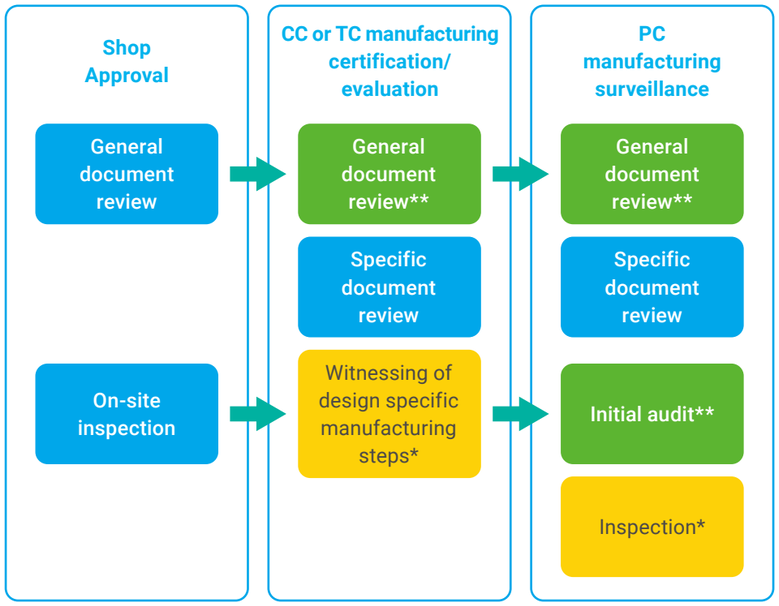
DNV's Shop Approval certification is an international guarantee that can significantly enhance the visibility and competitiveness of local manufacturers in the global market, while also boosting developers' confidence in the quality of local manufacturers.

It can also substantially reduce the number and scope of audits required for local manufacturers to participate in future offshore wind farm projects, shifting from comprehensive inspections to assessments focused solely on specific project requirements.



DNV AS

Working with Taiwan's local suppliers, DNV conducts on-site inspections and document reviews to identify their position within the offshore foundation supply chain, providing professional advisory reports on areas that require improvement, which in turn yield tailored recommendations.




Benefits of DNV shop approval for suppliers
* Reduced scope and/or visits in case of DNV Shop Approval
** Not Required in case of existing DNV Shop Approval

For experienced suppliers, improvement suggestions will be made according to the procedures outlined in DNV-SE-0436. DNV will help in gaining renewable energy manufacturing certification, enhancing their competitiveness in the global offshore foundation supply chain. Based on the suppliers' past audit records, DNV will focus on reviewing and providing guidance on common quality and manufacturing issues.

For those that are less experienced, DNV will provide guidance on building foundational capabilities necessary for entering the foundation supply chain. Suggestions will be made based on DNV-SE-0436, focusing on essential improvements in manufacturing processes, quality control, and compliance with international standards. This will help inexperienced suppliers gradually meet the requirements for offshore wind projects and strengthen their competitiveness in the market.

In 2024, DNV issued shop approval certificates to four local Taiwanese workshops, marking the first issuance of such approvals in Taiwan for the manufacturing of steel structures for support structures of offshore wind turbines. This certification, following a thorough review of quality management systems and documentation, combined with comprehensive workshop inspections conducted in accordance with DNV-SE-0436: 2022-09, confirms that these workshops meet the stringent requirements outlined in applicable DNV standards, certification scheme specifications, work instructions, regulations, and quality management systems.

## The Future is Floating

With Taiwan's fixed-bottom offshore wind industry growing, it is expected that steps into developing the country's nascent floating offshore wind market will be made over time.

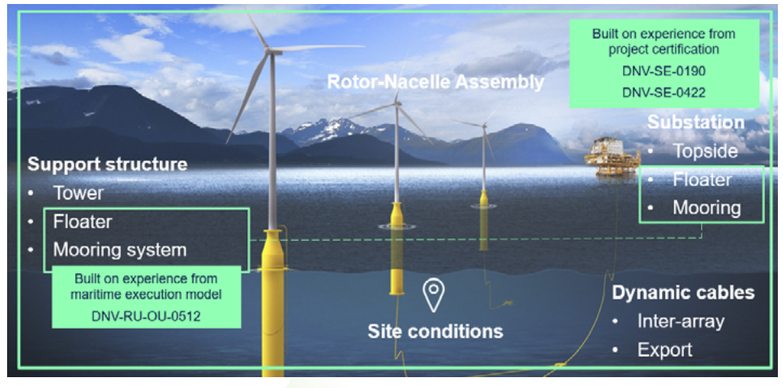
Following the first successful prototypes and demonstration projects for this type of technology, the global floating offshore wind industry is advancing closer to commercialization. DNV's analysts have projected that the total floating offshore wind capacity could scale to as much as 270 GW by 2050.

But with many countries now venturing into this relatively newer market, challenges unique to floating infrastructure are arising. Developers looking to successfully create floating offshore wind farms need assurance that all possible steps have been taken to minimize any risks and maximize the chances of the projects reaching financial close and advancing towards operation.

DNV has been involved with the floating wind industry since its very inception and has gone on to develop global experience in this space, making it ideally positioned to support Taiwan in gaining traction in the market. DNV's expertise in floating offshore wind includes the development of technical requirements, even having issued the world's first standard for floating offshore wind.

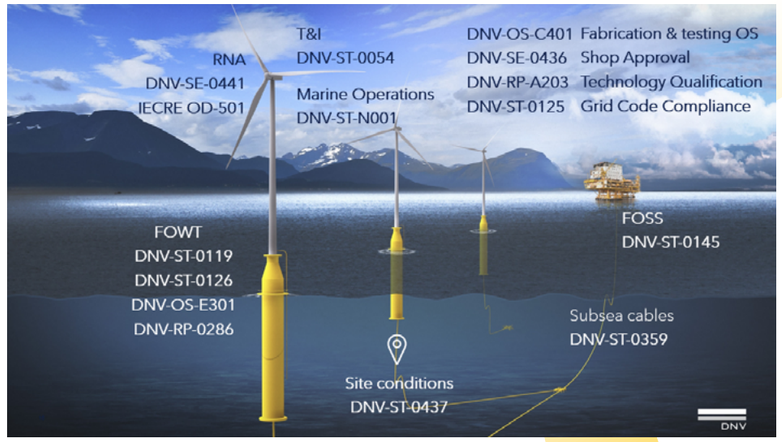
The experience gained in more than a decade is used to continuously update technical and procedural requirements for floating power plants. DNV Renewables Certification has completed around 50 floating offshore wind projects globally and is currently working on projects at various stages of development, including early concept, demonstrators and commercial scale project certification.

DNV offers a comprehensive suite of services for floating offshore wind projects, provided in accordance with DNV-SE-0422[4], which covers certification throughout the entire lifecycle. These services include concept design, basic design, project certification, in-service certification, as well as prototype and type certification for floating wind turbines, floating wind farms, and related components (e.g., hull, mooring lines and ballast systems).




DNV's floating assurance services from blade to shore covering the entire life cycle

DNV's document addresses industry needs of a comprehensive and updated scheme that covers full assurance of a floating wind turbine considering interfaces with IECRE certification schemes and DNV classification services. These documents provide the most wide-ranging technical reference suite for floating offshore wind, and can be applied to complete wind farms, individual turbines and their components.




DNV's standards and recommended practices for floating offshore wind farms

As DNV's involvement provides a tangible, widely recognized means of assurance, along with DNV's support and guidance, Taiwan can maximize the potential of its early steps into this area of renewable energy and cement its position as a leader and innovator in the globe's transition to sustainability.

## The Path Ahead

Taiwan's offshore wind sector is poised for significant growth in the coming years, with a range of new projects expected to complement those already operational or in development. To achieve the policy goal of having 40% of Taiwan's exported products powered by green energy by 2030, it is essential to strengthen the green energy supply available. In this context, as indicated by the MOEA, ensuring that offshore wind farms are connected to the grid on schedule becomes even more critical.

The country is already positioned as a key player in the global renewable energy market, and as it aims to meet its ambitious energy targets, the importance of rigorous certification processes cannot be overstated.

With its vast and global experience in offshore wind project certification, DNV is uniquely placed to support Taiwan's developers to ensure their wind farms are as safe and efficient as possible.

In addition to this, DNV's Shop Approval will be a critical tool in the country's renewables journey, offering a robust framework for elevating the standards of Taiwanese manufacturers and ensuring their readiness to compete on the global stage.

Additionally, our on-site inspections and thorough document reviews enable a detailed understanding of where each manufacturer stands within the offshore foundation supply chain. This comprehensive assessment allows DNV to provide tailored advisory reports, identifying areas that require improvement and offering concrete recommendations to enhance their capabilities.

By shifting the focus of assessments from broad, comprehensive inspections to more targeted reviews based on the specific needs of local projects, DNV enables greater efficiency and reduces potential bottlenecks in the supply chain. This, in turn, supports the overall development of Taiwan's offshore wind industry by enhancing the readiness and capacity of its domestic suppliers to meet global standards.

Specific regions have their own unique challenges, and Taiwan is no different. With issues such as extreme weather events, typhoons and seismic activity adding layers of complexity to offshore wind projects, DNV's rigorous project certification processes ensure that both equipment and infrastructure are designed, constructed, and operated with the highest levels of safety and performance. This focus on reliability is key to minimizing risks and maintaining the integrity of projects throughout their lifecycle.

DNV's broader role in offshore wind, not only in certification and assuring the validity of projects, but acting to boost the domestic supply chain, serves as a guiding force for Taiwan's transition to a sustainable energy future. As an organization, we are committed to supporting countries to reach net zero using our deep expertise in risk management, quality assurance, and technical support.

As Taiwan sets its sights on achieving 40-55 GW of installed wind capacity by 2050, the collaboration between local suppliers and international experts like DNV will be critical in overcoming the challenges that lie ahead. Through its dedication to quality, safety, and continuous improvement, DNV is helping to build a resilient supply chain that can withstand the complexities of offshore wind projects, both fixed and floating, in Taiwan's unique environment.

By providing project certification and ongoing support, DNV is ensuring that Taiwanese manufacturers are well-equipped to meet the high demands of the global offshore wind industry, ultimately paving the way for a sustainable and prosperous energy future.

[1] https://www.dnv.com/energy/standards-guidelines/dnv-se-0190-project-certification-of-wind-power-plants/
[2] https://www.dnv.com/energy-transition-outlook/
[3] https://www.dnv.com/energy/standards-guidelines/dnv-se-0436-shop-approval-in-renewable-energy/
[4] https://www.dnv.com/energy/standards-guidelines/dnv-se-0422-certification-of-floating-wind-turbines/




## Author

### Mark Richmond

**Taiwan Area Manager**
**DNV**


Mark is the Taiwan Area Manager for DNV, playing an integral role in DNV's renewable certification team based in Taipei, Taiwan. Mark has been involved with the project management for several offshore wind projects during his time at DNV, including two large offshore wind farms in Taiwan. Mark also has vast experience in metocean and loads, reviewing most of Taiwan's metocean conditions and conducting Independent Load Assessments for DNV's projects in the region.

## Education

University of Strathclyde/Cranfield University - EngD, Renewable Energy Marine Structures CDT

Swansea University - MSc, Mechanical Engineering, and Bachelor of Engineering (B.Eng.), Aerospace, Aeronautical and Astronautical Engineering

## About DNV

DNV is the independent expert in risk management and assurance, operating in more than 100 countries. Through its broad experience and deep expertise DNV advances safety and sustainable performance, sets industry benchmarks, and inspires and invents solutions.

Whether assessing a new ship design, optimizing the performance of a wind farm, analyzing sensor data from a gas pipeline, or certifying a food company's supply chain, DNV enables its customers and their stakeholders to make critical decisions with confidence.

Driven by its purpose, to safeguard life, property, and the environment, DNV helps tackle the challenges and global transformations facing its customers and the world today and is a trusted voice for many of the world's most successful and forward-thinking companies.

Hitachi Energy



## Hitachi Energy's Solar Innovations: Driving Taiwan's Path to a Sustainable Energy Future

Taiwan, an island nation with a high population density and limited natural resources, faces significant challenges in meeting its energy needs. To reduce carbon emissions and transition away from nuclear power, Taiwan has prioritized expanding its renewable energy capacity, particularly in solar energy. The government's aggressive goal of increasing solar power capacity from 5.8 GW in 2020 to 20 GW by 2025 underscores Taiwan's commitment to this transition. Solar power is expected to account for a significant portion of the island's total energy output, positioning Taiwan as a global leader in sustainable energy practices. This shift aligns with the global trend toward net zero emissions, with Taiwan aiming for energy autonomy through renewable sources.

Hitachi Energy, a global leader in energy solutions, plays a crucial role in Taiwan's renewable energy transformation. Through its innovations and expertise in grid integration and energy infrastructure, Hitachi Energy is a key contributor to helping Taiwan achieve its solar ambitions while addressing the unique challenges posed by limited land availability and extreme weather conditions. The company's Grid-eXpand™ Connect system has emerged as an essential solution for efficiently distributing energy from solar plants to the grid, offering scalable, modular designs that meet the demands of Taiwan's rapidly growing solar market.

## The Role of Grid-eXpand™ in Solar Integration

One of the core innovations introduced by Hitachi Energy is its Grid-eXpand™ solution, which focuses on modular substations that enable reliable power evacuation and delivery from renewable energy sources. This system's flexibility allows for the integration of a wide range of solar energy projects, from rooftop installations to large-scale solar farms, while minimizing the need for extensive civil engineering works.

Traditional substations require significant on-site construction, which often leads to delays and increased costs. Hitachi Energy's Grid-eXpand™ system, by contrast, offers pre-engineered, modular, and prefabricated substations, significantly reducing both installation time and civil costs by up to 50%. The standardized, modular design ensures quicker deployment, allowing solar projects to come online faster than conventional setups. Moreover, the 170 kV gas-insulated switchgear (GIS) incorporated into the system reduces the substation footprint by 25%, making it an ideal solution for space-constrained environments like Taiwan's fish farms and rooftop solar installations .



Hitachi Energy

## Grid-eXpand™ Connect: A Key Enabler of Taiwan's Solar Future

The Grid-eXpand™ Connect solution is a modular system specifically designed to simplify the connection between solar panels and the existing power grid. It provides a comprehensive approach to managing renewable energy flows, ensuring that solar-generated power is transmitted efficiently to the grid. This technology has proven to be especially valuable in Taiwan, where land availability for energy infrastructure is limited, and fast deployment is essential.

One of the most significant benefits of the Grid-eXpand™ Connect system is its ability to streamline the entire solar project lifecycle, from design to commissioning. The system's modularization and pre-fabrication allow for rapid deployment and fast-track construction, enabling renewable energy projects to scale efficiently. Additionally, asset base harmonization—a key feature of the Grid-eXpand™ Connect system—allows for the re-deployment of assets, making it a versatile solution for a wide range of solar installations.

Another crucial aspect of Grid-eXpand™ Connect is its adaptability. It supports a wide range of power densities and offers full protection even in extreme environments, making it ideal for the diverse geographical and environmental challenges present in Taiwan. The Grid-eXpand™ Connect system is designed to accommodate various solar energy collection and transmission configurations, offering flexible solutions that meet the needs of Taiwan's expanding solar industry .

## Case Study: Sunny Rich Group and the Synergy Between Solar and Aquaculture

The Sunny Rich Group, a leading player in Taiwan's aquaculture industry, partnered with Hitachi Energy to integrate photovoltaic (PV) energy generation into its fish farming operations. Traditionally, fish farms in Taiwan, especially shrimp farms, have relied heavily on imported seafood, but there has been a growing demand for locally produced seafood. Small, family-run farms have been striving to meet this demand, but they face significant challenges, such as high energy costs and limited land resources for expansion.

To address these challenges, Sunny Rich Group adopted an innovative approach by incorporating photovoltaic power generation into its fish farming operations. By leveraging Hitachi Energy's Grid-eXpand™ Connect system, the company was able to install greenhouse-like structures that not only protect the shrimp farms from extreme weather conditions but also support solar panels. This dual-purpose structure allows Sunny Rich to generate solar energy while continuing its aquaculture operations. The energy produced can be used to power the fish farm's operations, reducing energy costs, while excess energy can be sold back to Taiwan Power Company, providing an additional revenue stream.

The success of this project has led to the scaling of the configuration, with Sunny Rich now serving as a model for other fish farms in Taiwan. The integration of Grid-eXpand™ technology has enabled Sunny Rich to operate more sustainably, contributing to Taiwan's renewable energy goals while supporting local food production. This synergy between solar energy and aquaculture demonstrates the versatility and adaptability of Hitachi Energy's solutions.





## Digital Transformation and Smart Grids

In addition to its physical solutions, Hitachi Energy is a leader in digital grid technologies. As Taiwan's solar capacity increases, the need for smart grids becomes essential. Smart grids utilize data to optimize energy distribution, ensuring that solar energy is efficiently transmitted from generation sites to areas with the highest demand. Hitachi Energy's Digital Substation Automation Systems (SAS) enable real-time monitoring and management of grid performance, enhancing the reliability of solar energy distribution and minimizing downtime.

This digital transformation also extends to predictive maintenance, where solar infrastructure is continuously monitored to prevent failures before they occur. Predictive maintenance reduces long-term operational costs, making renewable energy more competitive with traditional power sources. Through its innovative use of digital technology, Hitachi Energy is helping Taiwan build a smarter, more resilient energy grid.

## Global Impacts and Future Directions

Hitachi Energy's involvement in Taiwan's solar market is part of a broader global strategy to support the energy transition in countries around the world. As more nations adopt aggressive carbon reduction targets, the demand for scalable, efficient solar solutions will continue to grow. Hitachi Energy is well-positioned to lead this charge, with its innovations in containerized substations and smart grid technologies. The success of these technologies in Taiwan serves as a model for other island nations and regions with limited land availability.

As Taiwan moves toward its goal of 20 GW of solar capacity by 2025, Hitachi Energy remains at the forefront of the country's renewable energy transformation. With its combination of modularized and prefabricated Grid-eXpand™ solutions, smart grid solutions, and expertise in renewable energy integration, Hitachi Energy is more than just a service provider—it is a strategic partner in Taiwan's journey toward a sustainable energy future. As solar energy continues to expand globally, the lessons learned, and technologies developed in Taiwan will serve as a blueprint for other regions looking to make the leap to renewable power. Hitachi Energy's commitment to innovation and sustainability ensures that it will remain a key player in the renewable energy industry for years to come.





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## Author

### Hitachi Energy Taiwan

Hitachi Energy Taiwan, previously known as ABB Power Grids, has been serving Taiwan's power industry since 1988. For over 30 years, the company has continuously innovated and evolved to meet the demands of a dynamic market. On July 1, 2020, Hitachi Group and ABB established the joint venture "Hitachi ABB Power Grids," combining expertise to enhance the power grid business. The company was officially renamed "Hitachi Energy Taiwan" on December 1, 2021, marking a new chapter in its commitment to creating value for customers, employees, and society.

Currently, Hitachi Energy Taiwan employs around 132 professionals, operating from offices in Taipei, Taichung, and Kaohsiung. As a critical link between Taiwanese enterprises and the global resources of the Hitachi Energy Group, the company leverages over a century of experience in the energy sector to provide world-class solutions tailored to various industries, including semiconductors, electronics, petrochemicals, renewable energy, steel, construction, and more.

The company specializes in a wide array of offerings, including grid system automation, grid integration, transformers, high-voltage products, offshore wind power, solar energy, and energy storage solutions. These comprehensive services ensure reliability and efficiency for industries pursuing sustainable energy strategies.

As a trusted partner to Taiwanese businesses, Hitachi Energy Taiwan is renowned for its professionalism, dedication, and customer-centric approach. Its expert engineers are always available to provide meticulous technical support, ensuring smooth operations and uninterrupted production for its clients.



# Battery Energy Storage Systems are Key to Power Systems' Efficiency and Resilience

Meeting our net zero targets requires, in most modern power systems, a substantial increase in the use of renewable energies, mostly wind and solar. Taiwan's 2050 net-zero emissions pathway and strategy targets 40-80 GW solar and 50 GW offshore wind capacity, which would equal the country's entire 2023 electricity production (in TWh) and twice the country's current electricity generation capacity (in GW). The growing penetration of variable, non-dispatchable renewable generation not only increases the need for system flexibilities to balance the variations of demand and supply, it also raises the need for capacity reserves to guarantee supply security for several hours, particularly during peak demand or contingency situations. Furthermore, it poses some challenges to our electricity grids, both in terms of operational management and grid stability. In short, both the need for flexibilities and for capacity reserves is heightened due to the lower predictability and dispatchability of renewables.

Traditionally, flexibility and capacity reserves are provided by fast-reacting resources like combined cycle gas turbines (CCGT).

Battery Energy Storage Systems (BESS) offer a greener replacement to this fossil-fuel based resource. Whilst their role was mainly focused on ancillary services in the early days, today's state-of-the-art BESS are designed to stack multiple functions over different time constants, helping

1. to balance supply and demand,
2. to ensure security of supply, and
3. to optimize grid management and guarantee grid capacity and stability.

As we all work towards Net Zero, they play a critical role in capturing and valuing precious zero-carbon electricity which otherwise risks being curtailed — at an economic and environmental cost — and to substitute vital, but currently fossil-fuel based flexibility and capacity resources.

Battery storage is becoming increasingly competitive delivering peak power at a cost similar to gas peakers. In the US, tenders have already been awarded to ESS rather than gas peaking. In the EU, because energy costs have increased, any battery storage-based function is now a more profitable venture than it was before.

In Taiwan, Saft's largest installation out of 10 utility-scale projects in operation or under construction is a 172 MWh lithium-ion BESS located in Yilan and operated by Foxwell. The system provides dynamic regulation reserve (dReg) providing short power bursts to stabilize the grid. It also supports other frequency applications and integration of renewables.

## Energy Shifting with ESS

The major role of storage therefore consists of absorbing renewable energy when produced in excess of consumption or in excess of the transmission capacity of the grids, and to inject this energy to the grid when needed. This function is technically described as “energy shifting”, typically realized with 2-hour to 4-hour storage systems, with a trend to longer discharge durations. Most systems operate in a daily charge/discharge scheme (e.g. charging solar energy during daylight hours and discharging during evening hours), but some go up to the equivalent of two discharge cycles per day.

The predominant remuneration model for BESS is storing electricity in periods of abundant production and low market prices, and selling electricity when prices are high, typically during early evening peaks. This operation can be directly coupled to a wind or solar generator, in which case the operator simply delays selling a portion of his production to periods of higher market prices – the prevailing operation and revenue generation model in the USA driven by tax incentives installed by the US Inflation Reduction Act (IRA). The BESS can also be operated as a “standalone” asset, absorbing and storing energy from the grid and re-injecting energy back to the grid. In this case, arbitrage is usually combined with other ancillary services (i.e. primary and secondary frequency regulation) – the predominant remuneration model in Europe.

The value generation is enhanced when it comes to curtailment avoidance: not only is the energy valued at market prices instead of being lost, but additional savings are realized by avoiding substitution costs and, possibly, grid enhancements. Currently we see a steady increase of curtailed renewable energy, which is lost for the community at a relatively high and continually increasing- economic and environmental cost.

However, such remuneration mechanisms are based on merchant markets, and hence exposed to market price variability, considered as a relatively high risk from the investor’s perspective.

## Security of Supply

Especially in Europe, the recent energy crisis has revealed the vulnerability of electricity systems in periods of constraints, related to its dependency on (often imported) natural gaz. We now see capacity markets being created in many countries to ensure electricity is available at affordable cost even during infrequent peak periods (e.g. cold winter evenings) and contingency situations. The typical required duration for capacity markets is 2 hours, again with a trend to increase towards longer time periods.

Capacity markets are an interesting revenue adder for storage operators, as contracts are signed for multi-year periods with usually stable prices ensuring a secure and predictable income for investors.

## Grid Services

Besides the balancing and security of supply functions, the contribution and competitiveness of BESS in frequency regulation and voltage support ancillary services is well established and used by transmission and distribution grid operators as a lifeline to ensure voltage and frequency stability of the power systems. BESS have reached significant shares on frequency regulation markets in several countries.

However, the ever-increasing penetration of variable renewable sources (wind, solar) brings new challenges to grid operators, in particular problems of grid congestions. They are linked to the different locational distribution of wind and solar generators, much more distributed compared to conventional power plants, yet with “hot spots” of renewable generation in places not foreseen in the grid topology. A prominent example is the massive generation of wind energy in Germany’s northern coastal area, challenging grid operators to transport energy to the southern regions where most power-hungry industries are located. In the short run, this situation leads to curtailments, and increasing cost for dispatch management and feed-in management. For example, they have increased by a factor of over the past few years. In the long run, investment into grid infrastructure will become unavoidable, increasing the overall cost of energy for the community.

State-of-the art BESS offers technically sound solutions to address various problems in a single solution. They can temporarily relieve transmission lines by storing energy ahead of grid bottlenecks, thus avoiding curtailments. More importantly, they allow for the reduction or deferral of CAPEX intensive infrastructure expenditures on grid re-enforcement and grid stability, such as re-conducting of existing lines or investments in new lines and other inertial supports.

## The Latest ESS Developments

Currently, we are seeing an increasing trend in energy density, system architecture and digitalization.

Today, systems of 100 MW for two hours (200 MWh) or four hours (400 MWh) are commonplace, and we start to see single installations at the gigawatt level. To accommodate this requires more ESS containers. So, installation space is becoming an increasing challenge, knowing that battery containers need to be connected to Power Conversion Systems (PCS) and Transformers, and be installed at safe distances allowing access for maintenance. So, how do we account for the need to economize space, whilst ensuring highest levels of safety?

Since the first lithium-ion battery container left Saft factories in 2012, the energy density of a single 20-foot container has increased 6-fold from 500 kWh to 3.3 MWh today and will reach 5.1MWh by 2026. Whilst bigger sizes and densities of li-ion cells are enabling such densities, the challenge in engineering lies in developing and qualifying high-performance battery system solutions which can be transported to merely any place in the world, and to guarantee reliable operation over 15 to 20 years lifetimes, highest safety standards, as well as high energy efficiency.

Saft's latest generation of li-ion BESS, called Intensium® Shift+, provides 3.3 MWh of storage capacity in standard ISO 20-foot containers. Manufactured under stringent quality controls in our factories, the product has been developed, tested and qualified by in-house engineering teams to integrate:

- proprietary control electronics from module level to system level,
- a patented air-cooling system ensuring temperature homogeneity among all 136 battery modules, under extreme environmental conditions and with high energy efficiency, i.e. low consumption of the HVAC,
- a risk-analysis based safety approach implementing redundant, electronic and physical safety barriers at multiple levels to manage, among others, fire and explosions risks. Saft's safety approach is holistic, anticipating worst-case scenarios at product level, site installation level, and with the operating personnel and fire fighters.

The footprint of a full BESS is also impacted by the size and number of power conversion systems (PCS) needed to convert the DC energy of multiple containers into AC. Saft's control system accurately manages up to eight containers in parallel, i.e. more than 25 MWh can be connected to a single PCS. This allows for the design system architectures based on the largest, cost-optimized PCS systems available on the market.

The increased energy density of the container building blocks, combined with advanced controls, sophisticated safety features and a space-saving plug-and-play installation, is game-changing. All in all, this means the industry can now deliver utility-scale BESS for up to eight hours of energy shifting, all while halving the floorspace and installation time.

## Increasing Digitalization

Modern BESS are also becoming increasingly digitalized, enabling real-time system management and the use of Artificial Intelligence and Machine Learning. This improves efficiency while reducing downtime and maintenance costs. Data interfacing with the cloud provides remote monitoring of key performance indicators (KPIs) and control over all operational parameters of their system.

With Saft's I-Sight system, for example, the digital cloud-connected platform monitors performance in real-time to ensure the BESS delivers on contract specific KPI's. The platform will alert of any deviations, enabling it to take immediate action. AI allows the implementation of predictive maintenance functionalities, further reducing downtime, cost and safety risks thanks to the detection and thorough interpretation of weak signals within a tremendous amount of data gathered and stored by the system.

It is also now possible to resolve most issues without ever needing a site visit, thanks to remote diagnostic and reconfiguration tools.





## Conclusion

The tide is now turning. According to Taiwan's 2050 net zero emissions pathway and strategy, electrical energy storage will be one of the necessary projects to implement low-carbon energy. As we integrate more and more renewables, BESS are not only efficient alternatives to fossil-based flexibilities, but they are also crucial enablers for capturing, storing, and deploying that energy when it is needed. Otherwise, we risk wasting energy – an increasingly precious resource in today's world.

With a track record of more than 4.5 GWh of BESS installed or projected worldwide, including significant projects in Taiwan, the Philippines, Australia and New Zealand, Saft offers expertise in battery energy storage systems to project developers from project inception to installation and end of life. Our brand stands for reliable, guaranteed high performance product solutions, excellence in project execution and reliable service over decades, thus securing return on investment for long-life battery assets.


## Author

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**SAFT**


Saft specializes in advanced technology battery solutions for industry, from the design and development to the production, customization and service provision. For more than 100 years, Saft's longer-lasting batteries and systems have provided critical safety applications, back-up power and propulsion for our customers. Our innovative, safe and reliable technology delivers high performance on land, at sea, in the air and in space. Saft is powering industry and smarter cities, while providing critical back-up functionality in remote and harsh environments from the Arctic Circle to the Sahara Desert. Saft is a wholly owned subsidiary of TotalEnergies, a broad energy company that produces and markets energies on a global scale: oil and biofuels, natural gas and green gases, renewables and electricity.

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## Powering the Green Hydrogen Value Chain

The International Energy Agency (IEA) sees green hydrogen as a critical piece of the puzzle in the global energy transition. Momentum around green hydrogen is now building as companies and governments look for scalable solutions to address climate change.

## Optimizing Power for Green Hydrogen Production

Electrolysis is an energy-intensive process. The efficiency with which an electrolyzer converts water and electrical energy into hydrogen directly impacts the overall cost and sustainability of green hydrogen production. Electrolyzers require a direct current (DC) power supply to function. However, the electricity generated from renewable sources like solar and wind is typically alternating current (AC). Technologies called rectifiers bridge this gap by converting fluctuating grid voltage and frequency into a steady DC supply, ensuring consistent and efficient power delivery to the electrolyzer.

The resulting hydrogen can then be stored efficiently – as compressed hydrogen gas, in liquefied form, or converted to ammonia or methanol – to be used later, for example in fuel cells that provide electricity when renewable sources are unavailable. In essence, green hydrogen acts as a kind of battery, storing renewable energy and enabling grid stability with a high penetration of clean energy sources.

In addition to rectifiers, variable-speed drives (VSDs) play a significant role in green hydrogen production. VSDs power pumps in water treatment plants to deliver ultra-pure water to electrolyzer arrays and control centralized water-cooling systems. They are also used to run compressors efficiently, refrigerating and liquefying the hydrogen gas produced.

Today's drive technology offers precise torque and speed control to optimize the performance and efficiency of motors, along with capabilities to smooth out fluctuations in the power supply and help overcome the intermittent nature of solar or wind-powered grids.

With green hydrogen, backed by rectifiers and VSDs, one of the biggest barriers to renewable adoption – intermittency – is far more manageable. Green hydrogen is therefore not just a mechanism for storing and moving energy, but a driver of renewable energy uptake.



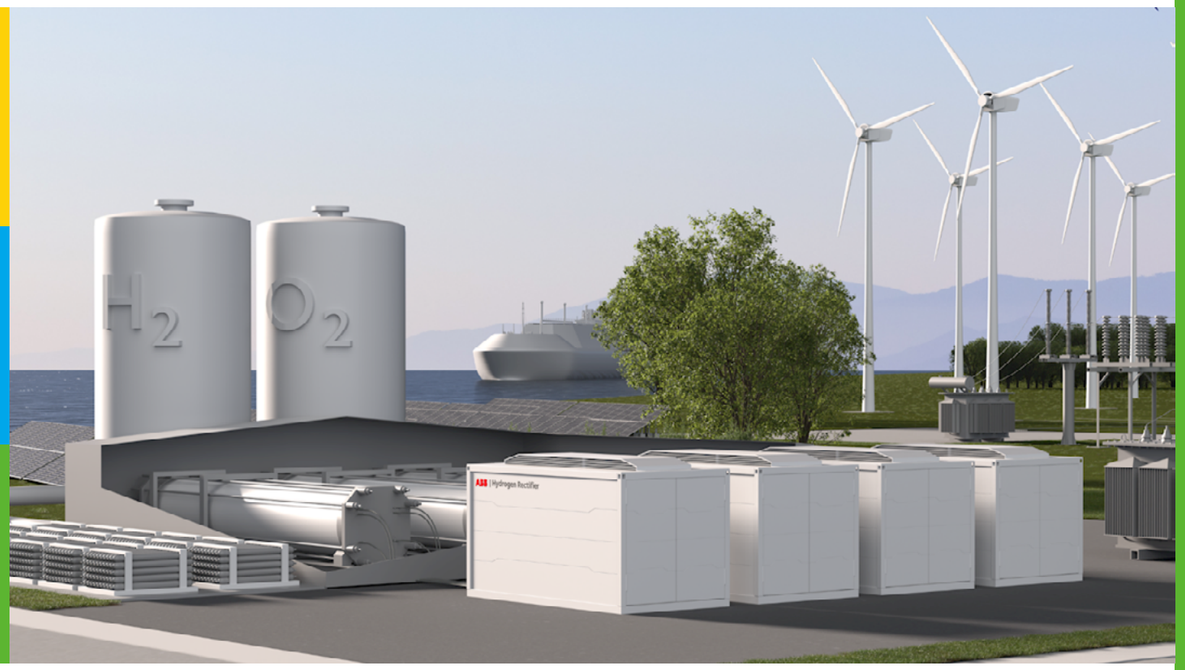
An example of ABB's work in this space is the HyPilot project, the green hydrogen pilot underway at the Gassco-operated Kårstø Gas Processing Plant in Rogaland, Norway.

ABB is providing critical power supply technologies for the project's one-megawatt containerized electrolyzer, low-harmonic insulated-gate bipolar transistor (IGBT) rectifiers and DC-DC converters, ensuring a stable and efficient flow of electricity to the electrolyzer.

Another example of ABB's collaborative approach to green hydrogen projects comes from the SoutH2Port facility in Sweden. Partnering with Skyborn and Lhyfe, ABB is working to connect the former's offshore wind farm with the latter's onshore electrolyzer in this large-scale green hydrogen production project. This collaboration underscores ABB's commitment to clean energy integration, ensuring a reliable and efficient connection between renewable energy generation and green hydrogen production.

ABB is supplying advanced thyristor rectifier system to Nagasaki Carbon Neutral Park (Nagasaki Prefecture), in Japan, where Mitsubishi Heavy Industries, a developer of hydrogen production equipment, is developing a technology research and development base center for energy decarbonization.

ABB thyristor rectifiers ensure approximately 99 percent power conversion efficiency when running at full load operation, leading to minimal energy wastage and reducing the overall costs of reliable hydrogen production. The delivery of the 200 kilowatt (kW) rectifier system for SOEC electrolyzers underscores ABB's commitment to supporting the development of new technologies for the energy transition.




## Author

ABB Ltd.

ABB is a technology leader in electrification and automation, enabling a more sustainable and resource-efficient future. The company's solutions connect engineering know-how and software to optimize how things are manufactured, moved, powered and operated. Building on over 140 years of excellence, ABB's more than 105,000 employees are committed to driving innovations that accelerate industrial transformation.



# Collaborating with Taiwan to Accelerate the Development of the Low-Carbon Hydrogen Industry Chain

**Andrew Kao**, General Manager of Industrial Services & Cybersecurity Division, TÜV Rheinland Taiwan Ltd.

Humanity is entering the fourth energy transition, focusing on replacing fossil fuels with renewable energy and transforming high carbon "dirty energy" into "clean energy." Similarly, the goal of hydrogen energy, as a clean energy source, is to transition high-carbon grey hydrogen into clean hydrogen or low-carbon hydrogen.

In March 2022, Taiwan officially released the "Taiwan 2050 Net Zero Emissions Pathway and Strategic Overview," which includes "energy transition" and the two critical strategies of zero-carbon technology (hydrogen) and negative-carbon technology (carbon capture, utilization, and storage (CCUS)). Based on international experience and Taiwan's current hydrogen projects, TÜV Rheinland completed the "Taiwan Industrial Low-Carbon Hydrogen Industry Operation Challenges Study" in November 2023 and proposed the following seven key strategies to accelerate progress:

## 1. Accelerating Low-Carbon Hydrogen Production: Transitioning to Blue and Green Hydrogen

The development of the hydrogen industry chain must be able to reduce carbon emissions before it can be meaningful. Green hydrogen is produced using surplus renewable energy (such as solar and wind power) to split water into hydrogen through electrolysis. Blue hydrogen, on the other hand, is produced using traditional fossil fuels (grey hydrogen) combined with carbon capture, utilization, and storage (CCUS) to neutralize carbon emissions. Given the limited capacity and development of carbon utilization technologies, blue hydrogen primarily relies on large-scale geological carbon storage. At present, Taiwan produces 300,000 to 400,000 tons of high-emission carbon gray hydrogen per year, and urgently needs to be transformed to low-carbon hydrogen as soon as possible. In addition, in response to the challenges of increasing hydrogen demand in the future, it is recommended that Taiwan must accelerate the transformation of blue hydrogen and green hydrogen development in order to reduce carbon emissions.

In addition, the low-carbon hydrogen industry chain must take into account three key factors - hydrogen safety, hydrogen decarbonization, and hydrogen economic benefits (Figure 1), which are indispensable in the six stages of primary energy, hydrogen production, hydrogen storage, hydrogen transportation, hydrogen refueling, and hydrogen application. Taiwan must simultaneously grasp these three key factors in order to correctly integrate with the sustainable development of hydrogen in the world.

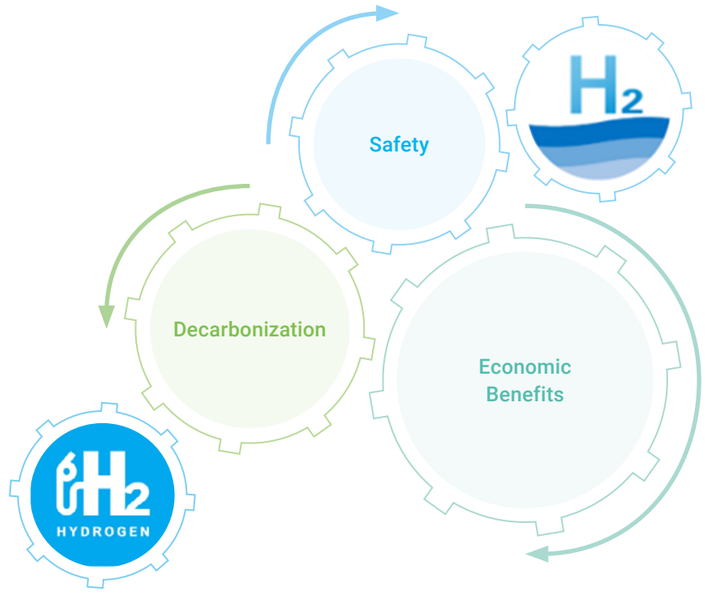



Figure 1 Three Key Factors for the Successful Development of the Hydrogen Industry Chain

## 2. Learning from International Hydrogen Development Strategies: Government-Led National Hydrogen Strategies

According to the International Energy Agency (IEA) in its 2023 "Global Hydrogen Review" report, 41 countries have already developed hydrogen strategies, including the European Union, Germany, the United States, Japan, and Australia. For instance, Germany's updated National Hydrogen Strategy in 2023 (Figure 2) set a target to increase low-carbon hydrogen production to 10 GW between 2023 and 2030. The strategy is based on four fields:

1. Ensuring availability of sufficient hydrogen (including Expansion of the production of hydrogen and hydrogen derivatives in Germany, Import of hydrogen and hydrogen derivatives)
2. Developing a hydrogen infrastructure (including National hydrogen infrastructure, European Hydrogen Backbone network, Infrastructure for imports from third countries)
3. Implementing hydrogen applications (including Industry, Transport, Power, Heat)
4. Creating good framework conditions (including Planning and approval procedure, Sustainability standards and certification, Strengthening research, innovation and training of professional)

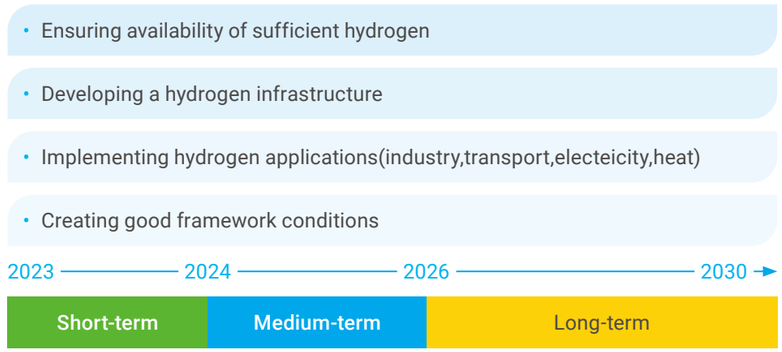



Figure 2 Germany's National Hydrogen Strategy 2023 Revision

Therefore, the focus of national hydrogen strategies must be hydrogen decarbonization and economic viability. Given that such strategies involve geopolitics, resource allocation, incentive mechanisms, engineering technologies, and social acceptance, the low-carbon hydrogen industry chain must be government-led across departments to succeed. We recommend that Taiwan's "National Hydrogen Task Force" adopt Germany's approach to continuously update its hydrogen strategy, creating favorable conditions and overcoming barriers to achieve targets.

## 3. Seizing the Development Opportunities of Blue Hydrogen

The advantages and disadvantages of blue hydrogen and green hydrogen are subjects of differing opinions. In the context of parallel development, it is necessary to evaluate each country's regional characteristics and plan its own optimal development path and strategy. The cost of hydrogen depends on the technology used, supply and demand fluctuations, and energy price volatility in different markets. The IEA's 2023 "Global Hydrogen Review" estimates that the cost of producing blue hydrogen in 2021 ranged from $1.5 to $3.6 per kilogram, whereas green hydrogen costs between $3.4 and $12 per kilogram—green hydrogen being 2.3 to 3.3 times more expensive than blue hydrogen. While green hydrogen is the ideal technology for achieving net zero emissions, its high production costs, land requirements, and technical challenges mean that widespread green hydrogen production is still some way off. In contrast, blue hydrogen is more technically mature, can be commercialized on a large scale, and is relatively lower in cost. Consequently, countries with advanced CCS technologies, such as the United States, Canada, the United Kingdom, and Norway, are vigorously promoting blue hydrogen, considering it a catalyst for green hydrogen development and a bridge to long-term green hydrogen goals.

Taiwan has mature underground gas storage capabilities for carbon sequestration, particularly through CPC Corporation, Taiwan, which has significant experience using depleted oil and gas fields and sealed geological formations as storage. Taiwan's onshore closed structures and offshore saline aquifers have a carbon storage capacity of up to 60 billion tons, far exceeding Taiwan's 2050 storage target of 40 million tons. Therefore, Taiwan is well-positioned to develop a robust blue hydrogen industry chain. We recommend prioritizing the development of Taiwan's blue hydrogen industry, enhancing hydrogen production capabilities, energy security, and infrastructure resilience. This will not only ensure short-term carbon reduction but also lay the foundation for future green hydrogen development.

## 4. Promote a sound hydrogen industry chain with incentive mechanisms

Both supply and demand ends of the hydrogen industry chain must be balanced development simultaneously, and sectors must see profitable returns for the industry to grow healthily. Korea's "Hydrogen Economy Promotion and Hydrogen Safety Management Act" is a successful example, providing comprehensive legal support for the hydrogen industry. Taiwan should follow suit, improving regulations on hydrogen safety, decarbonization, and economic incentives, including laws governing low-carbon hydrogen production facilities, carbon capture and storage sites, and incentive mechanisms (e.g., tax credits, fixed amount subsidies, differential contracts, dual-auction mechanisms, and sustainability multi-elements scoring, etc.). These measures will help sectors secure development permits, reduce operational costs and risks, and boost economic benefits. To encourage sectors to invest with confidence, ESG development must be simultaneously grasped in order to build a sound hydrogen industry chain in Taiwan.

## 5. Establishing a Low-Carbon Hydrogen Certification Mechanism

To minimize energy losses, carbon emissions, and operating costs, the fewer energy transformations during low-carbon hydrogen production, the better. Since the cost and price of low-carbon hydrogen are core to the hydrogen economy, we recommend that Taiwan's regulatory authorities collaborate with international certification bodies to establish a low-carbon hydrogen certification mechanism (Figure 3). This will ensure reasonable hydrogen pricing and, combined with incentive mechanisms, guarantee the decarbonization quality of hydrogen. Such a certification will create strong motivations for low-carbon hydrogen production, prompting Taiwan to produce the first tonne of low-carbon hydrogen at a reasonable price as soon as possible.

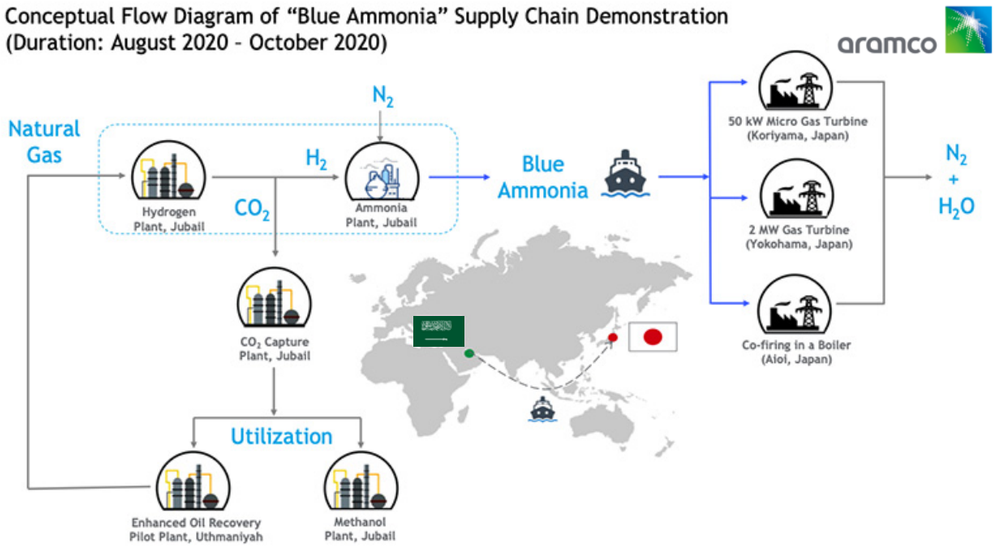



Figure 3 Diagram of Saudi Aramco's Blue Hydrogen and Blue Ammonia Supply Chain Certified by TÜV Rheinland

## 6. Implementing Safety Risk Management to Build Public Trust

To seize the development opportunities of Taiwan's blue hydrogen industry, it is essential to address key technological challenges and ensure safety risk management. In the case of blue hydrogen's geological carbon storage, Taiwan should strengthen its lifecycle risk assessment, leakage monitoring, and geological storage verification according to international standards such as ISO 27914 (Figure 4). Ensuring technical safety, effective carbon reduction, and sustainable operations, combined with proactive social communication, will increase public acceptance and trust in Taiwan's blue hydrogen industry chain.

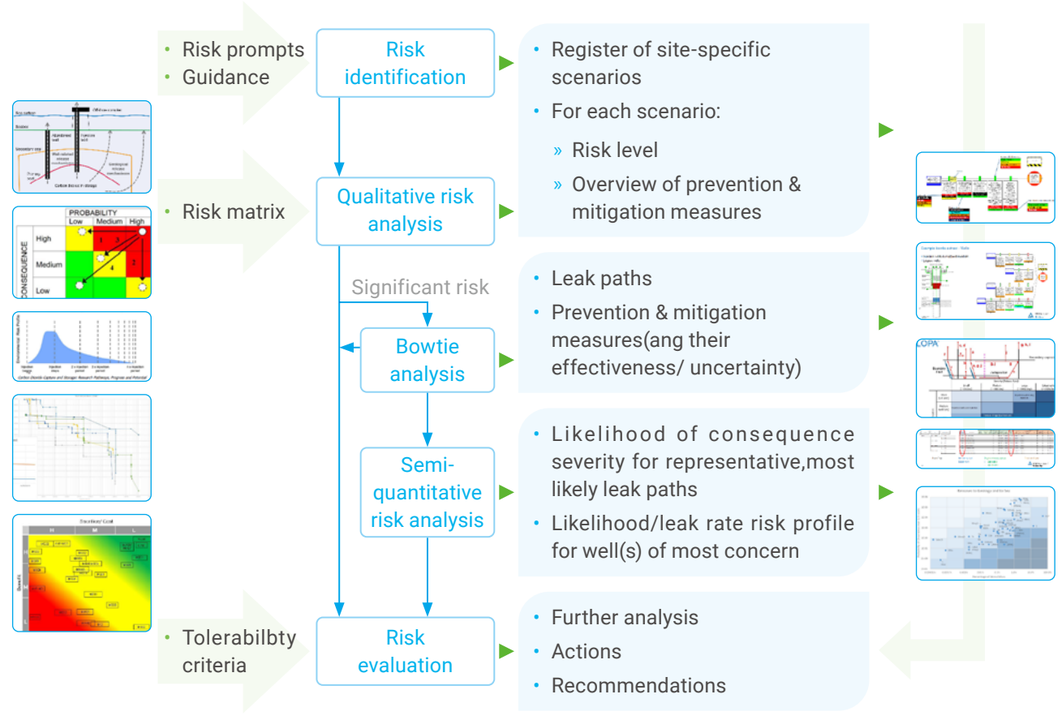



Figure 4 Example of TÜV Rheinland's Carbon Storage Site Risk Assessment Based on the EU 2009/31/EC Geological Carbon Storage Directive

## 7. International Cooperation in Hydrogen Valley Verification Programs

To mitigate the risks of developing the low-carbon hydrogen industry chain, the European Union's Hydrogen Valley initiative has created demonstration zones with different characteristics to verify best practices. Germany has established 14 hydrogen valleys, evaluating hydrogen priority users, low-carbon production methods and resource allocation. It aims to verify and optimize hydrogen transportation plans, make rational investment of public funds, ensure public participation and acceptance, and, finally, integrate the hydrogen valley database to provide a series of hydrogen valley networks. We recommend Taiwan cooperate internationally to introduce a hydrogen valley verification program, continuously improving the feasibility, safety, and efficacy of the low-carbon hydrogen industry chain.

TÜV Rheinland established the "Hydrogen Technology Competence Center" in 2021 to provide technical solutions across the hydrogen value chain (Figure 5).



| Primary Energy | Production | Storage | Transport | Distribution | Application |
|---|---|---|---|---|---|
| • Regenerative H2 (Power-To-X)<br>» Wind/PV ➡ Electrolysis | | • Above / Underground storage tanks<br>» LH2<br>» GH2<br>» LOHC<br>» Ammonia<br>» Synthetic gas | • High pressure pipeline network<br>• Tank trucks<br>» LH2<br>» GH2<br>» LOHC<br>• Maritime vessels | • Natural gas distribution network<br>• Hydrogen network<br>• Refueling stations | • X Raw Material<br>» Refinery<br>» Steel mill<br>» Synthetic ammonia<br>» Semi-conductor<br>» Industrial feedstock<br>• X Fuel<br>» Heat<br>» Electricity<br>» Mobility<br>» Synthetic fuel |
| • Low-carbon H2<br>» Natural gas steam methane reforming ➡ CCUS<br>» Coke gasification ➡ CCUS<br>» Methane pyrolysis<br>» Other low carbon process | | | | | |

Figure 5 TÜV Rheinland' s Hydrogen Value Chain Solutions





TÜV Rheinland provides comprehensive hydrogen value chain solutions, assisting in the production, storage, transport, refueling, industrial use, transportation, power generation, and residential applications of hydrogen. By verifying hydrogen safety, decarbonization, and economic efficiency at every stage, TÜV Rheinland can accelerate Taiwan's integration into the global low-carbon hydrogen industry, ensuring sustainable development, and achieving Taiwan's 2050 net zero emissions goal.



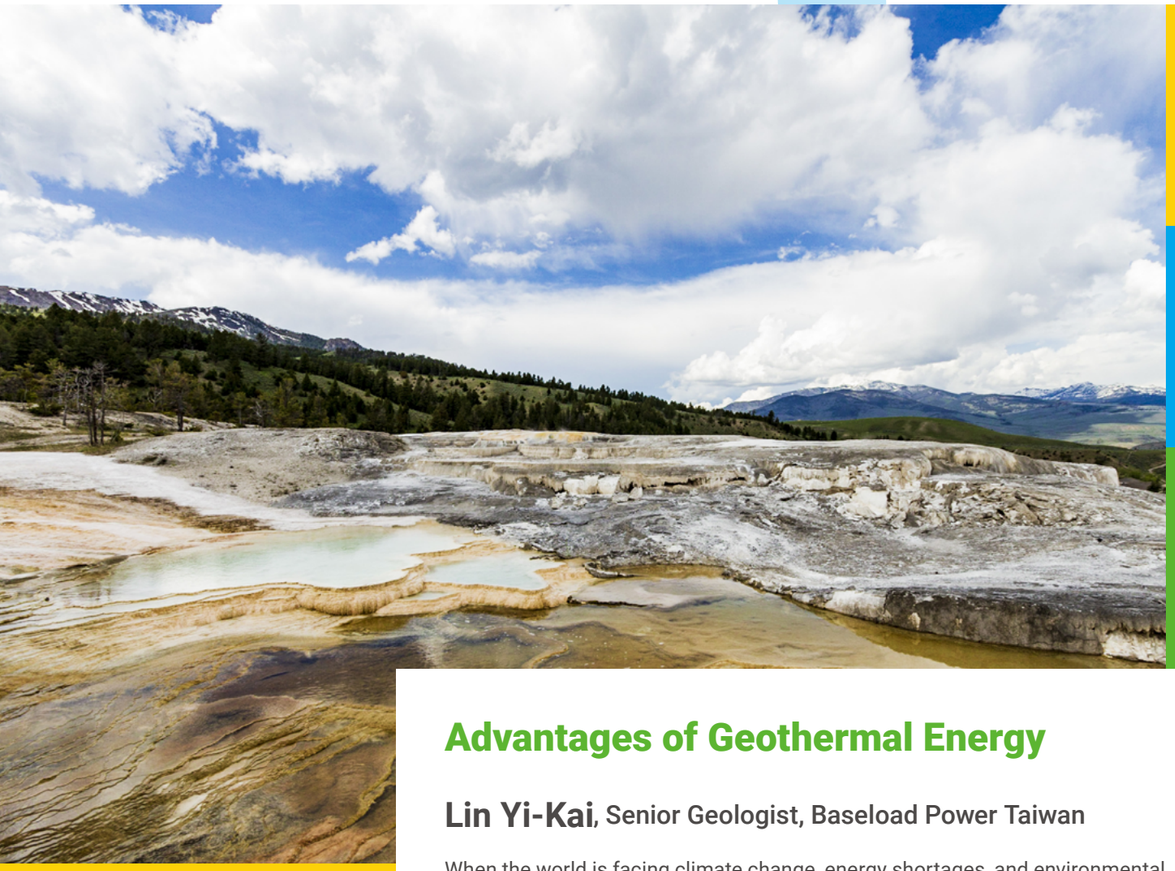
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**Andrew Kao**

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Andrew Kao is currently the General Manager of Industrial Services & Cybersecurity Division at TÜV Rheinland Taiwan Ltd. He specializes in the petrochemical, energy, and environmental industries with over several decades of experience. He leads the Greater China Energy and Environmental department and the Hydrogen Technology Competence Center. Along with international teams, he is dedicated to promoting sustainable industrial development, net zero carbon technology, new energy applications, and process safety management consultancy and certification.



# Advantages of Geothermal Energy

**Lin Yi-Kai**, Senior Geologist, Baseload Power Taiwan

When the world is facing climate change, energy shortages, and environmental pollution, developing clean energy that can continuously provide stable electric supply is becoming more and more important. Geothermal energy is one of the renewable energy sources with the greatest potential. Its unique advantage of providing baseload power makes it a key option for addressing current energy issues. As a geothermal developer, we are highly aware of the potential and challenges of geothermal energy in Taiwan. According to the research conducted by the Geological Survey and Mining Management Agency under the Ministry of Economic Affairs, Taiwan's geothermal potential is estimated to be up to 40 GW. Furthermore, in 2024, the Energy Administration under the Ministry of Economic Affairs introduced the Geothermal Exploration and Development Permit and Management Regulations, which establishes the boundaries for geothermal development sites to avoid interference across projects. However, there is still room for discussion given the interconnection between the boundaries of geothermal wells and the underground reservoir management. The government should increase investment in geothermal development to facilitate the construction of renewable energy and to achieve the goal of net zero emissions.

## 1. Stability and Reliability

Compared to other renewable energy sources, geothermal power is more stable, with a capacity factor of up to 95%, making it a reliable source of baseload power. The Earth's core temperature reaches as high as 6,000°C, and the deeper it is, the hotter it becomes. In some areas of Taiwan, the geothermal gradient can reach 80°C per kilometer, providing an excellent geothermal resource. (Fig 1) This heat can consistently provide energy regardless of weather conditions. Such stability makes geothermal energy a reliable source of baseload power, effectively compensating for the instability of other renewable energy sources.



Fig 1 Geothermal resource in Tatun area

## 2. Low Environmental Impact

Geothermal power generation emits very low amounts of $CO_2$. Compared to fossil fuel-based power generation, geothermal energy has a significantly smaller carbon footprint (Fig 2). Even during the initial development phase, geothermal energy has a much smaller environmental impact than conventional sources of energy. Moreover, geothermal development consumes less water. Compared to hydroelectric power, geothermal power relies less on water resources. Recently, the Ministry of Environment has amended the regulations regarding environmental impact assessments for geothermal power plants by raising the threshold from 10 MW to 50 MW, so only plants with a capacity above 50 MW require an environmental impact assessment review.



Fig2 Baseload Power Iceland - Flúðir power plant

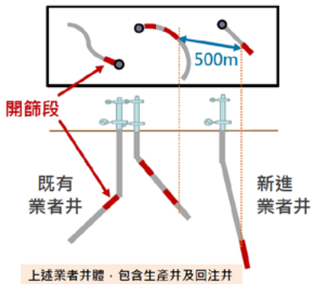



Fig3 Distance between wells for different projects (from EA, 2023)

## Interconnection between Geothermal Development and Reservoir Management

In the early stages of geothermal development, geological surveys and the creation of geothermal models are the primary tasks. After establishing an initial conceptual model, drilling is conducted to verify the geothermal resources. Once the resources are confirmed, planning for the construction and development of power plants follows. However, the continuous operation of a geothermal plant is inextricably intertwined with the management and development of geothermal reservoirs. Therefore, geothermal management and simulation become critical at this stage. Often, due to the authorities' lack of knowledge of geothermal energy characteristics and the absence of management systems, multiple developers are allowed to use the same reservoir. This can lead to a decline in production and premature depletion of geothermal resources due to shared heat extraction from the same reservoir. Furthermore, the method of geothermal fluid reinjection plays a crucial role in the sustainable use of geothermal systems, as these systems are often dependent on fractures for the flow of underground fluids. As a result, the poorly designed reinjection well placement and land constraints can lead to rapid water injection through the geothermal reservoir which cools production wells and reduces production. Currently, the surface projection distance between production wells is managed at approximately 500 meters, and directional drilling is often required for geothermal development (Fig 3). The compensation mechanism for land use is not yet clearly defined. To accelerate geothermal development, comprehensive regulation reviews are necessary.

The challenges of geothermal reservoir management can be addressed by focusing on the following areas:

### 1. Environmental Impacts

Geothermal development may lead to the release of underground greenhouse gases, changes in the underwater level, or noise problems. These environmental impacts need to be fully assessed before the development starts and monitoring mechanisms should be built early on to track and to oversee the development and operation of power plants.

### 2. Resource Management

Effective resource management must be implemented along with geothermal resource development to avoid resource depletion caused by over-exploitation of the reservoir. This requires continuous monitoring and control of geothermal fluid flow, temperature, and pressure to ensure the sustainability of the resource.

### 3. Economic Factors

The initial costs of geothermal development are high, and the return on investment takes a long time, which is a challenge for investors and developers. Resource exploration and drilling during the resource evaluation and development phases require significant capital, which may have impacts on the economic feasibility of the project. Therefore, the evaluation of developers' financial status is necessary before granting exploration or development rights.

### 4. Regulations and Policies

Due to the lack of dedicated law, the development of geothermal resources is currently subject to various legal and regulatory constraints, which may slow down development. Moreover, policy uncertainty may increase risks of development and affect investor confidence. In summary, the challenges of geothermal reservoir management encompass environment, technology, resource management, economics, and regulations, which requires collaboration and comprehensive evaluation from multiple stakeholders to achieve sustainable development of geothermal resources.

## Conclusion

In conclusion, geothermal energy has multiple advantages, including stable power generation, low environmental impact, and promotion of local economic development, making it a crucial option for future energy development. The government should accelerate geothermal development by increasing investment, policy support, and international collaborations to optimize energy structure and achieve climate goals. Only through the joint efforts of industry, government, and academia can we succeed in the energy transition and achieve net zero emissions goal.



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GREEN FLASH




## Energy Transition Through Enterprise

**Luuk van Heerde**, Director, Green Flash

## All Hail to the Sun and Wind?

Sun and wind: Taiwan has plenty of it and is increasingly harvesting these resources on a massive scale. “Massive” because both solar and wind require a huge investment in infrastructure, both for capturing the energy (wind farms, solar farms) and distributing it (grid capacity and access, storage). There are no time and money-saving shortcuts here; these are all generational undertakings.

The only problem with these renewable sources is that they create a dependency, and not all users will be able to adapt to this new reality. That dependency is called “electricity”.

## The New Winners and Losers

The government’s focus on electricity-generating alternative energy sources such as wind and PV will likely create a two-class system in the Taiwanese business world in the near future, with clear winners and losers.

The winners will be large and wealthier corporations, as well as SME that already rely on electricity for most of their manufacturing process. For them, the transition to green energy will be easy. Wealthy companies for whom brand equity is at stake, will gladly pay for the cost of greening to secure their reputation. SME who use only limited energy, or who operate only a small fossil-fuel powered equipment fleet, can easily manage the limited cost of new electric equipment, employee training and downtime from switching to new equipment.

The losers will be SME who rely heavily on diesel and gasoline powered machines for which there is often no realistic electric alternative. Some equipment is custom-built and highly specialised – and therefore expensive to replace. Large-scale electric replacements - swapping out entire fleets – can be a budget-breaker.

Some operators will also face a host of operational challenges from switching to electric equipment, such as dealing with charging cycles and downtime or a costly alternative - investing heavily in complex battery-swapping equipment.

There are plenty of applications where diesel saves the day and where an electric alternative is simply not available. There is no economically and technically viable substitute for the tens of thousands of diesel generators that are being used all over Taiwan for onsite electricity generation or emergency backup power in large buildings such as hospitals and airports. It is also hard to image the Taiwanese armed forces begging for a cease-fire during a conflict to top up the batteries in their electric battle tanks, or fishing vessels trailing a very long extension cord out to sea.

## Keeping the SME Alive

Small and medium-sized enterprises (SME) are the economic lifeblood of Taiwan. They are responsible for a large section of Taiwan's GDP and employ millions. They also play a vital role in keeping Taiwan globally relevant, because Taiwanese products and components are an essential part of the global supply chain. Many of these enterprises are small and traditional companies: scratch the shiny surface and underneath you will likely find an old-fashioned family business, run on traditional values and established methods.

The transition towards more sustainable, low-carbon footprint operations will be a painful process for these smaller enterprises, many of whom have limited awareness of the issue and – even more important – do not see easy remedies that would work for them. The gap between the glorious, photogenic offshore wind projects and the SME struggling to find an immediate solution for tomorrow's ESG demands is huge.

This looming scenario of a two-class economic reality will be greatly exacerbated by two factors: the absence of good carrots, and the emergence of bigger sticks.

## Bigger Sticks: Regulation and Fines

We all know the classic carrot-and-stick analogy: to move someone, you need both an incentive– the carrot – and a punishment for not complying: a stick to beat them with.

Green measures used to be sticks exclusively. Rules and regulations that were imposed cost money, were disruptive and, in many cases, were difficult to implement. For years, we depended on government legislation (laws, fines, taxes) to persuade users to switch to more sustainable practices by making the polluting alternative unpalatable and expensive.

As 2050 looms closer, it is likely some kind of panic will set in. Future governments will likely be forced to walk back on the ambitious claims and promises made by their predecessors, with all the negative political consequences that result from disillusioning voters. The most likely result is the sudden emergence of a bigger stick, allowing governments to attain at least some of their goals.

A host of new regulations and punitive measures for users of traditional non-renewable energy sources are likely to emerge – a knee-jerk reaction to a long period of green sky thinking and a lack of timely, decisive actions. The results of a long-term diet rich in promises and talk, but low on carrots and meaningful incentives, will lead to green punishment down the line.

## Bigger Sticks: The International Supply Chain

For major brands, not having a meaningful ESG strategy has already become too expensive. Consumers are increasingly using their purchasing power to vote for a more sustainable future. When the sporting goods manufacturer Nike was exposed for using child labour in their sweatshop in Indonesia, it took a decade for the brand to recover from the fallout. Since then, global enterprises have learned they can no longer shift the blame to their supply chain and feign ignorance.

When global enterprises take action to ensure that the practices of their subcontractors are in line with the brand's core values and ESG promises, it is not always out of charity, or to protect their brand image: most European enterprises are also under increasing legal pressure from their own government and shareholders to keep their supply chain in check.

## The Absence of Good Carrots

The good news is that green measures are increasingly making business sense. They have become more affordable, flexible and easier to implement. With so many good greening options available, it has become increasingly difficult for enterprises to justify not doing anything meaningful. Carrots have become bigger and easier to digest.

However, to lure businesses towards more sustainable practices, a working solution must not just be affordable, but also available – literally. It is hard to fill up your tank with renewable fuels if those fuels are not allowed to be sold in your country because of outdated regulations.

## The Solution

There is a solution for many businesses that would both increase the carrot and decrease the need for a stick: transitional fuels. The next generation of transitional fuels has been designed to be a renewable one-on-one replacement for their mineral counterparts, offering the convenience of working seamlessly with the existing equipment and requiring no adaptations. Fuels like SAF (a replacement for aviation fuel) and HVO (a replacement for diesel) are famous for their ease of implementation: they can be dropped into any existing fuel tank at any ratio, without any disruption or drop in performance. Another great benefit of these fuels is their much cleaner emissions: less CO, $CO_2$, NOx and no sulphur, as well as significantly lower emissions of particulate matter.

## Buying Time

The biggest advantage of transitional fuels is that they buy time. This time can be used by entrepreneurs to plan their long-term transition to electric and build up the necessary capital to do so. This extra time will also allow businesses to keep operating their existing equipment with very low carbon outputs until the natural end of the machine's life cycle.

This makes sense in more than one way: diesel-powered equipment is both durable and expensive. Mineral fuel-powered machines that are being replaced by electric ones are often not taken out of the cycle but sold on the second-hand market. In most cases, these dirty machines will keep emitting their exhaust for quite a few more years – just somewhere else on the planet.

When a government allows transitional fuels into the market, it buys time, which is the most precious commodity. In a time of great change, all governments must balance the well-being of both the current and the future generations. Transitional fuels allow them more time to adapt the economy to the new realities, and to finalise the massive infrastructure that is needed to accommodate a realistic switch to renewable sources that produce heat and electricity.

## SAF

SAF – Sustainable Aviation Fuel - is a great technical medium-term solution. This organic replacement for airplane fuel is safe, easy to implement (using existing equipment and infrastructure) and produces cleaner emissions as well.

Unfortunately, SAF is an impractical large-scale solution for the immediate future. Current production of SAF is unable to meet existing global demand for large-scale implementation, which is why it is currently only dropped in at a few percent. It is prohibitively expensive, and SAF's main customers – airlines – are one of the very few examples of a business for whom the cost of fuel is the most important factor. A small hike in fuel prices can put an entire airline out of business within weeks. Paying three times as much for fuel is not an option for airlines.

## HVO

HVO is an organic diesel fuel that is chemically identical to regular diesel. HVO is produced by hydrotreating (adding hydrogen to) fats and oils at high temperatures in a process similar to making household margarine.




Currently, HVO is mostly produced from used cooking oil (UCO) and waste products from the food and cosmetics industry such as Palm Kernel Residue (PKR) and Palm Oil Mill Effluent (POME), a wastewater generated from palm oil milling activities. Newer types of feedstocks have been developed and are close to wide-scale implementation. Future generations of HVO are likely to be produced from seaweed, algae, agricultural waste and household waste as well.



HVO can be mixed in any ratio with regular diesel, without mixing or stirring (100% miscible), meaning that HVO is both a blending and replacement fuel. Its blending properties mean that users can select their level of commitment to reducing their carbon footprint, by choosing how much they drop in. A diesel engine running on 100% HVO can have its carbon footprint reduced by as much as 94% - close to carbon neutral.

One of the major advantages of HVO is that it is produced globally, and that the number of production sites is rising dramatically. This enables regional sourcing of HVO, meaning shorter supply lines, more purchasing options, lower prices and lower transportation cost.

For Taiwan, HVO Renewable Diesel has a number of additional advantages. Regional sourcing from a variety of neighbouring countries is strategically more secure than an almost complete dependence on oil from the Middle East, with long shipping routes through a variety of potential conflict areas that raise many security considerations. In addition, the ongoing research into new feedstocks mean that even domestic production of HVO in Taiwan is a distinct possibility in the future.

HVO has been around for centuries. It is a proven diesel fuel that is endorsed and promoted by all major diesel engine manufacturers and promoted by most EU governments. HVO is widely used by major brands and global enterprises. An increasing number of gas stations in Europe (e.g. Shell) sell HVO (100% or blended) for consumer use.

## Biodiesel

Biodiesel is another transitional fuel, but it is distinctly different from both SAF and HVO in chemical composition and application. Biodiesel is mostly a blending fuel, which can be added to regular diesel in small amounts to offset some of the carbon footprint. Some engines can be adapted to run on 100% biodiesel, but this requires a major mechanical overhaul, and the refurbished engine can no longer be used for regular diesel fuel after that.

Because of its different chemical composition, biodiesel has additional issues in hot and humid environments, such as a limited shelf life, bacterial contamination and water absorption. HVO and SAF have none of these.

## Roadblocks Instead of Road Maps

Our company Green Flash has been working for over eighteen months to license the importation, storage and sale of HVO in Taiwan, which at times feels like an uphill battle. The main culprits are outdated standards and legal definitions. Renewable fuels are technically not an “oil” product, according to the national Petroleum Administration Act (PAA), which defines oil as “produced from crude oil”, a circular reasoning that is not helping. Taiwanese bureaucrats are notoriously reluctant to take bold initiatives. Getting boxes checked on an existing form is easy; adding a new box to an existing form is a Sisyphean task.

While it is always a good idea for government to scrutinise and review existing legislation, this is not the time to put the decision-making processes on hold for a theoretical debate.  What Taiwan needs is a shift in government mindset: a new Key Performance Indicator that favours results and actions. Less conferences, less self-congratulating group photos with dignitaries on stage, more working committees with a can-do attitude that burn the midnight oil (mineral or otherwise) trying to hammer out cross-ministerial solutions.

## Energy Transition Through Entrepreneurship

SAF will be introduced in Taiwan next year. It has taken the state-owned oil giant CPC and the government’s own organizations (MOTC/CAA) well over a year of struggle to achieve this. The main reason is again not ill-will, but bad procedure. Too many stakeholders, too many layers to the cake, too much time spent on waiting for replies, a lack of ownership and agency for the people in the middle.

This means that the current roadmap to compliance for renewable fuels is only accessible to massive corporations with unlimited resources and time to wait, for years if necessary. Smaller entities on a budget who want to introduce renewable fuels to Taiwan are almost precluded from making a meaningful contribution to Taiwan’s net zero policies because of this.

Taiwan’s enduring economic power comes from its indomitable entrepreneurial spirit and its thirst for technological innovation. If we cannot empower Taiwan’s local entrepreneurs and small businesses in the renewable fuel sector and help them implement transitional fuel solutions, we are wasting our biggest resource yet.

## Europe Leads the Way

Taiwan does not need to look far to find examples of successful implementation of renewable fuels: they are alive and well in most European countries. The EU countries provide many great examples of both sticks and carrots.

In June 2023, the EU Commission adopted rules establishing the share of biofuels and biogas in mixed fuels that can count towards the Renewable Energy Directive target for renewables in transport. At the same time, the EU Database for Biofuels (2024) is open for online registration by the relevant economic operators of transactions of liquid renewable and recycled carbon fuels, to improve traceability of biofuels, avoid double counting, and address concerns about fraud as well. Not just carrots and sticks, but also clear rules on using both of them.

To be fair: introducing renewable fuels in Europe has not been a rose petal-strewn walk into paradise. The European Court of Auditors has found that EU biofuels policy lacked stability, mainly because of sustainability challenges, and that 2020 targets had not been reached by most member states. But here is the big take-away: **these teething troubles have not prevented the European countries from allowing private enterprises to explore the market for renewable fuels.** HVO and SAF are produced, traded, sold and used all over Europe, with great success. This has not only created green options for enterprises, but also yielded tons of essential data and invaluable insights into demand, usage and challenges, and saved millions of tons of emissions of new $CO_2$ to boot.

## Recommendations for the Government

Of course, we need carefully drafted rules and regulations, but we also need action right now. We need to walk and talk at the same time; a sandbox where new initiatives can be tried out and evaluated while better legislation is being drafted.

Our recommendations to the Taiwanese government are not just aimed at the Executive Yuan and the IDA; we also would like to see a change of heart within the relevant ministries as well; a commitment to action and dialogue across the organisational tree, from top to bottom.

1. **Acknowledge the importance of renewable fuels for the economy**

   Safeguard the interest of the Taiwanese economy by facilitating regulations that currently hinder the introduction of economically important renewable fuels in Taiwan.

2. **Acknowledge the importance of renewable fuels for the environment**

   Protect the environment and air quality in Taiwan by making cleaner renewable fuels a priority within the EPA and the MOENV.

3. **Appoint a “Renewable Fuel Tzar”**

   A person or department that will be the single point of contact for issues regarding the legislation and permits for renewable fuels. They/it will have the authority to hold government organisations and their departments accountable for fulfilling their mission and official duties.

4. **Cut red tape**

   Create a mandate for all relevant government departments to respond and deliver clear answers and actionable advice within a reasonable time limit.

5. **Build a sandbox**

   Create an immediate two-year exemption for all renewable fuels in Taiwan, so that the introduction of essential ESG measures such as HVO can get started while the relevant legislation is adapted and future-proofed.

Taiwan has the amazing ability to re-invent itself. We only have to look at the successful large-scale adoption of some of its greener transportation initiatives (Youbike, MRT, HSR, Gogoro) to see that Taiwan is ready, willing and capable of embracing paradigm-shifting solutions. Let’s make green fuel the next one.




## Author

**Luuk van Heerde**

**Director**

**Green Flash**

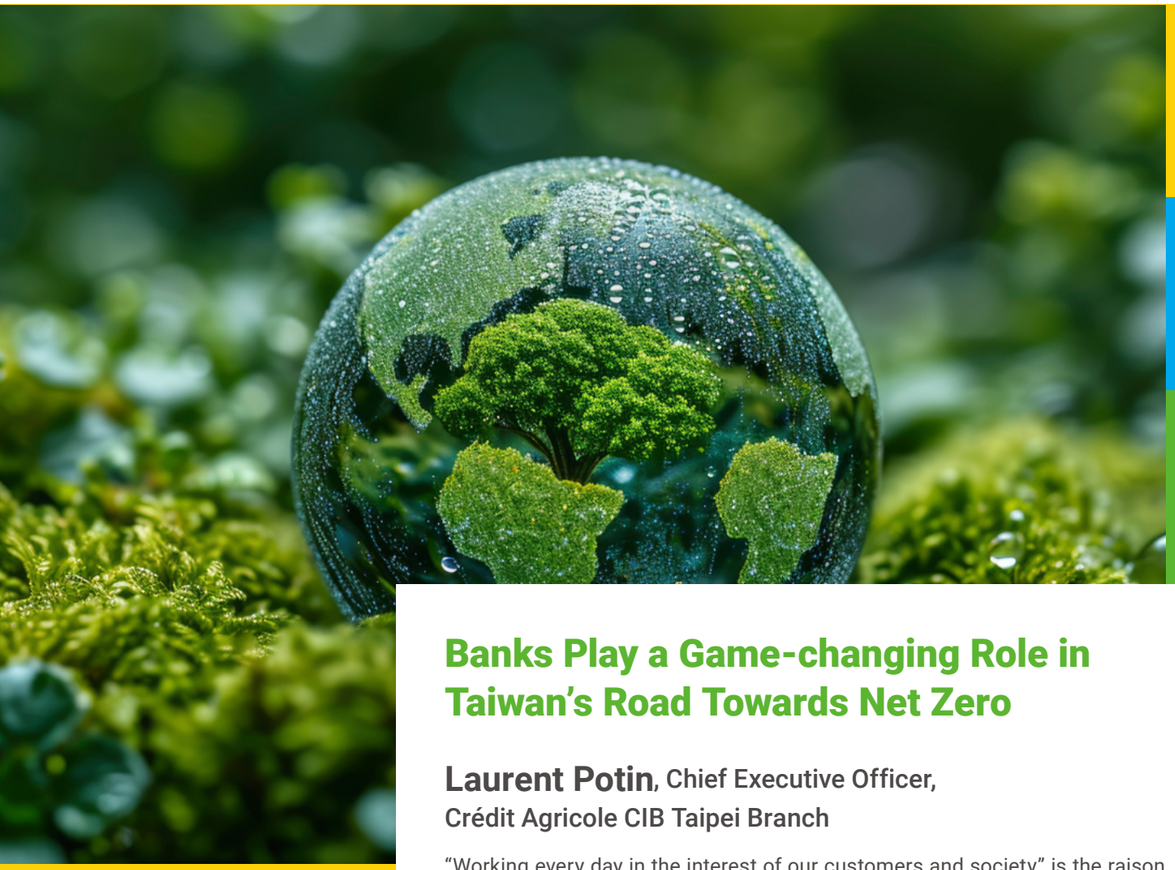

Green Flash, a pioneering Taiwanese company, is the first to introduce HVO Renewable Diesel in Taiwan. HVO is an alternative to traditional diesel. It is 100% compatible with existing diesel engines and does not require any equipment change. HVO burns cleaner, with less soot particles and lower emissions.

HVO Renewable Diesel allows enterprises to continue using their existing diesel-powered equipment until the end of their natural lifecycle, while still making a significant contribution towards a greener planet. A traditional diesel engine running on HVO can reduce its carbon footprint by up to 90%.

Green Flash has a simple mission: energy transition through enterprise. Their goal is to promote a greener entrepreneurial mindset and offer practical, environmentally sound solutions for businesses in Taiwan. To achieve these long-term goals, Green Flash is partnering up with educators, entrepreneurs and government organizations to create awareness and build a stronger ecosystem for green fuels in Taiwan.

Luuk van Heerde (Amsterdam, 1962) is founder of the international branding and marketing agency Look Right, and director of Green Flash. After an extensive career in media and communication in Europe and the USA, he is now focused on helping to promote sustainable fuels in his new home, Taiwan.

CRÉDIT AGRICOLE
CORPORATE & INVESTMENT BANK



# Banks Play a Game-changing Role in Taiwan's Road Towards Net Zero

**Laurent Potin**, Chief Executive Officer,
Crédit Agricole CIB Taipei Branch

"Working every day in the interest of our customers and society" is the raison d'être of Crédit Agricole Group, the world's ninth-largest bank by asset (The Banker, July 2024). Its corporate and investment banking arm, Crédit Agricole CIB, helped formulate the International Capital Markets Association's Green Bond Principles, which are voluntary guidelines for sustainable debt issuers. Additionally, it has also contributed to the launch of the Equator Principles, which set environmental and social standards for project financing.

Crédit Agricole CIB's history in Taiwan traces back to 1981. Deeply rooted in Taiwan, Crédit Agricole CIB not only provides quality services to corporate and financial institutions clients but also endeavours to bring in global best practices.

With sustainable banking and financing being at the heart of Crédit Agricole Group's global strategy, supporting the development of a sustainable Taiwan has been one of Crédit Agricole CIB Taipei's corporate missions.

In this article, we share our experience and learning in achieving net zero with our customers and society, as well as provide actionable suggestions for the next steps for Taiwan in its net zero ambitions.

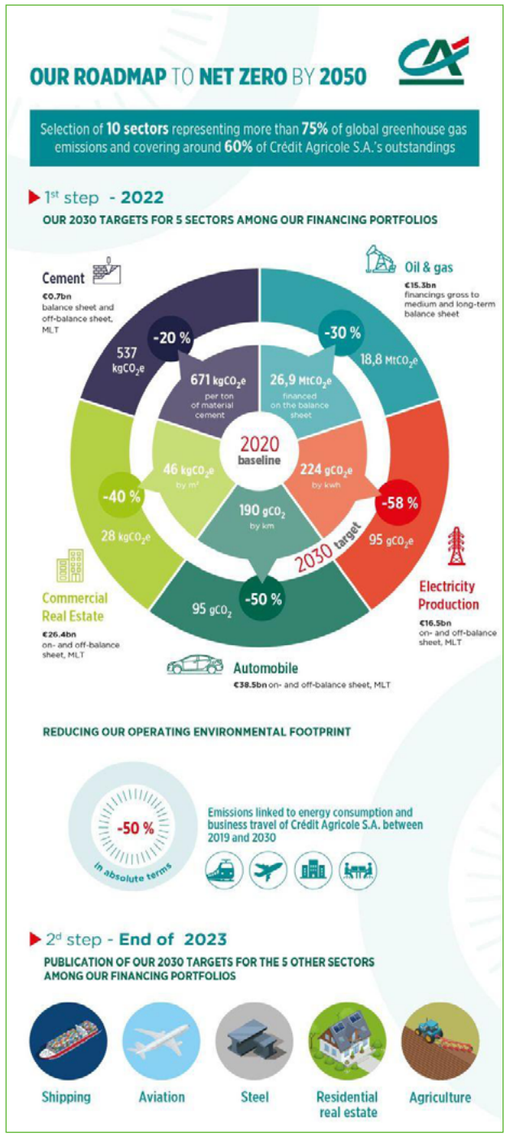
## Crédit Agricole's Climate Strategy: An Actionable Plan Towards Net Zero

Crédit Agricole CIB is making carbon neutrality by 2050 part of its strategic commitment. It set up its sustainability team in the late 2000s with the idea that sustainability will become increasingly important for the market.

Crédit Agricole CIB's climate strategy is based on three complementary axes:

1. Finance and invest massively in renewable energy, low-carbon infrastructure, clean technologies and energy-efficiency projects;
2. Support all customers in their social and economic transitions;
3. Stop financing any new fossil fuel extraction projects and adopt a selective approach to support energy players engaged in this transition, which will consequently reduce green-house gas emissions of this sector twice as fast as the net zero 2050 scenario defined by the International Energy Agency.

Crédit Agricole CIB updates its climate strategy periodically, with the latest updates announced in December 2023. It has targets for 10 of the most carbon-intensive sectors in its portfolio, with intermediate targets for 2030 and long-term targets for 2050:




Caption: Crédit Agricole CIB has targets for 10 of the most carbon-intensive sectors in its portfolio, with intermediate targets for 2030 and long-term targets for 2050

We carried out these strategies through clear execution, control and rigorous disclosure. For instance, in 2022, Crédit Agricole Group identified ten priority sectors to set Net Zero trajectories (specific targets for the reduction in financed emissions). These ten sectors represent more than 75% of Crédit Agricole Group's greenhouse gas emissions. We followed them closely, and by the end of 2023, we reported significant achievements for five targeted sectors:

### 1. Oil & Gas

At the end of 2022, the decarbonisation target set for 2030 was already reached, 8 years ahead of schedule.

- 40% decrease in financed emissions at the end of 2022, well ahead of the 2030 target of 30%.
- 17% reduction in Crédit Agricole CIB's exposure to oil extraction in 2022 vs 2020.

### 2. Power

16% decrease in the carbon intensity compared to the 2020 baseline, in line with the target. There is also a significant increase in Crédit Agricole CIB's exposure to low-carbon energy, including exposures through our clients.

### 3. Automotive

8% decrease in the carbon intensity of financed emissions in 2022, in line with the 2030 target.

### 4. Commercial Real Estate

Stability of the carbon intensity of financed emissions in 2022 vs 2020.

### 5. Cement

Slight increase of 3% in the carbon intensity of financed emissions in 2022 compared to 2020.

**For other sectors, we also announced new commitments in the strategy:**

### 6. Steel

- Reduce $CO_2$ emissions by 26% by 2030
- Prioritise financing of low-carbon steel production technologies
- Develop an active policy for financing the construction of new steel production facilities using green energy

### 7. Shipping

- Reduce $CO_2$ emissions by 36% by 2030
- Prioritise financing of low-carbon shipping technologies
- Develop an active policy for financing the construction of new vessels using green fuel

### 8. Aviation

- Reduce $CO_2$ emissions by 25% by 2030
- Prioritise financing of fourth-generation aircraft
- Develop an active policy for financing the construction of new vessels using green fuel

### 9. Residential Real Estate

- Support property owners and promote energy-efficient renovation
- Develop innovative customer solutions
- Adapt credit and pricing policies to incentivise renovation work

### 10. Agriculture

- Support farmers in their transition process
- Promote sustainable agriculture practices
- Develop a platform for virtuous practices

To ensure the success of implementing these strategies, the Bank has a governance structure in place to manage these decarbonisation trajectories. Within the Bank, it has allocated advisory and support roles, recruited necessary expertise (for example, the 250 coordinators within the Crédit Agricole CIB community of experts, or the 50 energy transition advisors within the Regional Banks) and created the Climate and Sustainability Committee to monitor the execution progress, which is reviewed quarterly by the Group's top management.

## Energy Transition Creates Challenges, but also Opportunities in Taiwan

Crédit Agricole CIB is the only bank that has financed all current offshore wind farm projects in Taiwan. As of the end of 2023, we have provided more than TWD16 billion in financing to offshore wind farm projects in Taiwan. Upon project completion, the projects are expected to generate 9,374 GWh of clean electricity each year, equivalent to a carbon emission reduction of 4.63 million tons (based on the methodology of the Ministry of Economic Affairs). We plan to continue doing so, believing that energy transition is critical for Taiwan to achieve broader sustainability and net zero goals.

After years of effort, Taiwan is now a leader in the renewable energy space and has earned widespread respect for progress in renewable energy development. Despite the many construction and industrial challenges, Taiwan currently has four major projects entering the commercial operations stage.

As the journey towards energy transition advances, new challenges are also arising. Take the recent Round 3 offshore wind farm projects as an example, developers are required to enter into a corporate power purchase agreement (CPPA) to provide businesses or corporations with a channel to purchase green power directly from the projects. This CPPA idea is a step forward from the previous arrangement where the state-run Taiwan Power purchases the power generated and redistributes it to the public. It is supposedly a more flexible commercial arrangement initially but brings challenges for developers and interested corporates. The primary reason is the credit uncertainty of the buyers for a 20-year horizon — the initial off-takers may disappoint their power purchase obligations during the term of the contract, rendering all cash-flow assumptions initially made unrealisable. The transactions may not occur in the first place because financiers cannot assess the projects' cash flow for repayments with a certain level of confidence, resulting in significantly reduced bankability.

This concern extends beyond Taiwan, and a range of mechanisms such as risk analyses, external support, or readily available markets for the power have been explored and adopted. However, the fact that most intended off-takers in Taiwan either lack globally recognisable credit ratings or have no group/sponsor support makes potential solutions more complicated.

Over the past few years, Crédit Agricole CIB has actively collaborated with other stakeholders and government representatives to develop risk mitigants for projects facing these challenges. Together, we have explored contingency plans, including having alternative financial resources and other off-takers ready to step in when the original players fail. We have also participated in discussions and studies for a two-tier power purchase structure based on a common interest in transiting towards green energy consumption, through a stronger off-taker, ultimately establishing a demand-supply balanced electricity trading market that prepares renewable energy as a readily purchasable commodity.

All of these steps are easier said than done, but Crédit Agricole CIB, as a global sustainable finance expert, is happy to work with related parties to put the ideas into action.

## Taiwan has Laid a Solid Foundation to Go the Extra Mile for More Successful Achievements

Below are some suggestions to the general effort of Taiwan in the energy transition path:

- **Communication is key:** Crédit Agricole CIB Taipei suggests that the government can continue its existing energy transition strategy and communicate and collaborate with stakeholders for advancement.
- **Effective use of green energy:** Green energy can be considered an effective supplement instead of a replacement for conventional energy sources such as nuclear power. Its main benefit lies in discontinuing fossil fuel consumption, which represents over 70% of Taiwan's power mix at the time of this paper. Successful execution of real cases, such as the Round 3 offshore wind farm plans, could also enhance market confidence in the green energy sector.
- **Energy storage and conservation:** In our view, solar, offshore wind and green energy storage and conservation (such as hydrogen) are essential to support Taiwan's energy transition goal.
- **Success relies on actionable steps:** These may include encouraging local banks to support green finance, executing tax treaty arrangements more efficiently to reduce withholding tax burden for credit insurance policy premiums, and offering more flexibility in employing offshore talents.
- **External consultants:** Crédit Agricole CIB encourages Taiwan to embrace global participation and leverage external consultants and their experiences for smooth execution.
- **A 'taste' of Taiwan:** Subsequently, Taiwan's indigeneity in these key sectors could be incorporated, leading to the establishment of a new industry capability. As one of the first banks to have a sustainable finance team, Crédit Agricole CIB is an expert in designing sustainable finance facilities tailored to individual local markets and is more than willing to support Taiwan's roadmap.

Most importantly, mutual success for Taiwan's energy transition relies on collaboration with all parties. This requires banks to provide support as financing is critical to the projects.

While foreign banks account for around 3% of Taiwanese banking assets, they disproportionately contribute to over 70% of the financing for offshore wind farm projects in Taiwan. Given the limits on each bank's capital, if the current banking support model persists, we predict that the existing financier group's resources will soon be exhausted, hindering their ability to provide financing for future projects.

The offshore wind farm financing pocket will widen if local banks, particularly state-owned banks, can actively join the line-up as active players in supporting Taiwan's energy transition ambitions. Crédit Agricole CIB can offer to share its experience in sustainable finance with local peers to bridge the knowledge gap and encourage them to take on a more active role in project finance.

## Offering Flexible and Innovative Instruments can Help Local Corporates Overcome the Traditional Sustainable Finance Barrier

As early as April 2017, the Taipei Exchange (TPEx) released green bond listing guidelines that reflected the internationally accepted ICMA Principles, with some local adaptations for projects settings, independent certification, and post-issuance disclosure requirements. TPEx has introduced additional elements incorporating market practices in other markets later on, as well as regulatory frameworks from more developed markets. These enhancements included a more rigorous process for information disclosure, the requirement for a company-wide framework, the necessity for quality second/independent party opinions, and the reference to technical criteria.

With years of effort, Taiwan has witnessed its green bond listing guidelines evolve into a comprehensive sustainable financing scheme, encompassing green and social bonds/loans/deposits, sustainability financing, and sustainability-linked offerings.

As a global leader in sustainability finance, Crédit Agricole CIB has been involved in this market effort since the programme's inception. In July 2017, Crédit Agricole CIB became the first foreign issuer to issue green bonds in Taiwan. Three years later, in 2020, Crédit Agricole CIB took a step further by issuing two series of TWD-denominated green bonds to directly support its lending activities in Taiwan. This includes financing for offshore wind power generation projects, where Crédit Agricole CIB Taipei is one of the major financiers.

An increasing number of local institutional investors and financiers are showing interests in responsible investment/lending activities and the demand for sustainable financing has picked up rapidly. Despite this, some traditional green financial instruments, such as use-of-proceeds products, have not been able to fully meet the needs of many financings for net zero ambitions. This barrier is particularly common for Taiwanese corporates, as most borrowers are not eligible for use-of-proceeds finance due to the nature of their operations, despite their intentions to enhance their sustainability performance.

Crédit Agricole CIB was among the first banks to introduce financial products to help Taiwanese corporate clients set and achieve their sustainability goals through sustainability-linked loans, commercial papers, guarantees, bonds, green deposits, and more. Back in 2022, we arranged a sustainability-linked financing for a conglomerate client in Taiwan. With the performance targets set in the scheme, the financing is expected to encourage carbon emission reduction for the company. Subsequently, we have executed other transactions with the same principle, and the product structure is now widely adopted among Taiwan financial institutions in various formats such as loans, guarantees and bonds.

Since the ICMA released its Sustainability-Linked Bond (SLB) Principles in June 2020, the market requirements and definitions for SLB issuances have become clearer, leading ICMA Principle-based SLBs to gain popularity. The momentum of sustainability-linked loans (SLLs) has also picked up quickly with the development of related guidelines from loan market associations.

The most prominent feature of SLBs and SLLs is that there are no restrictions on the use of proceeds. Borrowers are not obligated to invest all their financing proceeds in qualified green assets. Instead, they can choose to use the financing for general corporate purposes and leverage the funds to support their enterprise's sustainable transformation. These unique features have made SLBs and SLLs attractive to carbon-intensive industries and issuers/borrowers with limited green assets.

Moreover, the interest payment mechanisms of SLBs and SLLs are designed to align with borrowers' sustainable development goals. By conveying a company's commitment to achieving sustainable development goals and transiting towards net zero targets, these financings can highlight a borrower's core sustainability strategy and greenhouse gas management objectives. Successfully achieving the goals set in SLBs/SLLs can significantly enhance a company's reputation and reinforce the message to the outside world that the company is actively implementing its sustainable development plans.

## Transition is the Key

It is indeed possible for Taiwan to transform for transition.

For Taiwan to achieve its net zero ambition, the transition of the corporate and manufacturing sector is also pivotal, in addition to renewable energy development. It is essential for banks to play an active role in this journey and closely collaborate with their clients to reach the common goal.

Other than the indirect impact of achieving sustainability through providing sustainability-linked financing, transition finance aims for the same goal in a similar way — it helps borrowers obtain funding to address environmental issues related to their operations and transform their operational model towards a more sustainable future for both the environment and their business.

This concept does not develop organically. For corporate investments in climate transition and for business transformation, critical success factors include the sense of necessity and intensive collaboration between the bank and the client at almost every step involved. Crédit Agricole CIB's experience shows that when introducing sustainable practices to clients, more often than not, clients initially prefer to exercise caution due to reasons such as doubting the imminence of climate change, lacking confidence in achieving goals, or considering the transition as expensive. After presenting success stories from their peers and proving that spending on sustainability is a valuable investment rather than an expense, clients start to be convinced and agree to take action together. Over time, such successes build momentum for other players across industries to follow suit.

Our continuous interaction with the government and high-carbon-emission industries have also borne fruit. For years, we observed that in Taiwan, many of our clients find net zero targets challenging due to the nature of their operations and the limited implementable solutions or available resources.

We have persistently explored these difficulties with partners, and starting from 2022, various infrastructure (government-level green taxonomy, carbon credit market, etc.) and solutions (sustainability-linked loans and bonds, climate transition finance, etc.) have been introduced to make sustainable finance more accessible. Technological development is also making some carbon reduction methods either possible or more affordable.

Crédit Agricole CIB has a wealth of experience to share on this front. We have collaborated with clients towards climate transition targets in areas such as renewable energy usage, introducing new process/products for carbon reduction, energy storage, and global expansion to realise the green economy's potential. We have also arranged over €1 billion in financing for clients' technological development and global expansion for low-carbon cement and electronic vehicle components production to support their transition ambitions.

## Net Zero Goes Beyond Corporate Effort — We Need to Support Society to Work Towards the Common Target Through Closer Collaboration

Last but certainly not least, society's awareness of climate change and the importance of achieving Net Zero are essential factors that determine the success or failure of all the abovementioned efforts. Communication and engagement are crucial, and banks need to act.

Crédit Agricole CIB addresses this through active advocacy for climate transition and Net Zero. We have acted as organisers, sponsors, keynote speakers, guest lecturers, panel speakers, and contributors to projects/articles in more than 30 events from 2022 to 2024. In these engagements, we typically highlight how having a transition plan can reduce risks, the best practices to achieve sustainability goals, and suggest implementable actions. We communicate through targeted, in-depth workshops with other parties sharing the ambition, and engage directly with decision makers (such as financial regulators) to ensure the topics are relevant.

We also provide climate risk and biodiversity training to staff and our communities, such as students in Lycée International Français de Taipei. This is part of an ongoing effort to promote sustainability so that everyone works towards the common goal, and spreads knowledge to the young generation.

Another strategy is to encourage and implement collaborative efforts among related stakeholders. One example is our bank's issuance of the innovative solidarity-based green bonds. These bonds issues combined two separate but correlated concepts to address major sustainability challenges — supporting the growth of renewable energy in Taiwan through the use of bond proceeds and sustaining efforts to mitigate plastic pollution in oceans globally through a separate solidarity-based contribution to NGO Plastic Odyssey. The unique solidarity-based feature arises from collective efforts and a shared partnership among bond investors, joint-lead managers and Crédit Agricole CIB. After the bond issuance, a monetary contribution calculated as the aggregate of (1) the issuer's savings thanks to investors' concessions, (2) the issuer's savings due to joint lead managers' concessions in bonds offering, and (3) additional concessions provided by Crédit Agricole CIB Taipei branch, will be provided to Plastic Odyssey.

From 2021 to 2024, we partnered with more than 10 Taiwanese financial institutions and contributed more than TWD 5 million towards the global ambition of preserving biodiversity and supporting the circular economy.



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**Chief Executive Officer**
**Crédit Agricole CIB**
**Taipei Branch**

Laurent Potin is the Chief Executive Officer for CACIB Taipei Branch. He oversees all business activities and operations of the bank in Taiwan.

After starting his career in the audit and consulting industry, Laurent Potin joined the Crédit Agricole Group in France in 1999 within the Internal Audit teams dedicated to capital markets activities. In 2004, he was appointed Head of Structured Euro Medium-Term Note desk within the Global Markets Division, and relocated to Tokyo in 2007 to become Regional Chief Operating Officer for Interest Rates Derivatives activities in Asia. Laurent was most recently Head of Business Development and Chief Operating Officer of the Global Markets Division in Japan.



# The Role of Financial Institutions and the Transition Challenges Facing the Taiwanese Government and Enterprises from the Perspective of the Climate-related Disclosure Framework

Risk Society and Policy Research Center (RSPRC), National Taiwan University

As climate change worsens, achieving net zero emissions has become a global consensus to mitigate the irreversible impacts of rising temperatures. Consequently, various climate-related policies and regulations have been introduced domestically and internationally, challenging Taiwan's carbon-intensive industries to transform. According to the AON 2024 Climate and Catastrophe Insight Report, economic losses due to multiple climate disasters in 2023 reached record highs, with only 31% of these losses covered by insurance, leaving a protection gap of nearly 70% (AON, 2024). As the impacts of physical and transition risks grow, the financial sector is expected to support the transition by helping companies located in climate-vulnerable areas improve their adaptation capabilities and by directing investments towards energy-intensive and high-emission industries to promote low-carbon innovation and strengthen climate resilience.

## Taiwan's Alignment with International Policies for Climate-Related Disclosure

To address operational and financial impacts of climate change on industries and the financial sector and provide investors, banks, and insurance companies with a unified standard for assessing the climate risks companies face, the Financial Stability Board established the Task Force on Climate-related Financial Disclosures (TCFD) in 2015, which issued its recommendations in 2017. In response to international trends, Taiwan's regulatory authorities have, since 2021, progressively required domestic banks, insurance companies, and listed companies to disclose climate-related information starting from 2023. In June 2023, the International Sustainability Standards Board (ISSB) issued the sustainability disclosure standards IFRS S1 (General Requirements for Disclosure of Sustainability-related Financial Information) and IFRS S2 (Climate-related Disclosures). Taiwan's Financial Supervisory Commission (FSC) promptly followed suit by announcing in August 2023 a blueprint for Taiwan's alignment with the IFRS sustainability disclosure standards. Consequently, listed companies with capital over NT$10 billion are expected to adopt these standards starting in 2026.

Domestic and international trends show that climate-related disclosures are gradually moving from voluntary to mandatory regulations. This shift significantly challenges Taiwan, where climate governance has lagged. The Risk Society and Policy Research Center (RSPRC) at National Taiwan University has been conducting the Survey on Taiwanese Companies' Actions on TCFD-aligned Disclosures since 2022, targeting Taiwanese companies with annual revenues exceeding NT$100 million. Over 3 consecutive years, this survey has deepened the discussion on climate risk assessment and disclosure within Taiwanese companies and presented analytical results underscoring the challenges the government and businesses face regarding overcoming the delays in achieving net zero transition (RSPRC, 2024).

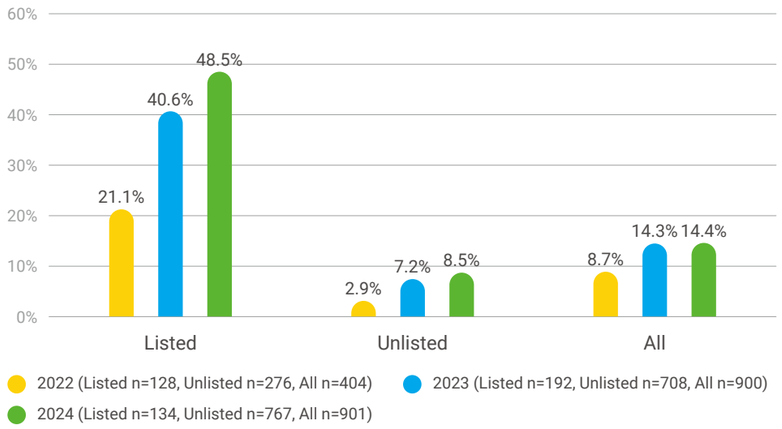


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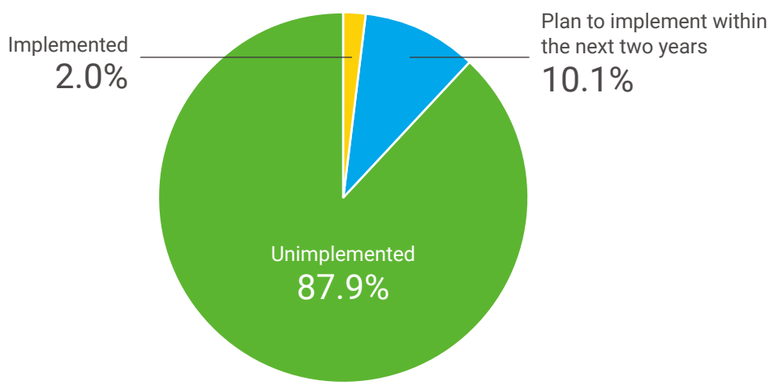
## Delays in Carbon Pricing and Energy Transition Lead Companies to Inaction

A comprehensive analysis of the past 3 years of survey results shows that policies and regulations are critical drivers of domestic companies' climate actions. Since 2020, Taiwan's Financial Supervisory Commission has promoted the Green Finance Action Plan 2.0, Corporate Governance 3.0, and sustainable development roadmap for listed companies. These policies have provided clear pathways for greenhouse gas inventories and verifications, leading to a gradual increase in climate-related disclosures. However, the implementation of the carbon pricing system has been repeatedly delayed, and progress on the review of the major electricity consumer clause of the Renewable Energy Development Act has fallen behind schedule. Consequently, companies remain cautious and delay acting. Only a few companies have introduced internal carbon pricing, indicating that most have not effectively integrated carbon costs into their governance and decision-making processes, which has stalled the progress of low-carbon initiatives and energy transitions. Furthermore, because many of Taiwan's key industries are part of the global supply chain, the inability to establish a domestic low-carbon energy environment in alignment with international brands' requirements could cost Taiwan's industries their competitive edge.

### Task Force on Climate-Related Financial Disclosures



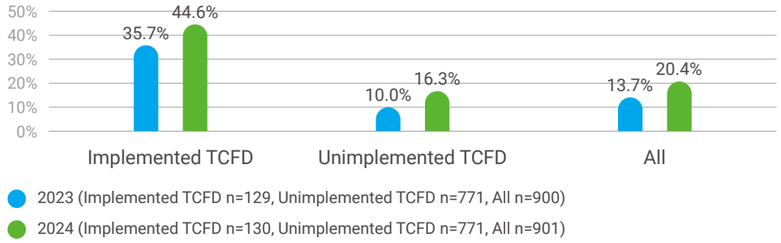

### Internal carbon pricing (2024, n=130)




## The Lack of a Low-Carbon Innovation Culture Among Businesses

Companies have made little progress regarding conducting mid-to long-term climate risk assessments, financial impact evaluations, and scenario analyses, which has rendered developing resilient and forward-thinking systematic strategies difficult. Businesses face talent development challenges, and there has been little effort to link compensation with climate-related performance, thus preventing the embedding of climate consciousness into corporate culture. Most companies have yet to seize the climate opportunities and formulate effective strategies for the low-carbon transition. However, cross-analysis reveals that companies that follow the TCFD framework are more likely to engage in low-carbon innovation. This indicates that adhering to the TCFD framework helps companies better identify and assess climate-related risks and opportunities, enabling their early action on low-carbon strategies and their avoidance of exclusion from the global low-carbon supply chain.

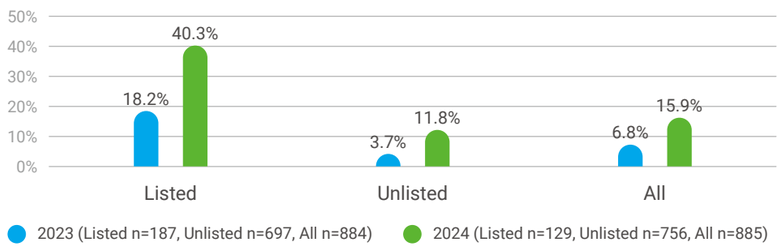
### Low-carbon innovation




## Financial Institutions as Key Enablers

Taiwan's financial sector, in alignment with regulatory policies, plays a key role in helping businesses respond to climate change. A growing number of listed companies have received requests from financial institutions to provide climate-related information, such as sustainability reports, electricity consumption and greenhouse gas emissions data, with this trend increasing significantly compared to the previous year. Financial institutions are also adopting multifaceted strategies, offering climate finance products, requiring climate-related information disclosure, and creating favorable financing conditions that encourage innovation in low-carbon products and processes. Therefore, they play a key role in facilitating businesses' transition to a low-carbon future.

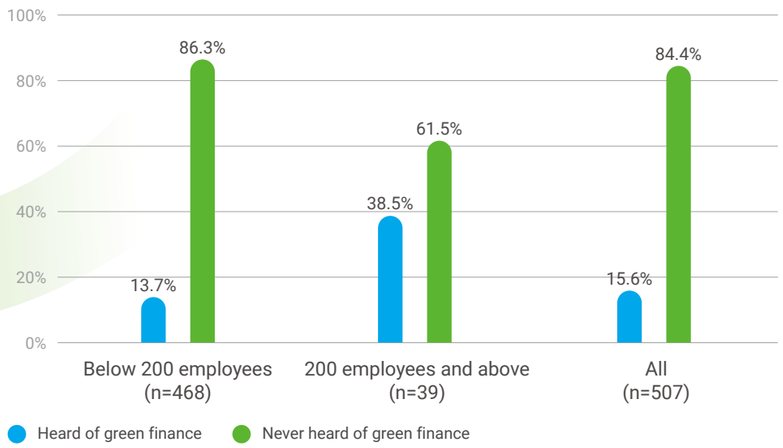
### Has been requested by financial institutions to provide climate-related information



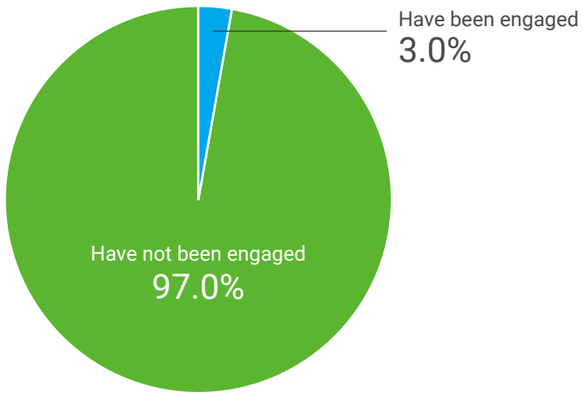
## The Green Finance Impact Excludes Small and Medium-Sized Enterprises (SMEs)

In 2024, the RSPRC conducted its first Survey on the Impact of Green Finance on High-Emission Industries. The survey targets Taiwanese companies with paid-in capital of over NT$5 million and uses stratified sampling based on industry proportions. The results indicate that most SMEs have not even heard of green finance, revealing that, despite steady green finance policy implementation, smaller companies have been largely unaffected, which may hinder large companies' efforts to reduce carbon emissions across the entire supply chain. In addition to the policies' limited impact on SMEs, financial institutions have been slow to engage with businesses on climate-related issues. Only a few surveyed companies report that financial institutions have begun paying attention to their carbon inventory, net zero pathway planning, low-carbon production technology and other issues. Nonetheless, research analysis shows that climate-related engagements with financial institutions positively affect corporate climate disclosures and carbon reduction actions. Financial institutions should integrate climate-related engagements in their daily operations and key performance indicators to motivate companies to adopt carbon reduction strategies.

### Green finance




### Climate-related engagement (n=507)

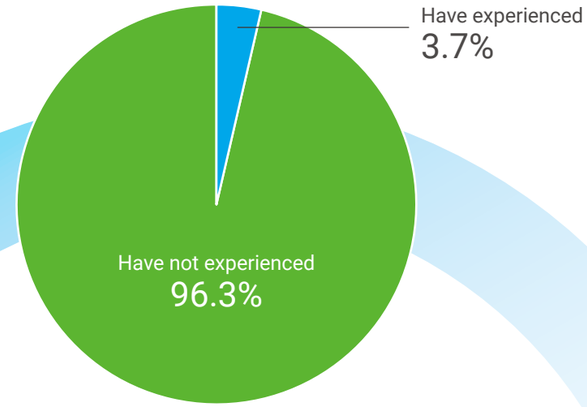



## Financial Institutions have Yet to Fully Integrate Climate Risks into Business Processes

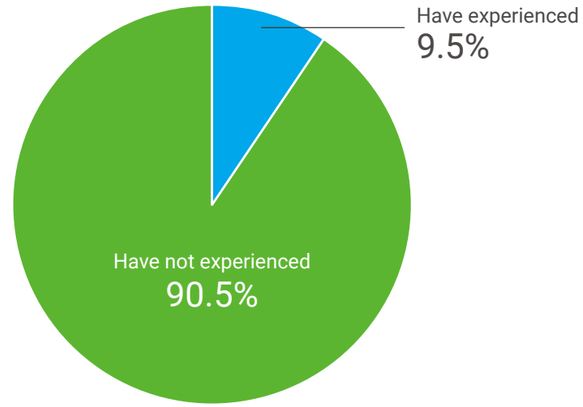
The survey results also show that a small number of companies that have sought financing or insurance for land, buildings, and machinery have experienced adjustments in their financing plans or insurance premiums by financial institutions due to considerations of past climate disasters and future risks. This suggests that companies should proactively identify climate-related risks, assess their potential impacts, and develop concrete adaptation strategies and practices to negotiate better terms with financial institutions. Overall, financial institutions currently place low demands on companies, indicating that climate risks have not yet been fully integrated into their core business strategies and internal decision-making processes. The analytical results suggest that bank financing support positively impacts businesses' investments in sustainable economic activities. The financial sector is urged to increase its capital allocation to companies that are actively engaged in low-carbon activities to drive the real economy's broader transition towards low-carbon sustainability.

### Have experienced adjustments by financial institutions due to considerations of physical risks

#### Adjustments in financing plans (n=507)




#### Adjustments in insurance premiums (n=507)



## Conclusion

The RSPRC conducted a comprehensive analysis of the differences and challenges that businesses face in climate governance, risk assessment, and low-carbon practices, using the climate-related disclosure framework as a starting point. The findings highlight the gap between government and corporate governance in the transition process. Although the Financial Supervisory Commission's clear guidance has gradually driven companies to disclose climate-related information, the government lacks forward-looking governance planning for a carbon pricing system and low-carbon energy, and financial institutions have yet to incorporate climate risk assessment into their overall business strategies, rendering the industry transition challenging. In the face of climate change challenges, financial institutions should actively enhance their engagement with companies and provide financial support and insurance coverage to accelerate corporate transitions to net zero and climate adaptation. However, the drive still requires integrated and coherent government low-carbon transition governance and mutual support to build a climate and cultivate a net zero innovation ecosystem and expand financial influence.

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The Risk Society and Policy Research Center (RSPRC), National Taiwan University

The Risk Society and Policy Research Center (RSPRC), National Taiwan University, is devoted to studying the transition to a low-carbon society and its governance. RSPRC encourages dialogue across society by sharing its academic research result in various channels. In this era of climate emergency, the transition to sustainable energy and development is a pressing need. RSPRC's research provides a social science perspective to aid governments, businesses, and civil organizations in developing innovative governance frameworks and policy proposals. Recently, RSPRC has also incorporated sustainable finance research, aligning with international SDGs and ESG benchmarks. Our goal is to achieve the Net-Zero Emission goal by 2050 by embracing diverse fields and connecting with global communities and ensuring an inclusive path of just transition that leaves no individual or community behind.

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# Development and Challenges of Carbon Capture and Storage in the Power Industry

**Chung Nien-Mien**, General Manager, Taiwan Power Research Institute (TPRI), TPC

Carbon Capture and Storage (CCS) is a technology that captures carbon dioxide emissions from industrial sources, separates it, and transports it to a suitable location for underground storage. It can effectively reduce large-scale emission sources such as carbon dioxide emitted by thermal power plants, chemical plants, and the natural gas extraction industry, among others. In recent years, technologies have expanded beyond CCS to include capturing carbon dioxide from the atmosphere, known as Direct Air Capture (DAC) for short, as well as Bioenergy with Carbon Capture and Storage (BECCS), which incorporates biomass energy to achieve the benefits of negative emissions.

According to the International Energy Agency's (IEA) proposal for global Net Zero Emissions (NZE), CCS accounts for 20% of total carbon reduction. This demonstrates the technology's significance in the carbon reduction pathway [1]. According to the "Taiwan's Pathway to Net Zero Emissions in 2050" published by the National Development Council in March 2022, Taiwan must achieve capture and storage of 40 million metric tons of carbon dioxide by 2050. Thermal power units with CCS installed should achieve a power generation ratio of 20–27%, according to the electric power industry's recommendations. Both show that CCS has a significant impact on carbon reduction both domestically and internationally [2].



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In the context of the electric power industry's development, CCS can be broadly classified into three roles. First, carbon capture factories are designed to target a single power plant; second, fossil fuel hydrogen technology is used to produce blue hydrogen; and third, DAC and biomass energy technology are combined to achieve negative emissions. This paper will explain the three roles outlined below.

First, carbon capture plants must be installed in thermal power plants to separate and capture the carbon dioxide released in the flue gases. This method can be used in power plants that generate power from various fuels and is commonly used in units that provide base load power generation. Improving their capacity factor can effectively and simultaneously reduce capital expenditure (CAPEX) for both. This, in turn, avoids the Levelized Cost of Electricity (LCOE) and the Cost of Avoided Carbon. However, because carbon capture falls under energy consumption procedures, when both economic and energy consumption benefits are considered, 85–95% carbon emission in the design of a capture power plant's emission sources proves to be a more economically viable ratio.

Secondly, as fossil fuels are converted into hydrogen, the process generates carbon dioxide, which is eliminated through CCS. Blue hydrogen is the term used to describe the hydrogen produced by this method. It has the potential to partially replace natural gas as the fuel for the current gas turbine generator set, thereby reducing carbon emissions. Internationally, the co-firing of hydrogen and natural gas at a rate of less than 30 vol.% is generally permissible in newer natural gas turbine generator sets, such as the Siemens SGT-6000G [3]. In general, this approach is more appropriate for units that are employed in frequency modulation (FM) or peak load power generation units. Carbon reduction is also reduced as the blue hydrogen mix ratio is increased. Carbon emissions can be reduced by 25% if 30% vol.% of blue hydrogen replaces natural gas in a gas turbine generator unit.

Thirdly, in addition to the negative emission benefits provided by DAC or biomass energy power generation plants, the installation of CCS compensates for the carbon emissions that are unlikely to be prevented by the two aforementioned technologies. The most well-known example of DAC is Iceland's Orca, while biomass energy combined with carbon capture is exemplified by Archer-Daniels-Midland Company's (ADM) ethanol plant in Illinois, United States.

CCS is not a new technology; the natural gas extraction industry first used it in the 1970s. However, a look at the international electric power industry reveals that only SaskPower's Boundary Dam Plant in Canada and NRG Energy Company's Petra Nova Plant in the United States are currently available, totaling two coal-fired power plants. Around 2013, commercial-scale carbon capture (with a carbon capture quantity greater than one million metric tons per year) was introduced. The main challenge was the high carbon capture facility setup and costs, with the funds for both plans totaling $1.5 billion and $1 billion, respectively. The unit carbon capture cost is between US$105 and US$70 [4 5] per ton of $CO_2$. To mitigate the high costs and facilitate the widespread adoption of CCS technology in the power industry, both projects received subsidies from local governments. However, the substantial volume of captured $CO_2$ poses another significant challenge, making it difficult to dispose of. Consequently, there is a pressing need for advanced storage technologies to address this issue. In recent years, as governments have gradually specified net zero carbon paths and objectives, policies such as carbon fees, carbon footprints, and international carbon transport, among others, have been gradually incorporated into regulations. A growing number of thermal power plants have begun to announce carbon capture, such as the coal-fired power generation units at Gerald Gentleman, United States, and the natural gas power generation units at Net Zero Teesside, United Kingdom, which have both started introducing CCS.



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Taiwan Power Company will face a challenge in the introduction of CCS into thermal power generation units: the impact of carbon capture on electricity prices. According to our company's CCS Technical Economic Analysis (TEA), the initial calculation shows that under the current technical context, 90% of carbon dioxide emitted by coal-fired and gas-fired units will result in 80% and 43% increases in levelized power generation costs, respectively. However, with technological advancement, there is still room for a decrease. As a result, Taiwan Power Company is currently preparing to establish small-scale carbon capture testing plants in order to first understand the challenges associated with introducing new technology into power plants (The CCS Campus at the Taichung Thermal Power Plant, Figure1). Our company developed two sets of carbon capture facilities (with an annual capture capacity of six metric tons of $CO_2$, (Figure2), which have been operational at the CCS Campus since 2019. They use chemical and physical absorption methods to remove carbon dioxide from flue gas emitted by coal-fired power plants. At the CCS Campus, there is also a small-scale carbon capture testing plant that captures 2,000 metric tons of $CO_2$ annually, a plant factory that captures carbon dioxide for utilization, an exhibition center that demonstrates Taiwan Power Company's carbon reduction process, and a technology that produces hydrogen through electrolysis and repurposes captured carbon dioxide to produce chemicals. The aforementioned will be completed and operational by 2025. Taiwan Power Company intends to invest in small-scale carbon storage demonstration projects, with an annual injection volume of 2,000 metric tons. In addition to the carbon dioxide captured by the aforementioned small-scale carbon capture testing plant, a series of CCS supply chain demonstration plans will be implemented.

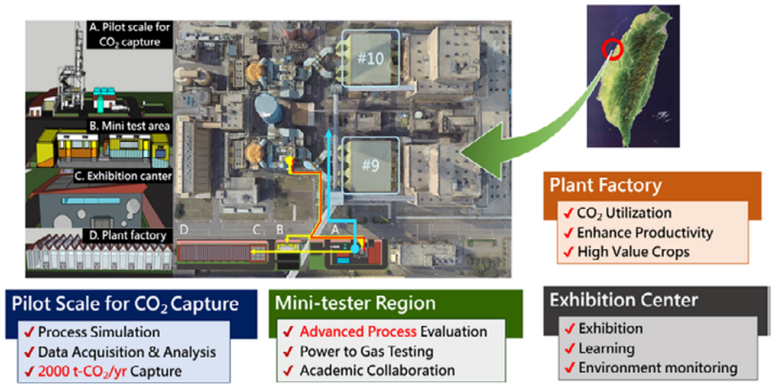



Figure 1 Taiwan Power Company's CCS Campus setup at the Taichung Power Plant




Figure 2 Carbon capture facilities independently developed by Taiwan Power Company. The photo on the left shows the chemical absorption facility; the photo on the right shows the physical absorption facility

Taiwan Power Company is actively involved in collaborative exchanges with academic and research institutions as well as foreign manufacturers to expedite the promotion of CCS. It aspires to aid existing power plants in the introduction of the aforementioned technology by leveraging mature foreign technology and experiences. The collaboration details include: the joint promotion and planning of the Taichung CCS Campus with Det Norske Veritas (DNV); conducting an early-stage feasibility assessment of Dalin Power Generation Plant's coal-fired units in collaboration with the U.S. company Kellogg Brown & Root (KBR); conducting an early-stage feasibility assessment of the Taichung Power Plant's gas-fired unit with the U.S. Electric Power Research Institute (EPRI); cooperation with the Central Research Institute of Electric Power Industry (CRIEPI) in the conduct of geophysical explorations; analysis of the geologic core samples extracted from the ChangBin Industrial Park, and so forth. The early-stage feasibility assessment of CCS technology was initiated on whole-plant coal-fired units this year with the LinKou plant as the target. (Figure 3)

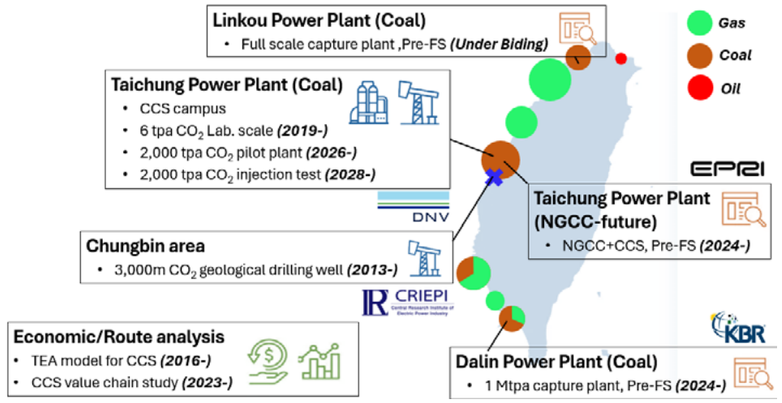



Figure 3 The current situation of Taiwan Power Company's international collaboration on CCS technology

CCS is a carbon reduction technology that has reached its highest level of maturity in existing thermal power plants. The introduction of this technology is expedited by Taiwan Power Company through the establishment of small-scale CCS testing and demonstration chains, acquiring international experience, the participation in collaboration exchanges, and the utilization of previous economic technical analyses. In the interim, the government can mitigate the risks associated with the establishment of carbon capture plants, thereby aiding in the attainment of the objective of net zero carbon emissions by 2050.

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## Taiwan Power Research Institute

The Taiwan Power Research Institute (TPRI), an affiliate of Taiwan Power Company (Taipower), serves as a research and testing institution with a pivotal role in spearheading technological advancement, functioning as a think tank for corporate strategy, and providing operational expertise. TPRI's strategic focus encompasses the formulation of short-, medium-, and long-term research plans for the company, the advancement of technological innovation and application, and the facilitation of cross-system collaboration in the promotion of pivotal projects. Additionally, the objective is to enhance customer service in order to meet future challenges.

In response to the energy transition and electricity industry reforms, TPRI provides Taipower with the essential research and testing services, investing in advanced power technology research and applications. By fostering collaboration between research and development and business operations, TPRI contributes to the company's sustained growth. Moreover, the institute advocates for the diversification of power technologies, integrating innovative strategies and startup accelerators to spearhead the upgrade and development of the power market and related industries.

In terms of operational activities, TPRI is aligned with government policies on energy transition and net zero emissions. This ensures a stable power supply, facilitates the integration of renewable energy and smart grid technologies, and promotes digital transformation and technological innovation. These activities are undertaken with the objective of achieving a sustainable zero-carbon future.






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- Researcher: Energy Research Laboratory, TPRI (Mar. 1999 –Nov. 2011)
- Nuclear Engineer: Electric Power Combined Research Institute (Nov. 1993–Mar. 1999)



## Capturing $CO_2$, An Essential Solution for Decarbonizing Industry

## Vision

More than 20% of the world's $CO_2$ emissions come from industry. Today, the challenge is to rapidly deploy concrete solutions that will significantly reduce these emissions. Among the technologies already available, carbon capture and sequestration (CCS) is a key solution for decarbonizing the industries with the highest emissions and those most difficult to decarbonize, such as cement, metallurgy, refining, and chemicals. These are also the sectors where this technology will have the greatest impact, as $CO_2$ concentrations are the highest.

The principle consists in capturing $CO_2$ emissions at the source, treating and purifying them, and then recycling or sequestering them in permanent geological storage. Large-scale CCS projects are being developed around the world, particularly in Europe and the United States, which together account for over 70% of global projects. Air Liquide is one of the leaders in this field, with its proprietary Cryocap™ technology, which captures, purifies, and liquefies $CO_2$ before it is transported to the sequestration site.



## Action

Air Liquide is involved in a number of large-scale CCS projects, particularly in Europe. In the Netherlands, where the government has set the ambitious target of reducing the country's greenhouse gas emissions by 95% by 2050, the Group is involved in the Porthos project, the Netherlands' largest $CO_2$ emissions reduction program. For Air Liquide, it consists in decarbonizing its own facilities by installing a Cryocap™ unit at its hydrogen production site in Rozenburg, near Rotterdam. The project also includes the construction of a pipeline which, from 2026, will transport the $CO_2$ emitted by several local plants through the port of Rotterdam to the North Sea, 20 km off the coast, where it will be sequestered at a depth of 3,000 meters in a depleted natural gas field.

In all, the Porthos project will contribute to reducing the emissions by 2.5 million tonnes of $CO_2$ per year, which represents about 10% of the $CO_2$ emitted by industrial activities in Rotterdam. Air Liquide is also involved in the K6 project, a partnership with cement manufacturer EQIOM. The aim is to make the Lumbres factory in northern France the first carbon-neutral cement plant in Europe, by capturing almost 8 million tonnes of $CO_2$ in the first 10 years of operation, thanks in particular to the Cryocap™ technology. In the same spirit, Air Liquide will also contribute to decarbonizing the Lhoist lime production plant in Réty, in the north of France.

Finally, as part of the D'Artagnan project, the $CO_2$ captured at the two plants will be transported to a temporary storage platform at the port of Dunkirk, from where it will be shipped to be then sequestered between 1,000 and 2,000 meters below the North Sea. By 2027-2028, the D'Artagnan project will contribute to the reduction of emissions by 1.5 million tonnes of $CO_2$ per year.

The Group also participates in many other initiatives of the kind in Europe, such as the Kairos@C, Antwerp@C, $ECO_2$ Normandie and Callisto projects. These large projects show Air Liquide's expertise and commitment to providing solutions to decarbonize both its own and its customers' assets.





## Author

**Air Liquide Far Eastern**

Air Liquide is a world leader in gases, technologies and services for industry and healthcare. Present in 60 countries with 66,300 employees, the Group serves more than 4 million customers and patients. Oxygen, nitrogen and hydrogen are essential small molecules for life, matter and energy. They embody Air Liquide's scientific territory and have been at the core of the Group's activities since its creation in 1902.

Taking action today while preparing the future is at the heart of Air Liquide's strategy. With ADVANCE, its strategic plan for 2025, Air Liquide is targeting a global performance, combining financial and extra-financial dimensions. Positioned on new markets, the Group benefits from major assets such as its business model combining resilience and strength, its ability to innovate and its technological expertise. The Group develops solutions contributing to climate and the energy transition—particularly with hydrogen—and takes action to progress in areas of healthcare, digital and high technologies.

Air Liquide's revenue amounted to more than 27.5 billion euros in 2023. Air Liquide is listed on the Euronext Paris stock exchange (compartment A) and belongs to the CAC 40, CAC 40 ESG, EURO STOXX 50, FTSE4Good and DJSI Europe indexes.

Established in 1987, Air Liquide Far Eastern (ALFE) is a prominent joint-venture between Air Liquide Group, a global leader in gases, technologies, and services for Industry and Health, and Far Eastern New Century Group. In recent years, ALFE has emerged as the top French company in terms of investment in Taiwan's manufacturing industry. Presently, ALFE boasts a workforce of over 780 employees and maintains a strong presence with 40 offices and plants located in Taipei, Hsinchu, Taichung, Tainan, Kaohsiung, as well as the major Science Parks across Taiwan.



# Integration of Net Zero Emissions and Circular Economy: The Potential for Wastes Used in Carbon Capture and Utilization

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## Introduction of Net Zero Emissions

Greenhouse gases (GHGs) are gases that can absorb and emit infrared radiation. These gases play a crucial role in the atmosphere by maintaining a temperature suitable for life. When solar radiation (primarily shortwave radiation) passes through the Earth's atmosphere and is released back into the atmosphere as longwave radiation (infrared), the greenhouse gases in the atmosphere (such as carbon dioxide, methane, and water vapor) can absorb this longwave radiation and re-radiate part of the energy back to the Earth's surface [1]. By absorbing energy, greenhouse gases help to keep the Earth's average surface temperature around 15°C. Without greenhouse gases, the Earth's surface temperature would drop to about -18°C.

However, when human activities lead to an excessive increase in the concentration of greenhouse gases in the atmosphere, it triggers an enhanced greenhouse effect. The most common greenhouse gases emitted in significant quantities by humans include carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), and fluorinated gases (F-gases). These gases are primarily produced by burning fossil fuels, deforestation, livestock farming, and industrial activities. Although the concentration of these greenhouse gases is relatively low compared to other components in the atmosphere, they cause a shift in the Earth's energy balance, leading to a series of climate change phenomena such as global temperature rise, sea level rise, and an increase in extreme weather events [2].



Currently, $CO_2$ is the most significant greenhouse gas emitted by human activities. Its atmospheric concentration has risen from 280 ppm before the Industrial Revolution to 420 ppm, causing the Earth's temperature to increase by approximately 1.4°C [3]. Due to the impact of atmospheric $CO_2$ concentration on climate change, the Intergovernmental Panel on Climate Change (IPCC) has called for a reduction of at least 43% in global carbon emissions by 2030 to limit the average temperature increase to within 1.5°C and for achieving net zero emissions by 2050 [4 5]. To reach the goal of net zero emissions, the International Energy Agency (IEA) has published a Net Zero Emissions roadmap (Figure 1). As shown in the roadmap, the focus before 2035 is on energy transition and industrial restructuring, while after 2035, significant efforts in carbon capture, utilization, and storage (CCUS) technology will be required, with a target capture volume of approximately 7.6 Gt [6].

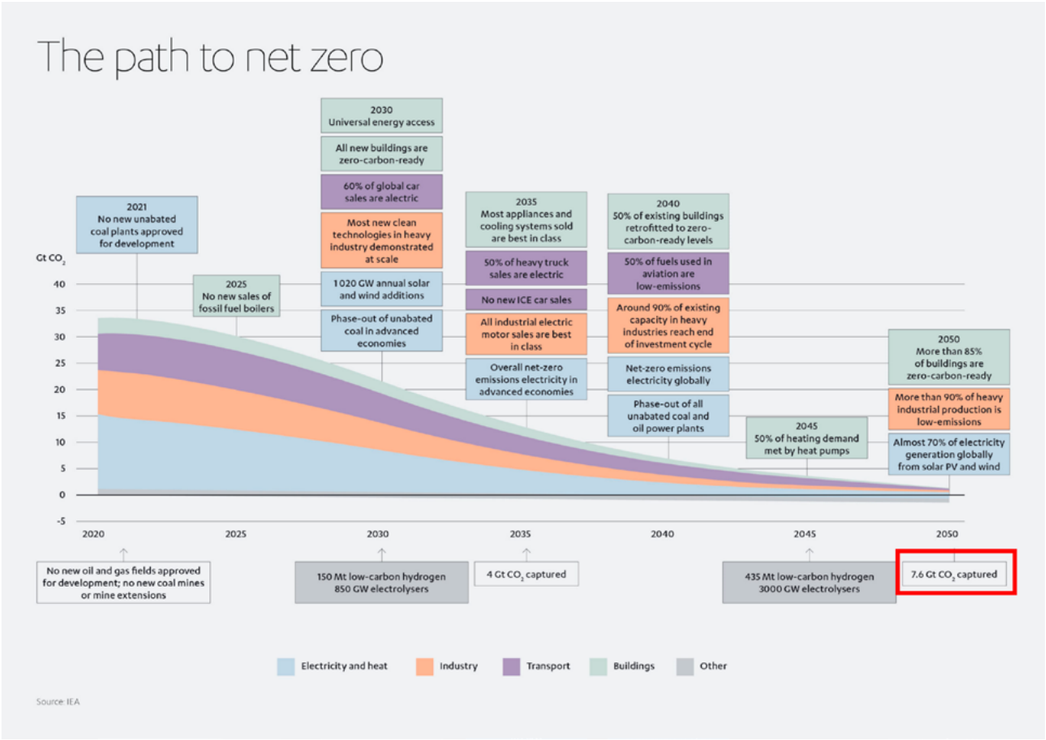



Figure 1 The roadmap of Net Zero Emissions

## Carbon Capture, Utilization and Storage (CCUS)

CCUS is a technique that captures $CO_2$ emitted from factories or the atmosphere and injects it underground for storage or reutilizes it for various uses. The introduction of capture, utilization, and storage are introduced as follows:

- **Carbon Capture** [7]: It involves separating $CO_2$ from emission sources in industrial processes or the burning of fossil fuels. The main methods are post-combustion capture, pre-combustion capture, and oxy-fuel combustion (Figure 2). Post-combustion capture refers to the technology of capturing $CO_2$ from flue gases after the combustion process has finished. This method typically involves using absorbents to separate $CO_2$ from the flue gas. Pre-combustion capture involves converting the fuel into syngas (a mixture of hydrogen and carbon monoxide) before combustion. CO can be used as fuel and later separated in the form of carbon dioxide or used as a raw material for other chemicals. $H_2$ can also be used as a clean energy source, reducing $CO_2$ emissions. This method is typically used in coal gasification or natural gas reforming processes. Oxy-fuel combustion separates oxygen from air before combustion, using high-purity oxygen for burning, which results in a flue gas with a higher concentration of $CO_2$. This makes $CO_2$ easier to use and store. Common separation technologies used in these processes include absorption (physical and chemical), adsorption (physical and chemical), membrane separation, chemical looping combustion, and cryogenic distillation, among others [8].

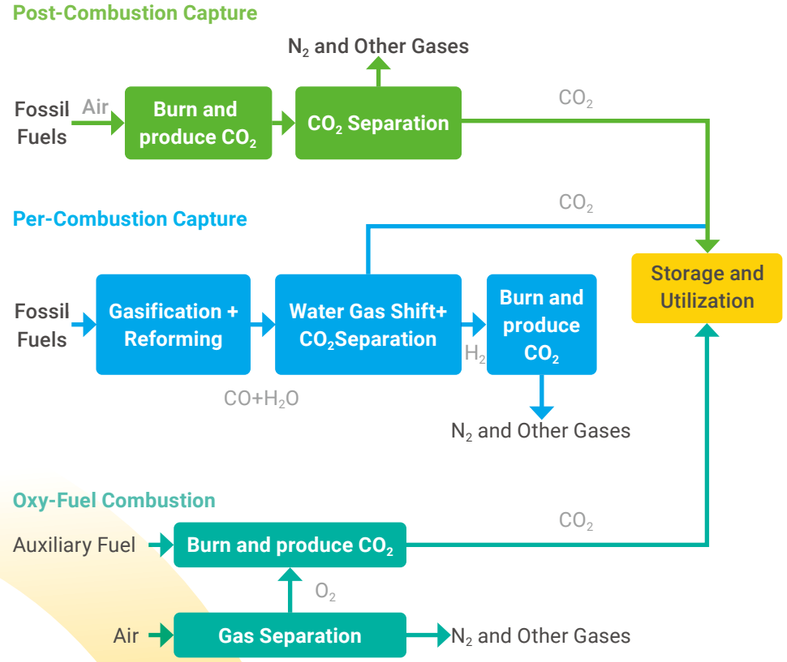



Figure 2 Flowcharts of post-combustion capture, pre-combustion capture, and oxy-fuel combustion

- **Utilization:** $CO_2$ can be converted into other valuable products. For example, it can be used to enhance oil and gas recovery (EOR) or to produce chemicals or inorganic materials (Figure 3) [9]. If we take manufacturing chemicals as an example, $CO_2$ can be transformed into high-value products such as chemicals, fuels, and polymers through various processes, including thermochemical, electrochemical, and photocatalytic methods. Photocatalytic $CO_2$ reduction stands out among these techniques because it uses solar energy, a renewable resource, to convert $CO_2$ into valuable chemicals like formic acid, methanol, ethanol, acetic acid, and hydrocarbons. This process mimics natural photosynthesis by using sunlight to transform $CO_2$ and water into valuable chemicals. Semiconductor materials like metal oxides, metal sulfides, and recently carbon-based photocatalysts are key to this process. The choice of catalyst, reaction conditions, and co-catalysts are critical for improving the efficiency and selectivity of $CO_2$ reduction. Additionally, integrating biomass such as glucose or cellulose with $CO_2$ reduction can make the process greener and more effective, simultaneously breaking down biomass and reducing $CO_2$ into valuable chemical products.

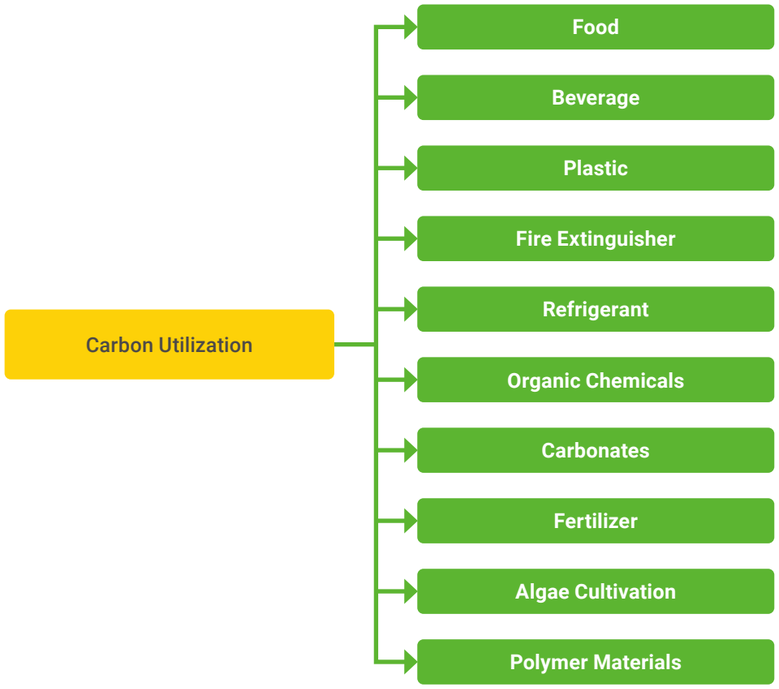



Figure 3 Applications of carbon capture and utilization

- **Storage:** If $CO_2$ cannot be effectively utilized, it can be stored long-term in geological structures, such as underground saline aquifers or depleted oil and gas fields, to prevent it from re-entering the atmosphere [10]. $CO_2$ storage methods are mainly divided into surface mineralization, ocean, and geological storage. Mineralization storage involves chemically reacting $CO_2$ with certain naturally occurring minerals to convert it into stable carbonate minerals for permanent storage. Ocean storage involves injecting $CO_2$ into the deep sea and storing it in solid or liquid form in the ocean's vast capacity. Geological storage involves injecting $CO_2$ into deep underground rock formations or depleted oil and gas fields, where it is permanently stored by geological structures [11].

## Development of Technologies for Carbon Capture and Utilization Through Wastes

Since not all regions have suitable geological conditions for carbon storage and some communities are concerned about underground conditions, particularly regarding potential environmental risks and impacts on local communities, many countries and companies are focusing on developing carbon capture and utilization technologies [12,13].

Following capture, $CO_2$ can be effectively utilized through a range of processes, including the creation of carbonates (mineral carbonation), organic chemical production, fuel synthesis, carbon fiber and polymer materials, and the food industry. Among these, mineral carbonation stands out for its versatility. This process, where $CO_2$ reacts with alkaline earth metals or alkali metals like calcium, magnesium, sodium, and potassium to form carbonates, offers numerous advantages. The raw materials for mineral carbonation, such as calcium-magnesium silicate minerals, are abundant on Earth, giving this technology broad application potential and making it less region-specific. Mineral carbonation does not produce harmful byproducts, and the reaction process is spontaneous, making it environmentally friendly. The final products can be employed in various fields, such as construction materials and soil improvement, further reducing resource extraction [14,15]. Moreover, since many types of waste are rich in elements like calcium, magnesium, sodium, and potassium (alkaline wastes), various industrial waste products can be utilized, allowing for both the treatment of industrial byproducts and the capture and reuse of $CO_2$, thus achieving the goals of net zero emissions and a circular economy [16].

Commonly used alkaline waste for carbon capture and utilization include fly ash, steel slag, cement kiln dust, concrete waste, and desalination brine [14,17,18]. Alkaline solid waste such as fly ash, steel slag, cement kiln dust, and concrete waste can be mineralized through direct or indirect mineral carbonation methods [14]. Direct mineral carbonation can be further divided into gas-solid direct carbonation and gas-liquid-solid direct carbonation. Gas-solid direct carbonation is the most basic and straightforward carbonation method, occurring in a single-step process where purified $CO_2$ directly reacts with the alkaline waste to form carbonates (Equations 1 and 2). However, since this reaction is exothermic and relatively slow, the low reaction rate is a major drawback of gas-solid direct carbonation. On the other hand, gas-liquid-solid direct carbonation involves the reaction of alkaline waste with $CO_2$ in the presence of water or steam. In this process, $CO_2$ first reacts with water vapor to form carbonic acid, which then reacts with alkaline waste to produce calcium and magnesium ions. After that, carbonates can be formed through calcium, magnesium, and carbonate ions (Equations 3 to 6). Although gas-liquid-solid direct carbonation can increase the reaction rate and the purity of the resulting carbonates, carbonic acid often does not fully acidify and dissolve the alkaline solids in this method, leading to lower yields and lower purity of the produced carbonates [14].

- **Equation 1:**

  $(Ca, Mg, Fe)O_{(s)} + CO_{2(g)} \rightarrow (Ca, Mg, Fe)CO_{3(s)}$

- **Equation 2:**

  $(Ca, Mg)SiO_{3(s)} + CO_{2(g)} \rightarrow (Ca, Mg)CO_{3(s)} + SiO_{2(s)}$

- **Equation 3:**

  $CO_{2(g)} + H_2O_{(aq)} \rightarrow H_2CO_{3(aq)}$

- **Equation 4:**

  $H_2CO_{3(aq)} \rightarrow H^+_{(aq)} + HCO_3^{2-}{}_{(aq)}$

- **Equation 5:**

  $(Ca, Mg)^{2+}_{(aq)} + HCO_3^{2-}{}_{(aq)} \rightarrow (Ca, Mg)CO_{3(s)} + H^+_{(aq)}$

- **Equation 6:**

  $(Ca, Mg)^{2+}_{(aq)} + CO32^-_{(aq)} \rightarrow (Ca, Mg)CO_{3(s)}$

To address this issue, the concept of indirect carbonation has been proposed. Indirect carbonation consists of two separate stages. The first stage involves dissolving calcium and magnesium from alkaline waste using acidic substances such as acetic acid, ammonium sulfate, ammonium chloride, hydrochloric acid, sulfuric acid, or ethylenediaminetetraacetic acid (EDTA). The second stage involves the carbonation process (Equations 7 and 8). Indirect carbonation can enhance the reaction rate, allow the reaction to proceed under ambient pressure, and require less energy than direct carbonation. Furthermore, during the dissolution process in the first stage, parameters such as acid concentration, dissolution time, and temperature can be controlled to separate alkali or alkaline earth metals from other impurities. As a result, high-purity calcium and magnesium solutions can be used in the second carbonation stage, achieving high purity and high yield [14].

- **Equation 7:**

  $CaO_{(s)} + 2CH3COO^-_{(aq)} \rightarrow Ca^{2+}_{(aq)} + 2CH_3COO^-_{(aq)} + H_2O_{(aq)}$

- **Equation 8:**

  $Ca^{2+}_{(aq)} + 2CH_3COO^-_{(aq)} + CO_{2(g)} + H_2O_{(aq)} \rightarrow CaCO_{3(s)} + 2CH_3COOH_{(aq)}$

Desalination brine, a byproduct of the seawater desalination process, can also be utilized for carbon capture and utilization. However, the carbonation methods applied for desalination brine are different from those used for typical alkaline solid waste due to the unique properties of the brine. With a salt concentration 2-10 times higher than regular seawater, it can lead to increased salinity and decreased oxygen levels in the marine environment if not managed properly [19]. Because of its high concentrations of alkali and alkaline earth metals, it is considered a potential waste material suitable for mineral carbonation. The methods used for mineral carbonation of desalination brine are Solvay Process and amine-based carrier methods [20 21 22 23].

The Solvay Process is a primary method for industrial production of sodium carbonate. This method is favored due to the cheap and readily available raw materials: brine (from rock salt or sea salt) and limestone (Equations 9 to 13 and Figure 4). Consequently, 75% of the world's sodium carbonate production comes from Solvay Process-based chemical plants [24]. The relevance of the Solvay Process to desalination brine and carbon capture is shown in Equation 10. Since brine contains high concentrations of sodium chloride, additional ammonia is required to carry out this step and produce sodium bicarbonate, which can then be used in the food industry or algae cultivation, among other applications. Moreover, the role of ammonia in Equation 10 is to provide an alkaline environment to absorb $CO_2$, so different amines can be applied based on specific needs, or even alkaline solids like calcium oxide or potassium oxide can be employed. When different amines or alkaline substances are utilized, the process is called the Modified Solvay Process [25].



- **Equation 9:**

  $CaCO_3 \rightarrow CaO + CO_2$

- **Equation 10:**

  $NaCl + NH_3 + CO_2 + H_2O \rightarrow NaHCO_3 + NH_4Cl$

- **Equation 11:**

  $2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$

- **Equation 12:**

  $CaO + H_2O \rightarrow Ca(OH)_2$

- **Equation 13:**

  $Ca(OH)_2 + 2NH_4Cl \rightarrow CaCl_2 + 2NH_3 + 2H_2O$

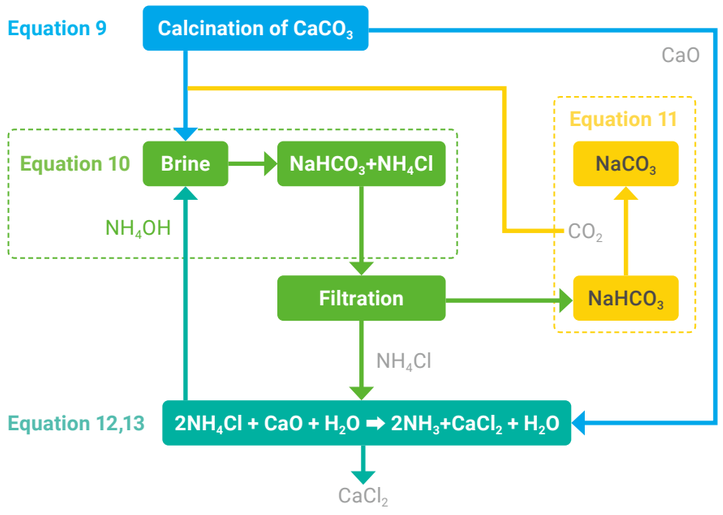



Figure 4 Flowchart of Solvay Process

The amine-based carrier method first involves adjusting the brine's pH to between 10 and 12 using the pH Swing Method to precipitate magnesium hydroxide ($Mg(OH)_2$) and calcium hydroxide ($Ca(OH)_2$). Subsequently, amine-based liquids are used as carriers to adsorb $CO_2$, and magnesium hydroxide and calcium hydroxide are added to the solution for reaction (Equation 14). Since $CO_2$ is easily absorbed by amine liquids, $Mg(OH)_2$ and $Ca(OH)_2$ in the solution can be converted into magnesium bicarbonate ($MgHCO_3$) and calcium bicarbonate ($CaHCO_3$) through this reaction. Subsequently, carbonate ($MgCO_3$) and calcium carbonate ($CaCO_3$) can be obtained through heating.

- **Equation 14:**

  $(Ca,Mg)(OH)_{2(s)} + CO_2(\text{In amine carrier}) \rightarrow (Ca,Mg)HCO_{3(s)}$

## Benefits and Conclusion of Carbon Capture and Utilization Using Waste

From the above content, it is evident that using waste materials for carbon capture and utilization can achieve the goals of capturing $CO_2$ and producing valuable materials, with the main products being calcium carbonate, magnesium carbonate, and sodium bicarbonate. These three substances are widely used chemicals with applications in construction materials, fertilizers, pharmaceuticals, food additives, and cleaning agents.

Mineral carbonation, in addition to its environmental benefits, offers significant economic advantages. Its ability to help various industries achieve a closed carbon loop is a game-changer. Take the cement industry for instance: limestone, clay, silica sand, and iron slag are mixed in appropriate proportions and then calcined at high temperatures of 1450–1500°C in a rotary kiln to produce clinker during cement production. Limestone decomposes into lime (CaO) and $CO_2$ in this process, leading to significant $CO_2$ emissions. However, alkaline waste such as cement kiln dust, concrete sludge, and demolition debris can be utilized to capture $CO_2$ and produce substances like CaCO3. These recycled materials can be subsequently employed in the cement production process (Figure 5), not only reducing $CO_2$ emissions but also reducing the amount of raw material extraction and further carbon emissions. Hence, it means the role of waste materials in reducing $CO_2$ emissions is a hopeful sign for the future.

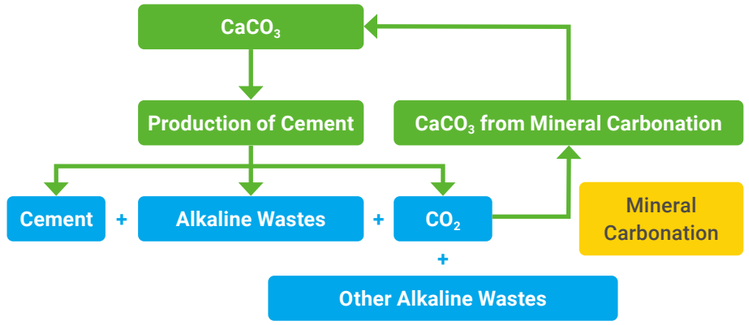



Figure 5 A diagram illustrating the reuse of calcium carbonate from mineral carbonation in the cement production process

Although the technology for using waste materials for carbon capture and utilization may still be in its early stages, statistics show that ordinary types of alkaline solid waste in Taiwan—such as steel slag, cement and concrete waste, incineration fly ash, coal fly ash, and paper waste—can capture approximately 2.11, 1.55, 0.29, 0.14, and 0.07 million tons of $CO_2$ per year, respectively [26]. When considered by industry, these forms of alkaline waste can help reduce $CO_2$ emissions by 14.5%, 28.1%, 136%, 0.18%, and 2.95% in their respective industries, indicating significant potential for using alkaline solid waste for carbon capture [26].

Regarding desalination brine, Taiwan discharges over 40,000 tons of brine daily. If brine can be used for mineral carbonation, it could offset the carbon emissions from seawater desalination plants and provide carbon credits to other industries, demonstrating the feasibility of using desalination brine for carbon capture and utilization [26 27].

Currently, while there is extensive research on achieving net zero emissions globally, the potential of utilizing waste materials for mineral carbonation is truly inspiring. This approach not only captures and reuses $CO_2$ but also strengthens the connection between waste management and carbon capture. It aims to redirect misplaced resources back on track and transform them into valuable products, aligning with the principles of a circular economy and net zero emissions.

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## Author


### Teng Hsi-Sheng

**Director of the Hierarchical Green Energy Materials Research Center (Hi-GEM) & University Chair Professor in the Department of Chemical Engineering**

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Professor Hsisheng Teng is a visionary leader in green energy innovation, currently serving as the Director of the Hierarchical Green Energy Materials Research Center (Hi-GEM) and a University Chair Professor in the Department of Chemical Engineering at National Cheng Kung University (NCKU). From 2018 to 2021, he represented Taiwan in the International Society of Electrochemistry (ISE) and the Electrochemical Society (ECS), reflecting his standing as a global ambassador for electrochemical science and technology.

Renowned for his groundbreaking contributions to energy production and storage, Professor Teng's research spans two transformative fields: pioneering photocatalytic technologies for hydrogen ($H_2$) production and carbon dioxide ($CO_2$) conversion into high-value chemicals, as well as advancing high-safety solid-state batteries, lithium-ion batteries, and supercapacitors.

As the principal investigator of the multi-year initiative "Taiwan-Germany Battery Research Collaboration and Advanced Green Energy Technology Promotion Office," Professor Teng has spearheaded efforts to elevate Taiwan's green energy battery industry to new heights. His leadership has catalyzed technological innovation and global integration, positioning Taiwan as a key player in the international energy landscape.

In the field of photocatalysis, Professor Teng is one of the pioneering scholars in utilizing graphene-based photocatalysts for hydrogen fuel production. His research achieved a remarkable quantum efficiency of 30% (at 420 nm) for photon-to-hydrogen conversion, a result that has garnered worldwide attention.

Professor Teng's distinguished career is adorned with numerous accolades that underscore his profound impact on science and technology. His honors include the 2024 TECO Award, the 2023 Academic Award from Taiwan's Ministry of Education, the Scientific Chair Professor Award from the Yu-Ziang Hsu Foundation, the 2011 Thomson Reuters Scientific Excellence Research Award, and the Outstanding Research Award from the National Science Council, received in 2014, 2011, and 2003.

Dedicated to leveraging his expertise, extensive research achievements, and leadership capabilities, Professor Teng collaborates with top domestic and international technology teams to develop innovative energy materials and promote the circular economy, striving to achieve the goals of sustainable low-carbon development.



## Author


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Assistant Professor, Cheng-Han Lee, is from the Department of Resources Engineering and Hierarchical Green-Energy Materials Research Center (Hi-GEM), National Cheng Kung University. The research field primarily focuses on the development of Resource Circulation, Circular Economy, Extractive Metallurgy, Green Innovation, and Net Zero Emissions techniques using waste. In addition to element recycling from waste, high-value techniques are used to directly convert waste into usable materials, achieving the goal of resource reutilization. The elements separated and recycled from waste can also be applied to various industries through high-value techniques, enhancing the economic efficiency of resource circulation. Carbon capture and utilization (Net Zero Emissions technique) is implemented directly from waste or using elements/materials recycled from waste. This will enhance the application value of each element/material while directly contributing to Net Zero Emissions.

Life Is On | Schneider Electric



# Our Fastest Path Towards Net Zero

**Kenny Liu**, Manager of Strategy & Sustainability Business, Schneider Electric Taiwan

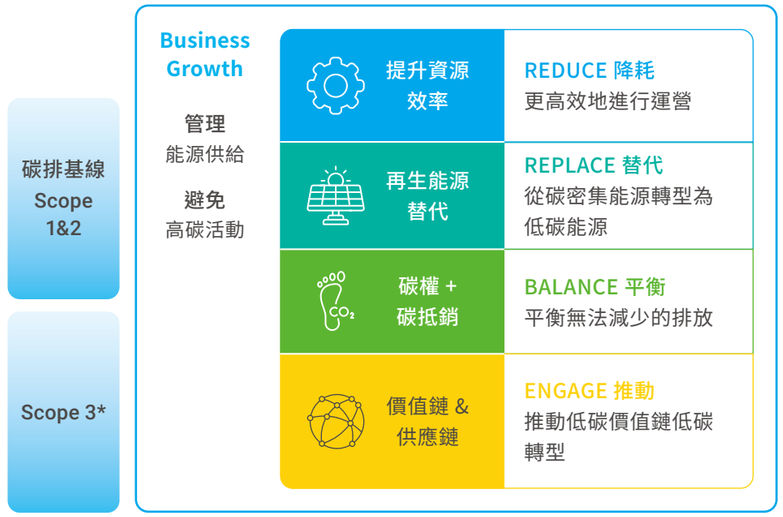
As industrial societies continue to evolve, the human pursuit of progress is inevitable. While innovation and behavioral changes are crucial, businesses play a pivotal role in driving this transition. However, enterprises face a complex landscape of challenges, including international trade regulations, domestic policies, supply chain complexities, and financial considerations. This paper will explore the role of energy efficiency optimization in enabling enterprises to navigate these challenges and achieve sustainable net zero goals.

We believe there are three key steps for enterprises to achieve net zero emissions: strategic planning, pathway implementation, and performance management. To develop a carbon neutrality strategy, companies must first conduct a carbon inventory to understand their current carbon footprint. Furthermore, while conducting a carbon inventory, it is essential to establish a corporate carbon emission database to provide data for further analysis, such as carbon emission trends, renewable energy, and forecasting on certification demand. Additionally, there is a need to cultivate carbon asset management professionals and build a dedicated team to address the growing demand for carbon asset management in the future.

Once a company has a clear understanding of its carbon emissions, the next crucial step in developing a net zero strategy is thoughtful planning. This involves identifying the optimal path to reducing emissions, evaluating the costs and benefits of various strategies, and benchmarking against industry best practices. We propose a three-dimensional approach to strategy development: recognizing external pressures, defining the company's unique position, and creating a tailored net zero pathway.



While enterprises should consider potential net zero solutions at a strategic level, the successful implementation of these solutions requires a detailed analysis and execution plan for each pathway. Based on their current carbon footprint and future business projections, companies should develop clear, cost-effective, and actionable decarbonization strategies that balance environmental sustainability and business growth. We suggest four key decarbonization pathways: enhancing energy efficiency, replacing fossil fuels with renewable energy, offsetting emissions, and decarbonizing the value chain.




Energy efficiency optimization is a cornerstone of achieving carbon neutrality. By implementing energy-efficient technologies, optimizing operational control, recovering and utilizing waste energy, and adopting a data-driven approach to energy management, enterprises can significantly reduce their carbon footprint while maintaining operational efficiency and competitiveness. Based on Schneider Electric's numerous service cases and research experience, we believe that energy efficiency optimization primarily includes the following four aspects:

- **Energy-efficient technologies and products:** Selecting energy-efficient technologies and high-efficiency products that align with the company's specific needs, taking into account the local natural conditions, as well as the company's actual energy consumption structure and habits, to maximize system efficiency.
- **Optimized operational control:** By introducing electrical and digital automation control systems, setting control parameters based on actual needs, and enabling equipment to dynamically adjust its operating status according to the company's actual production, manufacturing, and operational requirements, optimal operation of equipment or systems can be achieved.
- **Energy recovery and utilization:** By rationally recovering and reusing unused waste heat and energy during the company's production operations, losses and waste during the energy consumption process can be effectively reduced, thereby improving the overall energy efficiency of the enterprise.
- **Scientific management:** Scientific energy management is a crucial means for enterprises to reduce energy consumption and carbon emissions. By introducing digital technologies and building a digital energy management platform based on the company's energy management needs, real-time monitoring and analysis of the company's energy consumption data can be achieved, providing continuous insights and performance management for the company's energy conservation and carbon reduction efforts.

Energy efficiency optimization is a versatile tool applicable across a wide range of industries, from energy-intensive sectors like manufacturing and data centers to non-energy-intensive sectors like electronics and pharmaceuticals. By implementing energy-efficient practices during the design and construction phases of new projects, enterprises can create more sustainable facilities. For existing facilities, energy efficiency optimization can help identify and address inefficiencies, leading to reduced energy consumption and lower operating costs. Whether it's a new construction project or an existing facility, energy efficiency optimization can help businesses achieve their sustainability goals while improving their bottom line.

Since energy efficiency improvement is a systematic and professional engineering process in a company's sustainability transformation, involving specialized methodologies and tools for identifying, evaluating, implementing, and tracking improvements that can enhance energy efficiency, and given the often limited experience and specialized talent within companies, we recommend that companies seek professional external partners in conjunction with their sustainability transformation goals and plans at various stages to:

- **Energy Audit and Analysis:** Conduct a comprehensive audit and assessment of the company's energy usage. This includes collecting and analyzing energy data, identifying energy bottlenecks and inefficiencies, and evaluating potential energy efficiency improvement opportunities.
- **Energy Efficiency Optimization Plan Development:** Develop a detailed energy efficiency optimization plan, including selecting suitable energy-saving technologies, determining the business model, and defining specific optimization steps to ensure the plan is actionable and implementable.
- **Energy Efficiency Optimization Implementation:** Implement energy efficiency improvement measures step by step according to the optimization plan. This may involve technology upgrades, equipment replacement, process adjustments, and other aspects. Ensure that there are sufficient resources and support during the implementation process to overcome potential challenges and obstacles.
- **Efficiency Performance Tracking:** Monitor and evaluate the results regularly after implementing the optimization measures. This includes collecting and analyzing post-optimization energy data and comparing it to pre-optimization performance to ensure that the expected energy efficiency improvements are achieved.

The necessity for enterprises to take proactive measures in decarbonization is undeniable, yet many companies remain in a wait-and-see mode. Whether it's due to a lack of deep understanding of current or future policy trends and industry developments, or concerns about return on investment, a significant portion of this hesitation stems from a lack of holistic and long-term thinking. Each specific decarbonization measure implies a systemic transformation, rather than merely improving a single scenario or part:

- **Strategic Planning:** Starting from business development, combining the company's internal carbon emissions status with external market analysis, establishing a sustainable vision and goals, and determining priorities for action.
- **Pathway Selection:** Combining external resources and internal management improvements, embracing energy-saving and carbon reduction technologies as well as digital technologies, comprehensively analyzing various decarbonization paths and solutions from the perspectives of technical feasibility and return on investment, and executing decarbonization plans in line with the company's capacity.

Another reason for the slow pace of corporate action is a narrow understanding of net zero emissions, such as the mistaken belief that low-carbon transformation is at odds with cost savings. In fact, through our client services and research, we have found that many companies have already achieved both cost savings and carbon reduction through reasonable strategic planning and the implementation of energy efficiency optimization, lean management, and circular economy practices. By adopting a long-term perspective, companies can position low-carbon operations as a strategic advantage and a key driver of sustainable growth.





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Kenny Liu is the manager of Strategy & Sustainability Business in Schneider Electric Taiwan. His responsibilities include corporate partnerships, ecosystem development, sustainable transformation strategy consulting, and project implementation. With 10+ years' experience in Mainland China, Kenny is specialized in MNCs and Greater-China region practices.

Kenny received his Bachelor's Degree at College of Humanities and Social Sciences in National Tsing-Hua University. During his studies, he received a full-time scholarship to study at Guanghua School of Management at Peking University, where he expand his professional field to strategic management and marketing.

Kenny holds a suite of professional certifications, including ISO 14068-1 Carbon Neutrality Lead Verifier, ISO 14064-1,-2 Greenhouse Gas Emissions Verification Lead Verifier, ISO 14067 Carbon Footprint of Products Verification Lead Verifier, PAS 2060 Carbon Neutrality Implementation, and UNPRI Advanced Responsible Investment Analysis.



## Guiding Customers on How to Go Green

As a global company, we have a responsibility to reduce our greenhouse gas emissions throughout the value chain. You could check our climate commitments via QR code, aligned with science-based targets, and how we are contributing to the transition to a low-carbon society. Furthermore, we are here to guide customers about sustainable solutions to help customers reach their climate ambitions.

◀ Read more about our climate commitments

A compressor installation that consumes 500 kW and runs for 8,000 operating hours each year emits almost the same amount of $CO_2$ as 2,400 return flights from London to New York. That is why it's important to have the installation running as efficiently as possible. A few small changes can make big savings in both emissions and money.

Thankfully, as much as 94% of the energy supplied to the compressor can be recovered, allowing users to warm factories through winter, cool them during summer or even convert it into electricity. Not all options require a sophisticated system – heat can simply be routed using some ductwork, for example.

## Ten-step Guide to Going Greener

Useful information like this lies at the heart of our strategy by Compressor Technique. Our strategy seeks to guide clients about sustainable solutions, and you can explore the carbon reduction calculation tool and the 10 steps to a more efficient production on Atlas Copco's official website. We wanted to talk more in the language of our customers,Rather than talking about how great we are, we are focusing on why companies should choose us and the kind of solutions we have. The first step is about going green.

Sustainability is among the biggest challenges and opportunities facing industrial companies. Many are seeking to adhere to ambitious emissions reductions targets while seeking to utilize the latest green technology that will give them an edge over competitors.

## Savings Over Time

The ten-step guide enables companies to reduce waste and save money. Some industrial firms waste as much as half of the power required for compressed air generation through either inappropriate use of air or inefficient system designs. You need 8% more power for every bar of extra pressure, for example, so keeping working pressures at optimal levels can make a big difference. When the right move is a big upfront investment, it's likely reduced bills will result in a saving over time,and the payback time is pretty quick when you compare dated equipment with modern compressed air solutions.The purchase price is small compared to the energy savings and $CO_2$ reductions that can be achieved.

◀ Read more about our carbon reduction calculation tool **10 steps to a more efficient production**

Your checklist on how to save energy and make your production process more efficient.

**Analyze**

### 1. Application & Installation

Compressed air can be crucial for various productions processes. But installations can become inecient due to changing production requirements over time, resulting in increased energy costs and carbon footprint.

### 2. Storage & Distribution

Piping distribution and vessels in compressed air systems are often overlooked, but they play a crucial role in the systems eciency. Properly designed air systems avoid pressure drops and save both energy and money.

### 3. Air quality

Having the correct air quality can prevent contaminants such as water, oil, dust, and even microorganisms, which can aect the production reliability and your product quality.

### 4. Air volume & Flow patterns

Be aware of the dierent ow patterns in production. Changes in the demand need to be considered. An Atlas Copco AIRchitect study can map your ow patterns and demonstrate potential system improvements.

**Optimize**

### 5. Core technology

Oil-free, oil-injected, tooth, rotary screw, piston or centrifugal technologies are used in most industrial applications. Atlas Copco can help select the correct technology dependent on the needs of your production process.

### 6. Equipment control

Our advanced controllers can help manage the pressure and optimize power consumption with smart algorithms designed to minimize power consumption, and carbon footprint.

### 7. System control

Even the most ecient products (compressors, dryers,…) only reach their full potential when working together. Central controllers maximize system eciency while reducing your carbon footprint.

### 8. Recoverable energy

Compression generates heat, so don't let this go to waste. That's why our energy recovery systems are the best option to reduce your energy consumption for process or space heating.

**Monitor**

### 9. System maintenance

A well-maintained compressed air system will more than pay for the maintenance costs through energy savings. You're never saving by delaying maintenance.

### 10. System monitoring

Remote monitoring allows you to monitor and optimize your compressor room from anywhere. Supporting ISO 50001 energy management standard.





## Author

Atlas Copco
Taiwan Ltd

We are Atlas Copco Group, a company that has been deeply rooted in the Taiwan market for many years. With over 152 years of history, our group offers four main business areas: **Compressor Technology**, **Vacuum Technology**, **Industrial Technology**, and **Power Technology**, providing customers with high-quality, high-performance compressors and exceptional after-sales services.

Compressed air is everywhere and finds applications across numerous industries. In your factory, you'll likely see air compressors at work. Let's continue to grow together and drive society forward.



# VEOLIA's Strategies for Improving the Efficiency of Water Management and Recycling in the Microelectronics, Semiconductors, and Optoelectronic Industries

**Johnson Yuan**, P&A Project Development Manager,
Veolia Taiwan

## Introduction

Severe climates, characterized by high temperatures and heavy rainfall globally, have frequently resulted in natural disasters like droughts, wildfires, and floods, intensifying the effects of climate change. Despite Taiwan receiving significant rainfall—approximately 93.6 billion tons annually—after accounting for loss due to evaporation and river discharge into the sea, the annual available water resources are only around 14.3 to 17.7 billion cubic meters. This leads to an impressively low utilization rate of only 14% to 19%. Water storage facilities, or reservoirs, manage approximately 23% of total water usage, with 20% sourced from groundwater and 57% from direct river diversion. The steepness of the rivers and rapid rainfall runoff make it difficult to sustain a consistent flow for surface water. During the dry season, particularly in central and southern Taiwan, which lasts for eight months, there is a significant water shortage, leading to an even more unstable water supply. In recent years, Taiwan's industry and commerce have grown swiftly, the population has steadily increased, the economy has consistently expanded, and the quality of life has improved annually. This has led to a significant rise in water consumption and demand for water resources. To address the anticipated spike in water demand, the government will proactively promote essential water conservation and recycling measures as vital responses for sustainable development. (Yang Weifu, Director of the Water Resources Department of the Ministry of Economic Affairs 2010-10-15)

The Executive Yuan approved the industrial stable water supply strategy and announced an increase in the recycling rate of industrial water, emphasizing the sustainable development and utilization of water resources and the implementation of the total volume control mechanism. In 1995, the current industrial water development policy framework was approved. In 2000, the "Water Conservation Action Plan" was promoted. In 2005, the "Water Resources Sustainable Development Policy Plan" and other related policies were carried out to stabilize the supply of water for industrial use and continue to improve the efficiency of industrial water use, expand and promote water conservation to achieve the goal of an average water recovery rate of 65% in 2021 and accelerate planning for the overall water recovery rate of industrial zones to reach 75% in 2031. To improve and continuously enhance industrial water use efficiency, the current water resource management problems faced by industrial water recycling and reuse still need to be overcome regarding regulatory and administrative management, water use characteristics, and manufacturers' attitudes. Industrial Water Efficiency Improvement Plan (2023-09-22) Through the sharing and exchange of mature and proven treatment equipment and process management technologies, and in line with relevant policies, VEOLIA strengthens the management of water use plans (industrial zones), actively promotes the application evaluation of diversified water sources and water resources integration in the industry, and hopes to continuously improve the resilience of the sector in response to extreme weather and create a more efficient water environment.

# The Status Quo of Industrial Use of Water and Recycling in Taiwan

## 1. Driving demand for industrial water recycling

Domestic water resources are categorized into **domestic, agricultural, industrial, and conservation types based on usage standards**. Statistics from the Water Resources Administration of the Ministry of Economic Affairs indicate that Taiwan's average annual water consumption over the last decade is approximately 16.8 billion tons, with domestic use of water making up 18.9%, industrial use at 9.6%, and agricultural use comprising 71.4%. Although the share of water for industrial use is the lowest, the output value accounts for 30% of the gross production (GP). Due to Taiwan's economic growth, the demand for water for industrial use will grow rapidly every year in the future. According to the estimates of the Water Resources Administration of the Ministry of Economic Affairs, given the slight decline in Taiwan's population in the future, domestic water consumption will decrease slightly, agricultural water consumption will remain the same, but **industrial water consumption will increase significantly and exceed the reduction in domestic water consumption**. Currently, Taiwan's industrial water recovery rate lags behind that of advanced countries such as Europe, America, and Japan. The types and water quality of industrial wastewater are more complex, and the water recycling of each industry is mostly reused for cleaning and secondary purposes. To avoid competing for water with civilian use and stabilize Taiwan's economic growth, there is a relatively large room for R&D and improvement breakthroughs in the **technical aspects of water recycling and reuse and managing wastewater collection and diversion**.

According to the water resources sustainable development policy plan of the Water Resources Department of the Ministry of Economic Affairs, 2021 is the base year of normal consumption of water. In that year, Taiwan's industrial water consumption was about 2.9 billion tons, which is **the total amount of controlled industrial water resources**. Zhongxing Engineering Consultants Environmental Engineering Research Center) Taiwan's semiconductor microelectronics and optoelectronics industry has become an important international supply source in recent years. Taking into account the factors of other industries moving out, according to the preferential plan of the Ministry of Economic Affairs to promote industrial investment in recent years, the tax incentives such as land costs most needed by the semiconductor microelectronics and optoelectronic industries has encouraged enterprises to stay in Taiwan. Ensuring the rational use of industrial water resources of such enterprises, improving the efficiency of rational water use, creating water resource utilization benefits, and guiding the industry to implement water recycling, reuse technology, and management mechanisms will be important topics of the future industrial water use strategy.

## 2. Current status of industrial use of water and recycling

Table 1 shows that most of the wastewater recyclers are still concentrated in small and medium-sized businesses. In terms of recycling purposes, the current post-recycling use of industrial wastewater is mainly "process", followed by "cooling" and other secondary water uses.

| Range of WW flows at listed management (CMD) | Plants in listed management | Plants WW flow in average (CMD) | Reclaim water to go for use (%) | | | | |
|---|---|---|---|---|---|---|---|
| | | | % in WW flow | Manufacting Process | Cooling system | Treatment units | others |
| | | | | each use with in total reclaim water (%) | | | |
| 100,000-1,000'000 | 1 | 410,705 | 98.83 | 13.45 | 86.5 | 0 | 0.05 |
| 50,000-100,000 | 4 | 70,839 | 80.32 | 73.53 | 26.36 | 0 | 0.11 |
| 10,000-50,000 | 15 | 22,299 | 55.06 | 99.28 | 0 | 0 | 0 |
| 5,000-10,000 | 16 | 7,067 | 62.25 | 90.4 | 8.97 | 0 | 0.62 |
| 1,000-5,000 | 124 | 2,149 | 67.6 | 91.3 | 5.75 | 0.65 | 3.34 |
| 500-1,000 | 74 | 745 | 64.11 | 87.84 | 11.63 | 0.41 | 2.96 |
| 100-500 | 163 | 246 | 63.04 | 89.65 | 4.51 | 2.16 | 9.09 |
| 50-100 | 115 | 76 | 61.97 | 86.21 | 8.24 | 0.33 | 7.02 |
| 0-50 | 1,010 | 60.9 | 65.04 | 90.83 | 4.21 | 1.18 | 5.96 |

Table 1 Statistics on wastewater recycling and reuse of water pollution control application projects
Data original source: Lu Hongguang, "Water Recycling and Reuse", 2006

## 3. Water resources management issues faced by industrial development

According to the 1997 resource policy white paper of the former Water Resources Bureau of the Ministry of Economic Affairs, industrial water consumption in Taiwan was estimated to increase up to 11.61% by the year 2021. As Taiwan develops more industrial zones, industrial water use is regionally concentrated. Taking the northern region as an example, due to the large number of industrial zones, the industrial water use ratio has reached 16.51%, which is significantly higher than the 6.94% in the central region. In the Hsinchu area, where semiconductor factories are concentrated, the regional water concentration is higher than the general average ratio in the northern region. Both industrial and domestic use of water rely on water supply equipment and water supply pipelines for transportation. Rapid and concentrated water use growth has caused regional water supply imbalances due to the inability of supply equipment and supply to quickly keep up with demand, resulting in water shortages. In the past few years, Hsinchu Science Park has been under the threat of water restrictions and water shortages due to the rapid growth of water use. Under the lack of water source inlets supply, water resource saving measures have become the countermeasures that manufacturers in this region, especially the semiconductor industry, have been actively studying and implementing. (Research on water conservation in UMC Jiangdairui semiconductor factory)

### 台積公司三大科學園區用水占比

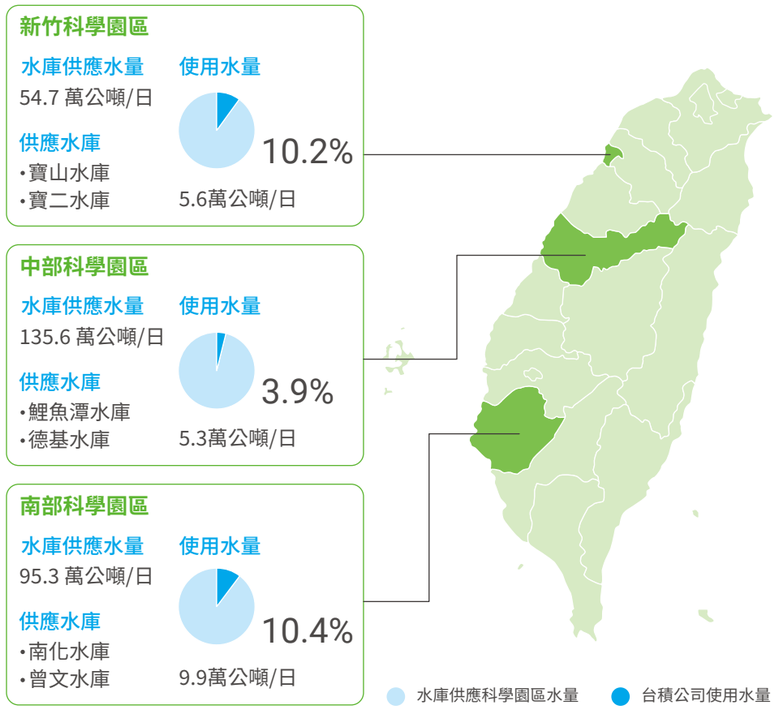



Figure 1 Analysis of the proportion of water used in the park
資料來源：經濟部水利署網站公開訊息

Encouraging manufacturers to introduce the use of recycled water, reduce the dependence on city water use, and improve the park's resilience towards drought are the top priorities of water resource management for industrial development: Yongkang, TSMC and Anping will gradually supply recycled water to Tainan Science Park starting from 2022, and the water supply would reach about 38,000 cubic metres per day (CMD) by the end of 2023. In addition to the recycled water plants under construction, such as Rende and Shuinan (including water exchange), the recycled water usage is expected to reach more than 319,100 CMD per day in 2023 (including 97,000 CMD in Hsinchu Science Park, 98,600 CMD in Taichung Science Park and 123,500 CMD in Tainan Science Park). It is expected that the water recovery efficiency will be further improved in the future, with the recovery rate of the semiconductor and optoelectronic industry reaching more than 85%, and the water recovery rate of the science park is expected to increase to more than 80% in 2032 to reduce the overall water consumption. (Business Times 03/28/2023 National Science Council: Semiconductor, optoelectronic industry, water recovery rate of more than 85%)

Data source: Industrial water consumption is based on the industrial water statistics of the Water Resources Department of the Ministry of Economic Affairs over the years; recovery rate is based on (Lian Jinzhang, 2006)

## VEOLIA's Suggestions for Increasing the Recovery Rate of Industrial Water Reuse

TSMC has a delegating destiny to fulfill the role of the park leader in the use of traditional reservoirs and plans to use water to recover water from its own effluent. However, in the face of severe conditions such as an increase in demand for water as well as the trend of resource efficiency and sustainability issues, it is necessary to consider improving the efficiency and reasonable procedures to increase water recycling and reuse. Energy conservation and carbon reduction have made it increasingly difficult and urgent to increase the amount of water recycled (70% up to 80%).

However, VEOLIA is also willing to provide solutions to work together with clients to accomplish the desired mission. VEOLIA's values and contribution approach is outlined below:

The proven technical treatment devices and traditional wastewater treatment processes can achieve zero pollution and micro-pollutant removal, reducing the carbon footprint of the process while ensuring a further reduction in the pollution load of the effluent water quality. This approach provides advantages such as energy savings, low power consumption, and improved operational efficiency of the water recovery system. At the same time, it significantly reduces capital expenditure for construction and contributes to operational savings in recycled water plants, while minimizing the complexity and risk associated with the operation and management interfaces of the system units in the recycling water plant.

## VEOLIA understands the characteristics of water use and seek support and provision from cooperative customers

VEOLIA sincerely looks forward to the establishment of water baseline data for the water use standards of business customers, including original water withdrawal, reused water volume, water production, water consumption and discharge water in the water volume balance. Regarding water quality, we will assess the water quality required by the process unit, and the mechanisms that govern changes in water quality. The water supply system diagram and process flow diagram are used to explore the correlation between the water quantity consumption and water quality requirements of each process on the production line. According to the results of the water inventory, the water flow process, water supply and drainage volume and water quality changes of each unit in the plant are collected on the water map, and then the leakage analysis and water balance trial calculation are carried out for each system composition.

There are two types of water optimization assessment: recycling and reuse. As far as recycled water is concerned, such as cooling water or heating water, the water quality is not affected to a considerable extent except for the change in temperature, and it can be recycled. For the recycling of water, the discharge points with recycling potential throughout the plant, and the water quality data required by the process unit at the reuse point should be checked, and then the water recycling technology and equipment that meet the water quality requirements should be further carried out to recycle and reuse the processed water with a more efficient process.

## VEOLIA's Strategy with Recommended Technology Prospectus for Industrial Water Recycling and Reuse

The strategic and management aspects of industrial water recycling and reuse in Taiwan are complementary to each other. In addition, due to the complexity of the processing system, the demand and the water quality discharged by the process often vary according to the characteristics of the process. Such as 1. Organic and inorganic compounds 2. Dissolved and particulate matter 3. Volatile and non-volatile 4. Strong reactivity and inertness 5. Substances with hydrophilic and hydrophobic properties 6. Dissolved gases, etc. Water may be polluted by incomplete process diversion management or other abnormal operations or cleaning contamination, which may cause abnormal wastewater discharge and cause interference and risk in the stable management of recycled water quality.

VEOLIA conducts programme optimization evaluation based on the interference characteristics of the above pollutants and the costs required for their equivalent pollutant removal performance (including civil engineering, electricity consumption, carbon emission consumables, etc.) (as shown in Figure 2) to achieve wastewater treatment efficiency improvement. The ultimate goal is to maximize water production, coupled with intelligent control and simplified water production process management interface.

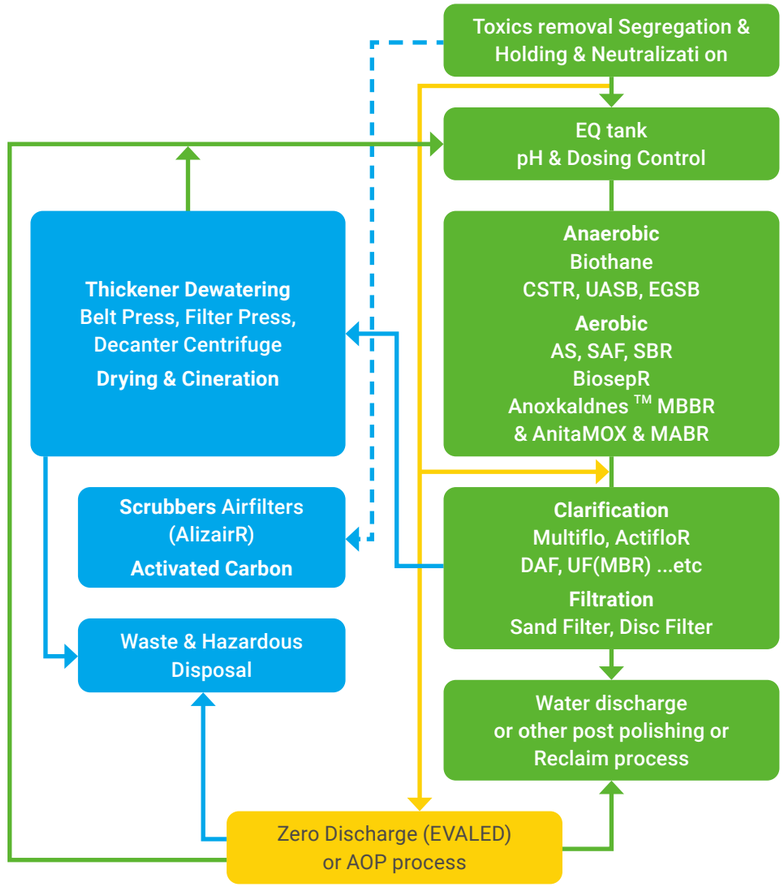



Figure 2 Supporting equipment for VEOLIA wastewater treatment, and recycling and reuseprocedures

VEOLIA will carefully evaluate and analyze the integration method of process units and water-saving wastewater treatment equipment in the factory based on the systematic thinking of industrial customers' water use and factory management. At the same time, it is important to consider the rationality of the price after the integration and optimization of water recycling and reuse technology, and to maintain the mutually beneficial development of customer relationships. Carbon reduction planning and the design of special pollutant removal treatment and recovery economic benefits are considered the top priorities of the method and strategy to achieve the purpose of VEOLIA's biotransformation global policy and promote water recycling and reuse.

## Conclusion

After the promulgation of the "Regulations on the Development of Recycled Water Resources", it was clearly stipulated that "in areas where water supply is at risk of shortages, the developers shall use a certain percentage of system recycled water", and related sub-laws such as the "Method for the Use of Recycled Water in Areas at Risk of Water Supply Shortage" are being actively developed, which also highlights the importance of water resources integration. Facing the water shortage problem, in addition to developing new water sources, recycling waste sewage from waste sewage treatment plants in various regions and supplying it to local industrial users has become the focus of the development of emerging water sources. Due to the diversity and instability of water quality, it is difficult to recycle wastewater, and a very small number of factories recycled piped water as water for cooling towers and secondary cleaning, and the rest are directly discharged. If the water resources of the manufacturers in the region can be integrated, and the water quality and quantity of the water supply manufacturers can be matched with the appropriate user manufacturers, in addition to saving on wastewater treatment fees and management fees of the water supply manufacturers, it can also reduce the amount of raw water intake and costs of the water supply manufacturers, achieve the integration and reuse of regional water resources, and enhance the company's green image.

High water-consuming industries and large water users should implement water-saving measures and, and cooperate to achieve industrial water diversification, wastewater recycling and reuse, water resource integration, promotion of water management systems and water-saving innovative technology advocacy to improve the industrial water recovery rate. The recycling rate has increased significantly from 46.0% in 2002 to about 70% today, and it is expected to move towards the goal of higher recovery of more difficult water in the future. At the same time, in addition to overcoming the high cost of water recycling technology, VEOLIA will promote its global vision and policies, in cooperation with decarbonization and regenerable innovative solutions together with regulations and administrative mechanisms in line with the win-win cooperation strategy of localization. In response to the government's policy disseminated targets, we should be able to move towards the future water recycling target, and match the government's future requirement of 80% industrial water use and recycling rate by 2031.

Please visit Veolia's website for more details & reference: http://veolia.tw/en.



## Author


### Johnson Yuan

**P&A Project Development Manger**

**Veolia Taiwan**


### Professional experience

27 years

### Education

The University of Bradford (UK); PhD of Environmental Science

### Experiences (2015~2023)

- AnitaMOX anaerobic ammonium oxidation) biological test/pilot test performance results have been verified, functional design approved by Veolia headquarters
- A/O…MBBR (1000 CMD) pilot project tested at Shatin Sewage Treatment Plant in Hong Kong
- The newly built UASB is used for debugging to remove TMAH and is connected to the existing A/O...MBR at the Giant-Plus Wastewater Treatment Plant (2000 CMD). This is done to improve the BNR process performance and adjust the commissioning until the final discharge of the entire plant reaches the standard.
- On-site audit of the catering industry wastewater treatment plant at Firmenich (Indonesia) for performance evaluation to increase the production efficiency of the transformation.
- At Nestlé's (Thailand) catering industry wastewater treatment plant, the newly installed MBBR has been started up, and the plant-wide effluent flow now meets the required standard.
- An on-site audit was conducted at the Friesland (Indonesia) F&B industrial wastewater treatment plant to review the performance of the Zero Liquid Discharge (ZLD) retrofits.

Hitachi Energy



# Decarbonization Trends & Product Solutions for Mobility

Reducing carbon emissions in the transport sector is crucial for meeting global sustainability goals. Since 2000, $CO_2$ emissions from heavy-duty vehicles have surged, driving governments and industries to pursue more sustainable transportation solutions. Today, road transport in Europe accounts for approximately 25% of total greenhouse gas emissions, with buses and heavy-duty trucks as significant contributors. Achieving zero emissions from heavy-duty vehicles has therefore become a top priority.

The electrification of transport is at the heart of decarbonization trends. Across industries like manufacturing, construction, and transportation, the shift towards electrification is vital to meeting sustainability targets. As the electrification of road transport accelerates, electricity and hydrogen are poised to become dominant energy sources. According to the International Energy Agency (IEA), the share of electrification in final energy consumption is expected to rise from the current 23% to 55%, supporting the goal of net-zero emissions.

## Key Trends Driving Change

One of the most prominent trends in mobility is the rapid adoption of electric buses and trucks. Public transportation agencies and fleet operators are embracing high-powered electric vehicle (EV) solutions. Meanwhile, investments in public charging infrastructure and grid upgrades have led to the development of innovative charging systems. Electric buses, in particular, are emerging as a key element in reducing urban transport emissions. These buses not only cut emissions but also enhance the efficiency of public transport systems.

To support the electrification of large vehicle fleets, charging infrastructure—from the grid to the socket—is continuously evolving to ensure stable power supply and efficient distribution. As the market for heavy-duty electric trucks and buses expands, newer models are being introduced. Advances in battery technology are further fueling this trend by extending driving range and shortening charging times, making EVs more practical for long-haul applications.

## Challenges on the Road to Decarbonization

Despite the progress, the decarbonization of transportation still faces several significant challenges, including technical, financial, and operational hurdles.

One of the most substantial barriers is the high upfront cost of electric vehicles. Electric buses, for instance, are typically twice the price of their traditional diesel counterparts, with batteries representing a significant portion of that cost. While long-term savings can be achieved through reduced fuel and maintenance expenses, the initial financial burden remains a major concern for fleet operators.

Another pressing challenge is the need to upgrade existing grid infrastructure. As more electric vehicles, particularly heavy-duty ones, hit the roads, power demand will increase significantly. Current grids may not be equipped to handle the additional load, leading to issues such as peak demand surges and capacity constraints. As a result, large-scale investments in grid modernization and more robust connections are necessary.

Operational challenges also present obstacles. Electric buses and trucks require carefully designed service systems to ensure reliable operation. EV performance can vary under different operating conditions—such as load, temperature, and distance—requiring constant monitoring and intelligent logistics systems. Routes may also need to be adjusted to account for specific EV requirements, such as charging schedules and availability, potentially reducing operational flexibility.

## Interoperability and Energy Supply Issues

The lack of standardized charging infrastructure is another concern. Different charging speeds—slow, fast, and opportunity charging—lack uniform standards, complicating infrastructure planning and investment for cities and businesses. Energy providers must also play a crucial role in the electrification process. Variations in energy distribution models across cities mean electricity costs can differ significantly by region. Ensuring a stable, cost-effective power supply is critical to the success of electrification efforts.

Maintenance poses additional complexities. EVs have unique diagnostic, repair, and safety requirements, adding layers of complexity to fleet management and increasing operational challenges.

## Hitachi Energy's Grid-eMotion® Solutions



Hitachi Energy is proactively addressing these challenges through its Grid-eMotion® solutions, offering two distinct systems: Grid-eMotion® Fleet and Grid-eMotion® Flash. These systems provide end-to-end charging infrastructure designed specifically for buses and heavy-duty vehicles, facilitating a seamless transition to electric mobility.

Grid-eMotion® Fleet is ideal for parking areas that require significant amounts of direct current (DC). This solution leverages rectifier transformers connected directly to medium voltage grids, offering a flexible and scalable approach. Its centralized power module design simplifies the charging process, reducing complexity, enhancing reliability, and ensuring smoother operations. The centralized rectification process also simplifies maintenance, increasing system reliability as charging modules can be easily replaced without major disruptions.

Grid-eMotion® Flash focuses on high-powered opportunity charging for public buses. This system allows buses to rapidly charge during short stops, such as when passengers board and alight, significantly reducing downtime. By enabling efficient quick charges, this technology aligns electric bus performance with that of traditional diesel vehicles. Flash charging also reduces the need for large battery capacities, optimizing energy consumption and lowering overall costs. Additionally, the system is designed to operate without communication between buses and infrastructure in the future, ensuring its forward compatibility and flexibility.

## Driving Operational Efficiency and Sustainability

These solutions bring a variety of benefits, starting with emission reduction. By electrifying buses and trucks, Grid-eMotion® solutions directly contribute to cutting $CO_2$ emissions, helping cities and businesses achieve their sustainability goals. The technology also enhances operational efficiency. Intelligent charging solutions and modular maintenance systems minimize downtime, making fleet operations more reliable and cost-effective.

Though initial costs may be higher, Grid-eMotion® enables significant savings over time. Operators can reduce fuel costs, maintenance needs, and optimize energy usage, delivering substantial long-term savings. Hitachi Energy's solutions are also designed to scale with fleet growth, making them suitable for both small and large operators. The system's flexibility allows operators to easily adapt to future technological advancements.

## Proven Success in Global Markets

Hitachi Energy's Grid-eMotion® solutions have been successfully implemented around the world. In Quebec City, Canada, Hitachi Energy deployed six 100 kW chargers in 2023 to support the local electric bus fleet, showcasing the effectiveness of its solutions in urban environments. Similarly, in Berlin, Germany, 56 75 kW chargers were installed across two bus depots in 2023, supporting the city's public transport system in achieving its decarbonization targets.



In Geneva, Switzerland, since 2018, Grid-eMotion® Flash solutions have been deployed with three 430 kW terminal chargers and twelve 600 kW fast chargers, enabling the bus system to match the efficiency of traditional diesel fleets while significantly reducing emissions. In Brisbane, Australia, 16 600 kW flash chargers were activated in 2023 to further bolster the city's electric transportation infrastructure.

These successful case studies demonstrate the reliability and adaptability of Hitachi Energy's solutions in diverse environments. Grid-eMotion® has shown its capacity to support the electrification of urban public transportation, reduce carbon emissions, and enhance operational efficiency across various global regions.

### Depot charging

**2 Bus Depots**
Britz and Cicero

**CCS2 double plug**
Single and dual plug charging stations

### Technology

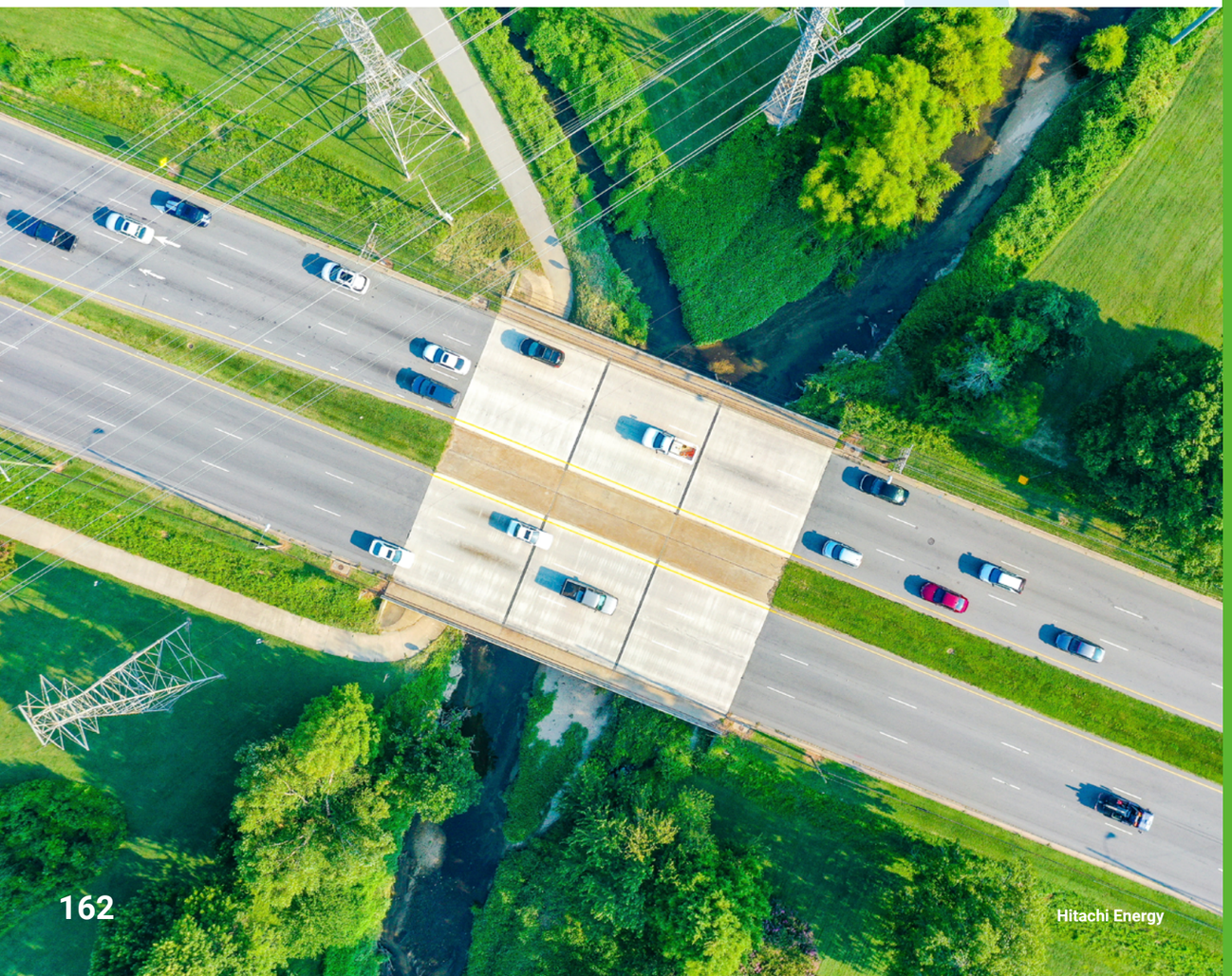
**14 x 75kW (x2)**
**3x DC-DC modules**
Chargers simultaneous or sequential

**1.25 MVA**
Grid connection

# The Future of Electrified Mobility in Taiwan

In Taiwan, the momentum for decarbonizing transportation is building. Taiwan Power Company (TPC) has earmarked land along Zhongxiao Road in Hsinchu for developing a cutting-edge smart parking structure. The facility is expected to feature 325 parking spaces, with some designated for mixed V2G (Vehicle-to-Grid) and V1G (Vehicle-to-Everything) charging stations, underscoring Taiwan's commitment to sustainable energy and smart infrastructure development.

With Hitachi Energy's proven track record of success around the globe, its GrideMotion® solutions are well-positioned to accelerate Taiwan's progress toward decarbonizing its transport sector. By leveraging advanced technology and scalable solutions, Taiwan can rapidly advance its efforts in sustainable transportation, helping the nation meet its long-term environmental goals.







HITACHI
Inspire the Next

Hitachi Energy

## Author

**Hitachi Energy Taiwan**

Hitachi Energy Taiwan, previously known as ABB Power Grids, has been serving Taiwan's power industry since 1988. For over 30 years, the company has continuously innovated and evolved to meet the demands of a dynamic market. On July 1, 2020, Hitachi Group and ABB established the joint venture "Hitachi ABB Power Grids," combining expertise to enhance the power grid business. The company was officially renamed "Hitachi Energy Taiwan" on December 1, 2021, marking a new chapter in its commitment to creating value for customers, employees, and society.

Currently, Hitachi Energy Taiwan employs around 132 professionals, operating from offices in Taipei, Taichung, and Kaohsiung. As a critical link between Taiwanese enterprises and the global resources of the Hitachi Energy Group, the company leverages over a century of experience in the energy sector to provide world-class solutions tailored to various industries, including semiconductors, electronics, petrochemicals, renewable energy, steel, construction, and more.

The company specializes in a wide array of offerings, including grid system automation, grid integration, transformers, high-voltage products, offshore wind power, solar energy, and energy storage solutions. These comprehensive services ensure reliability and efficiency for industries pursuing sustainable energy strategies.

As a trusted partner to Taiwanese businesses, Hitachi Energy Taiwan is renowned for its professionalism, dedication, and customer-centric approach. Its expert engineers are always available to provide meticulous technical support, ensuring smooth operations and uninterrupted production for its clients.

BOSCH
Invented for life



Bosch is committed to leading the path toward climate-neutral mobility

## Shaping a New Era of Electromobility

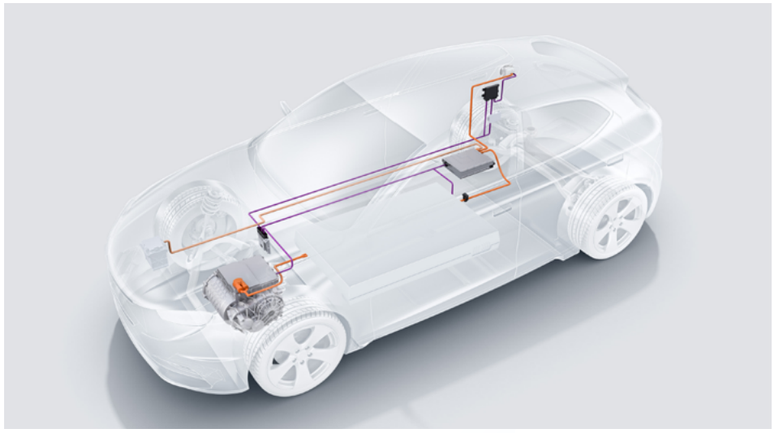
### **Danny Yang**, General Manager of Automotive Original Equipment Sales, Bosch Taiwan

Mobility is changing in an effort to protect the environment even more effectively. As a leading mobility technology supplier in the world, Bosch is committed to leading the path toward climate-neutral mobility. In this, Bosch draws on the wealth of experience and expertise from all areas of the company to ensure it is the best partner for electromobility. Bosch is a leading supplier along the entire electromobility value chain – from chips, e-axles, software and services to battery recycling technology, and more. In our view, electromobility is a growth market and is part of our core business. It will be the predominant technology for decarbonizing mobility worldwide.

## Sustained Leadership in Powertrain Solutions

Bosch is driving the transition to electromobility and seizing the opportunities it presents. As a market leader of powertrain solutions, Bosch is taking electric drives forward and is broadly positioned – from e-bikes to commercial vehicles. In 2022, we were able to increase the production of components for electric drives by 50 percent compared to the previous year, and the number of our customers doubled between 2019 and 2023.

When it comes to electric drives, safety, performance, range, weight, and installation space are the requirements that must be taken into consideration. E-axle, our electric all-in-one drive solution, is the answer to these challenges for electric vehicles. The electric motor, power electronics, and transmission are combined in a compact unit, directly powering the vehicle's axle. This aids in making electric drives less complex and simpler. The power electronics convert the direct current from the battery into the alternating current required by the electric motor. The electric motor provides the mechanical conversion of the energy, which ultimately transmits the speed to the axle through the transmission and thus drives the vehicle. With system voltages of up to 800-Volts, higher power densities through silicon carbide (SiC) semiconductors technology, and efficiencies of up to 96%, electric drive solutions are taken to the next level, enabling immense acceleration through high torque, rapid charging, and increased ranges. In addition to optimized performance, the compact design and the high level of system integration in one housing, e-axle provides a cost-attractive overall solution, combining innovation, economy, and efficiency in one system.



In the e-axle, the electric motor, power electronics and transmission are combined in a compact unit, directly powering the vehicle's axle

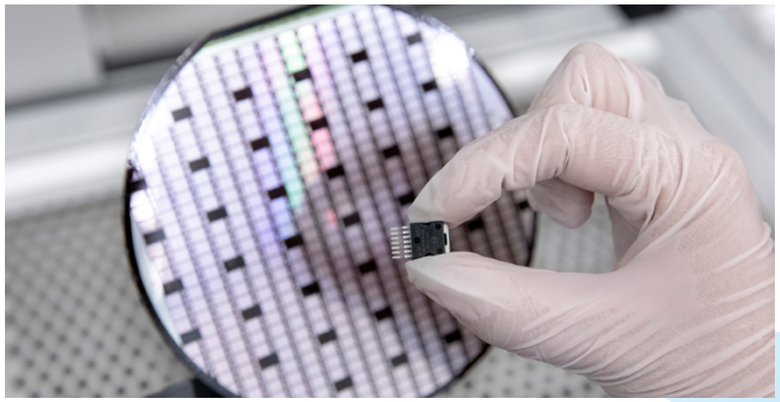
Powertrain diversification is on the rise and includes a wide degree of electrification. The centralized powertrain controller is the solution for increased functions and software complexity and more processing power required for interconnectivity. The vehicle control unit coordinates the components in the powertrain or even assumes some of their functions. This includes control of the inverter and battery management system, as well as transmission and engine control. Battery charging control responsible for communication with the charging station via a standardized interface can be integrated into the vehicle control unit as well. In addition, the introduction of a new level of abstraction in the electrical/electronic (E/E) architecture makes variant handling of changing powertrain components much easier and saves resources in the subsidiary component-related control units. Due to its modular and configurable hardware and software, the vehicle control unit can be flexibly designed to meet future requirements. The vehicle control unit standard is available in two standard versions – vehicle control unit standard mid and vehicle control unit standard max – and is scalable to fit customer demands. It uses resource-optimized classic micro-controller technology based on the latest engine management generation.

With electric powertrain systems becoming more powerful and efficient, the right thermal management is constantly gaining significance, ensuring more range and comfort in electric vehicles. Bosch uses intelligent thermal management to increase the range of electric and hybrid vehicles. Optimal coordination of the refrigerant circuit and the cooling circuit enables precise distribution of heat and cold, improves the efficiency of the battery, and ensures that all components are working within their optimum temperature range. For this purpose, Bosch is developing flexible thermal units as pre-integrated solutions. With fewer parts, assembly steps, and cables, these reduce installation space and weight. The thermal management system delivers a pleasant temperature inside the vehicle, thus benefiting passengers. The global brushless blower plays an active part in increasing climate comfort in the passenger compartment. Depending on the outside temperature and the vehicle occupants' requirements, it transports the flow of air into the vehicle interior for cooling or heating. Smart motor topology enables a compact design that significantly reduces weight, increases power density, and reduces noise emissions.

## Small Chips with Big Impact

Bosch has unique expertise both in the automotive systems business and in the production of semiconductors. With more than 60 years of experience, a global manufacturing and partner network, as well as sustainable investments in production and development, Bosch is shaping the mobility of the future. Semiconductors and sensors from Bosch ensure safe, comfortable, and low-emission driving. Bosch is continually investing in research and development and in expanding its worldwide semiconductor manufacturing network. Its portfolio includes integrated circuits, MEMS (microelectromechanical systems) sensors, power semiconductors, and power modules. For automakers who define their own E/E vehicle architectures, Bosch offers the ability to precisely tailor the functional scope of semiconductors to this architecture.

In the field of electromobility, Bosch is focusing on the innovative semiconductor material SiC, a key component that makes a significant difference to range anxiety. In electric cars, SiC chips extend driving range and make charging more efficient, as their energy losses are up to 50 percent lower. They enable the car to travel further on a single battery charge – on average, range is up to six percent greater than with silicon-based chips. Bosch is consistently expanding its semiconductor operations, aiming for further growth in the semiconductor segment, and continuing to invest heavily in the expansion of its semiconductor operations. With the acquisition of a U.S. chip manufacturer in Roseville, California, in 2023, Bosch is expanding its semiconductor business through the addition of silicon carbide chips. The ramp-up of electromobility worldwide is leading to enormous demand for these special semiconductors. Using highly complex processes developed in-house, Bosch has been producing SiC chips at its wafer fab in Reutlingen, Germany, since 2021, and is currently investing more than 1.5 billion dollars in a further wafer fab in Roseville. This move will strengthen the company's international semiconductor manufacturing network. The aim is to start production of the first SiC chips in the U.S. by 2026, and in doing so increase the company's output tenfold in the years ahead. By building silicon-carbide structures vertically and no longer on a flat plane, Bosch can further increase the power density of the chips. Bosch was the first SiC manufacturer to put this technology on the road, and with the second generation, we were able to increase performance by a further 30 percent in 2023. At Bosch, investment supplements innovation. Starting in 2026, Bosch plans to manufacture the first vertically structured SiC chips on cost-effective 200-millimeter wafers.



Bosch is focusing on the innovative semiconductor material SiC, a key component that makes a significant difference to range anxiety, to support the development of electromobility

## Software-defined Electromobility

In the future, what is expected of mobility will go far beyond classic vehicle functions and this for sure applies to electromobility. Users are seeking an abundance of easily accessible, exciting mobility services, similar to the seamless digital services they are used to from their smartphones. An era of software-defined mobility is dawning, shaping a new user-centered and cloud-based ecosystem where electromobility can greatly benefit from. With software and services, such as Battery in the Cloud and connected vehicle energy management system, Bosch is powering electric vehicles with enhanced efficiency, lifetime, and convenience.

The battery is one of the most valuable parts in an electric vehicle. The older the batteries get, the lower their performance and capacity, and the shorter the range of the vehicle. For manufacturers, fleet operators, and users of electric vehicles, the battery is often still a largely unknown factor regarding the reliability and performance of their vehicles. It is often rather difficult to assess the current condition of the battery from the outside, and so there is a risk that a vehicle may in fact only have a reduced range, or the battery is prone to sudden breakdowns, or high costs will be incurred if the battery needs replacing entirely. Bosch has thus combined its wide-ranging expertise in batteries and electric drives with its extensive know-how in connectivity and cloud-based services into a comprehensive, cost-effective single-source solution. This smart software functions in the cloud to continually analyze the battery status and take appropriate action to prevent or slow down cell aging. These measures can reduce the wear and tear on the battery, the most expensive component of an electric vehicle, by as much as 20 percent. Real-time data gathered from the vehicle and its surroundings plays a key role here. The cloud services utilize this data to optimize every single recharging process and to provide drivers with tailored driving tips on how to conserve battery power via the dash display. The connected battery services from Bosch support the development of an economic ecosystem centered around the electric vehicle battery – with new value chains and business models that cover all aspects of the product life cycle.

With connected vehicle energy management system, Bosch offers modular, innovative software solutions that bring together electric vehicles' thermal management, powertrain, and electrical system. This ensures the optimum distribution of energy at the vehicle level, thereby reducing energy consumption and increasing comfort. It also paves the way for new functions such as safe home mode. This assists the vehicle in reaching its destination with the remaining battery charge by reducing the power consumption of comfort items such as heating and climate control as necessary. Smart distribution of energy within the vehicle that is adapted to the current operating mode is one of the central factors for the efficiency of the electric drive, comfort in the vehicle's interior, and the service life of the vehicle and its components. This approach can lower system and operating costs. In addition, energy-saving operation increases the range of the electric vehicle, meaning fewer charging stops are needed. The exact range prediction simplifies planning the most efficient route and navigating to the optimal charging station along the way. During charging, battery health can be protected through smart load and energy management. The user can also personalize the charging process using different charging modes and choose a mode that charges particularly quickly or cost-effectively, for example.



With connected vehicle energy management system, Bosch offers modular, innovative software solutions that bring together electric vehicles' thermal management, powertrain, and electrical system

## Circulation Economy Driven by Industrial Technology

The battery is one of the most cost- and resource-intensive components of a battery electric vehicle. It is evident that with growing numbers of electric cars combined with limited resources and increasing legal requirements for recycling – the challenges are increasing. While the rapid transition to electromobility is certainly positive news from an environmental perspective, there is no denying that it is going to require a lot of lithium-ion batteries. Their batteries contain rare and valuable raw materials such as lithium and nickel, the recovery of which makes economic and ecological sense. However, only fully discharged batteries can be safely shredded and then broken down into their chemical components. That is why Bosch developed a complete automation solution for the deep discharging of batteries, which provides an introduction to industrial recycling with the potential for rapid scaling.

According to the Fraunhofer Institute for Systems and Innovation Research, the technical systems required for recycling will require investment of more than 6 billion euros by 2040 in Europe alone (Source: Fraunhofer, 2021). Recycling will be worthwhile: optimum recycling can recover up to 95 percent of a battery's chemical elements and recycle them into the battery production process. The automated discharging system developed by Bosch not only simplifies recycling, but also increases efficiency and enhances safety. The solution combines the TS 5 transfer system and ctrlX AUTOMATION, a complete automation solution surmounting the classic boundaries between machine controls. The TS 5 transfer system transports batteries of different sizes and types from various manufacturers between the diagnostic discharging and dismantling stations. A modular solution from the automation toolkit ctrlX AUTOMATION then discharges the battery cells in the discharging station. The discharging equipment automates the initial inspection, the deep discharging process with chemical inactivation and the final check.




Combining the TS 5 transfer system and ctrlX AUTOMATION, Bosch Rexroth provides a complete automation solution for battery recycling

With this new system, a process that used to take 24 hours when it was done manually, now takes less than 15 minutes. It also improves safety for workers and significantly reduces the fire risk later down the line. This process will help to make battery recycling quicker, safer and more cost-effective. The solution kit is offered to both plant operators and system integrators. Its modular design enables economical scaling to higher quantities and adaptation to future challenges in battery recycling. Bosch Rexroth relies on open standards throughout for communication and programming. This makes the solution very easy to integrate into the IT structures of different applications, making it possible to recycle batteries on an industrial scale and offers the possibility of flexible scaling.



## Author

**Danny Yang**

**General Manager of Automotive Original Equipment Sales**

**Bosch Taiwan**

Danny Yang has been general manager of automotive original equipment sales of Bosch Taiwan since 2013. He is responsible for sales activities of automotive parts to Taiwan's vehicle makers in the fields of both two wheels and four wheels. In addition to his role at Bosch Taiwan, Mr. Yang has been a member of the Mobility Committee of the European Chamber of Commerce Taiwan (ECCT), advocating for a fair and reasonable regulatory environment to enable the adoption of innovative mobility solutions in Taiwan.

ZUELLIG PHARMA
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## Green Low-Carbon Logistics: The Future of Electrification and Carbon Reduction

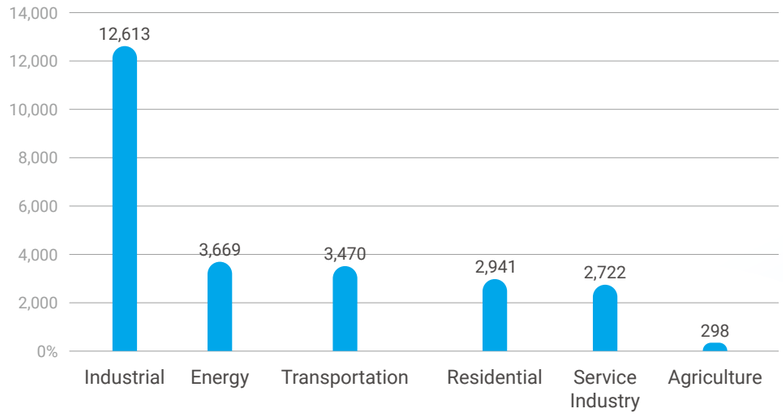
**John Chou**, Managing Director, Zuellig Pharma

In response to the global trend towards net zero emissions, Taiwan has set a pathway and target for achieving net zero emissions by 2050. Among the 12 key strategies, the Ministry of Transportation and Communications has included the "Electrification and Decarbonization of Transportation" and "Promotion of Green Freight" under the "Net Zero Green Life" initiative. Electrifying logistics vehicles has become a crucial method for logistics operators to achieve green and low-carbon transportation transformation. However, practical implementation faces numerous challenges. Only through public-private collaboration between the government and enterprises can the electrification and decarbonization of transportation be accelerated and carbon reduction goals be achieved.

## Logistics Emissions Contributes 4% to National Carbon Emissions – Urgent Call for Sustainability

According to the latest National Greenhouse Gas Emissions Inventory Report (2024 edition), the transportation sector emitted 34.7 million tons of $CO_2$ in 2022, accounting for 13.45% of total emissions, second only to the industrial sector (48.90%) and the energy sector (14.22%). Currently, it is the third-largest emitting sector. Over the past decade, Taiwan's transportation carbon emissions have not significantly decreased. Compared to 33.9 million tons in 2021, the annual growth rate of $CO_2$ emissions was 2.36%, primarily due to a 2.11% increase in road transportation.

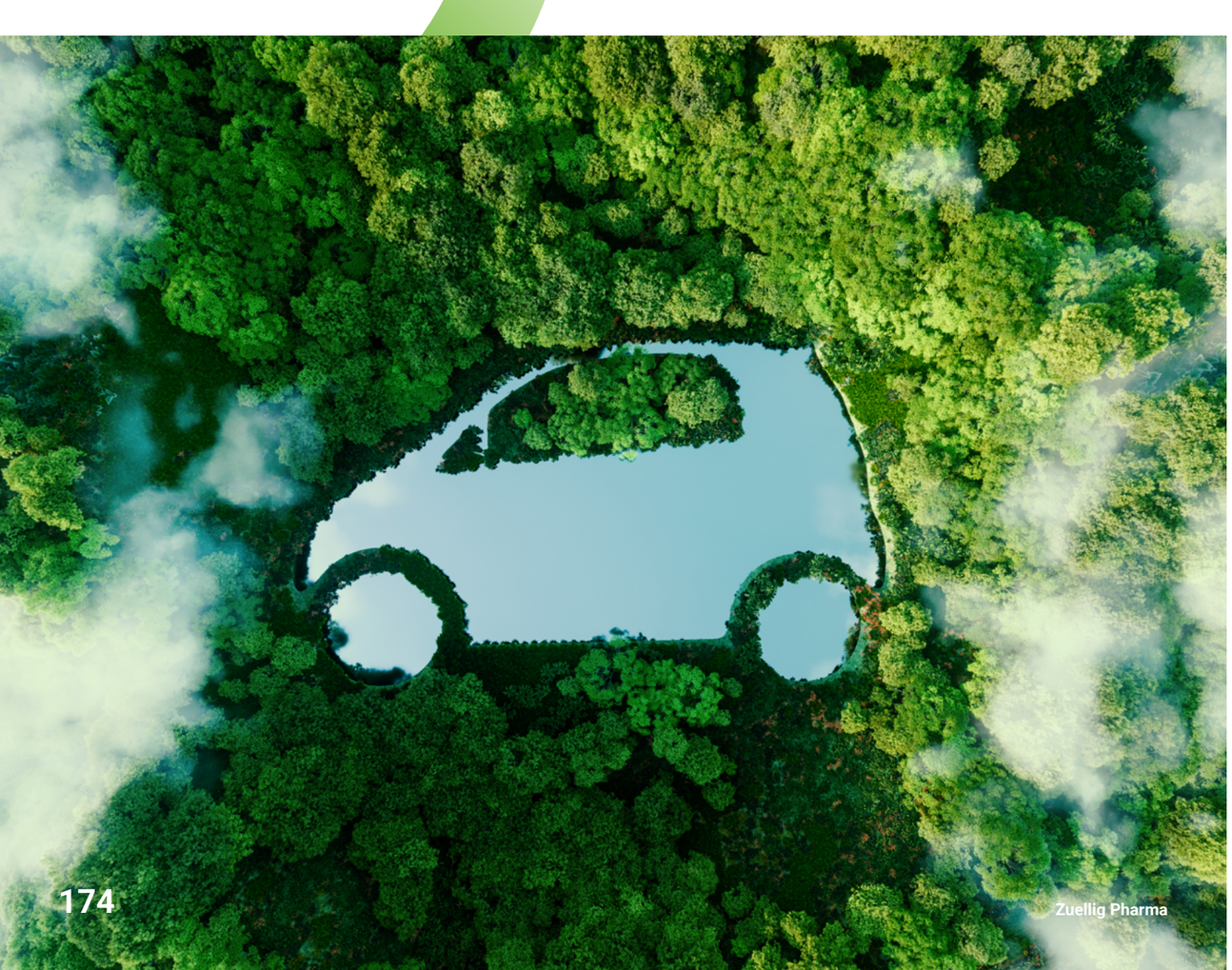
### $CO_2$ Emissions by sectors (Unit: 10,000 tons (10 $tCO_2e$))




A detailed analysis of the transportation sector's carbon emissions structure reveals that road transportation accounts for 98.33%. Although passenger cars still have the highest share at 50.54%, large trucks and small trucks account for 18.31% and 11.81%, respectively, meaning freight transportation accounts for over 30%. If we isolate logistics freight carbon emissions, it accounts for 4% of national carbon emissions, making sustainable development transformation in logistics urgent.

# Electrifying Taiwan's Logistics: The Current Landscape and Future Prospects

Currently, the development of electric logistics vehicles in Taiwan is still in its early stages. In the small vehicle segment, domestic manufacturers have recently launched a new 3.5-ton electric commercial truck, with plans for mass production by 2025. There are also Japanese-made 5-ton and 8.5-ton medium and small electric commercial vehicles available. For medium and large electric commercial vehicles, European and American brands dominate the market. However, to accelerate the practical application of electric vehicles in the logistics industry, the following three challenges in policy and support measures need to be addressed.



Zuellig Pharma

## Challenge 1: Limited Choices, Unclear Specifications, and the Green Premium in Electric Logistics Vehicles

Currently, the choices for electric logistics vehicles in the Taiwanese market are still limited. Although the Ministry of Economic Affairs is promoting the development of the domestic commercial electric vehicle industry chain and encouraging domestic manufacturers to invest in the development of electric trucks, the overall market still lacks a variety of models and specifications. Additionally, the issue of green premiums persists, with domestic prices yet to be clearly announced, and imported trucks costing twice as much as diesel models.

Research abroad indicates that most people are unwilling or unable to pay the green premium when given a choice, while those with high willingness expect better performance. From our experience, logistics operators are most concerned about mileage range. For each fully loaded trip, a round trip requires 200 kilometers. If electric vehicle specifications cannot address "range anxiety," logistics operators willing to switch will find it difficult to fully assess cost-effectiveness, hindering the transition.

## Challenge 2: Integrating Foreign Enterprises into Public-Private Collaborations

The Industrial Development Administration of the Ministry of Economic Affairs launched the "Electric Commercial Vehicle Demonstration Operation Subsidy Program" in 2023, supporting domestic manufacturers and logistics operators in field testing to verify the quality and safety of electric commercial vehicles. However, the subsidy program primarily targets state-owned and local logistics operators.

Foreign companies operating in Taiwan, in compliance with European and American sustainability regulations, are more proactive in setting carbon reduction targets and have a strong motivation to adopt sustainable solutions. For example, Zuellig Pharma has set a goal of carbon neutrality by 2030 under the Science-Based Targets initiative (SBTi), aiming to reduce Scope 1 and Scope 2 carbon emissions by 42% compared to the 2021 baseline. Zuellig Pharma has already successfully reduced emissions by 38% through various carbon reduction measures and continues to progress towards carbon neutrality.

We kindly suggest that the government consider incorporating feedback from foreign enterprises operating in Taiwan when promoting the development of domestic electric vehicles and low-carbon transportation solutions. By leveraging the global networks of these foreign companies, we can enhance the visibility and market opportunities for domestic electric vehicles and related systems in international markets.

## Challenge 3: Strengthening Government Support and Subsidies

We also encourage the government to consider increasing subsidies for electric trucks and providing additional support measures, such as purchase subsidies, exemptions from license and fuel taxes, subsidies for charging facilities, and maintenance service support. For instance, Japan's Ministry of Land, Infrastructure, Transport, and Tourism launched the "Subsidy for Introducing Commercial Electric Vehicles" program in 2021. This initiative aims to achieve 20% to 30% of new small vehicle sales being electric by 2030 and 100% of new vehicle sales being electric or zero-carbon fuel vehicles by 2040, by providing subsidies for vehicle purchases and charging infrastructure.

In contrast, Taiwan's current subsidy programs focus more on electric passenger cars, with policies for electric commercial vehicles yet to be established. Additionally, clear policies and timelines related to logistics freight should be formulated to support logistics operators in accelerating their low-carbon transformation.





Zuellig Pharma






## Sustainable Transformation Experience in Pharmaceutical Logistics

In Taiwan, one out of every two medicines and medical devices is delivered through Zuellig Pharma. As a key supply chain player in Taiwan's medical industry, Zuellig Pharma Taiwan introduced the first electric cold chain truck in the pharmaceutical industry in 2024. Collaborating with Volvo, they introduced a 17.5-ton electric cold chain truck to handle the transportation of medicines and medical supplies from the Taoyuan logistics center to central Taiwan.

Compared to diesel trucks of the same class, the electric truck significantly reduces carbon emissions by 60% and minimizes noise pollution in urban areas and medical institutions. Currently, we have gradually replaced its last-mile delivery fleet to 20,000 medical institutions, clinics, and pharmacies across Taiwan with Euro 6-compliant diesel vehicles over the past few years.

In terms of fleet and route management, we have also introduced AI-powered calculations to optimize delivery routes, vehicle dispatch, and fuel usage. In the future, we hope to share inventory information systems with hospitals. When the system detects a shortage of medical supplies, it can integrate and plan unified deliveries with nearby medical institutions, achieving the lowest carbon emissions and high-efficiency transportation.

In addition to electric vehicles, Zuellig Pharma offers several practical carbon reduction solutions for transporting medical supplies, such as using eZCooler packaging instead of polystyrene, which maintains low temperatures for 60 hours and is reusable. They also plan to introduce logistics boxes to reduce the use of consumables in general medicine transportation.




## Conclusion

While Taiwan has made some progress in the development of electric logistics vehicles, many challenges remain. Logistics operators face limited choices, unclear specifications, and prices when selecting electric logistics vehicles. Government support and subsidies are still insufficient to fully support the low-carbon transformation of the logistics industry.

To achieve the 2050 net zero emissions target, the government and industry must work together to strengthen support for electric trucks and promote the green transformation of the logistics industry. Zuellig Pharma will continue to monitor the development of electric commercial vehicles in Taiwan and hopes to prioritize the use in pharmaceutical logistics operations, accelerating decarbonization and electrification. This will help create a green pharmaceutical logistics fleet, reducing the environmental impact while treating patients and assisting the government in achieving net zero transformation goals.







**Author**

**John Chou**

**Managing Director**

**Zuellig Pharma**

With over 20 years of experience in the healthcare industry, John Chou joined Zuellig Pharma, Asia's largest pharmaceutical services company, in 2009. John oversees Taiwan's operations, driving comprehensive digitalization and sustainable transformation and establishing the company as a full-service provider in the healthcare industry. Over the past three years, Taiwan has become the largest subsidiary in terms of revenue within the Zuellig Group, with business segments spanning pharmaceutical logistics, pharmaceutical marketing agency, clinical trial logistics, and patient care, fulfilling the vision of "making healthcare more accessible."

John graduated from the Department of Forestry and Resource Management at National Taiwan University and hold an EMBA from NTU. I have previously served as Product Manager at 3M Taiwan, General Manager of Polaroid Far East Taiwan, and joined Wyeth Taiwan in 2002, managing markets in Taiwan, China, and Hong Kong, gaining extensive cross-market management experience.

Zuellig Pharma is Asia's largest healthcare services provider, established in 1922 with over a century of history. It operates across 13 markets, partnering with the world's top 20 pharmaceutical companies. Zuellig Pharma Taiwan, established in 1988, boasts the largest cold chain pharmaceutical logistics center in Taiwan, serving over 90 international and local pharmaceutical and biotech companies. It distributes medical products and devices to 20,000 medical institutions, clinics, and pharmacies across Taiwan. In recent years, it has also facilitated the delivery of over 70 million doses of

COVID-19 vaccines, test kits, and antiviral drugs for national pandemic prevention. From clinical trials to post-market sales, order processing, picking, shipping, and delivery to patients, Zuellig's services are integral at every step.



# A Better Space for Your Employees and the Planet

As a business operating in the modern world, sustainability has become essential. Investors expect it, customers demand it and employees value it. Working well on ESG related issues will enhance your reputation and create long-term value.

In particular since COVID, requirements for a quality work environment have also increased. Air quality, light quality, flexibility in the setup of workspaces are basic requirements. Fortunately, sustainability and employee wellbeing often go hand in hand.

This article will introduce how to create a better work environment for employees and better facilities for the planet. It outlines key aspects to consider when planning your new facility or upgrading an old one.

- **Environment:** The performance of a building in terms of energy efficiency, water consumption, waste management, building materials, and adoption of renewable energy all have an impact on the environment. The subsequent carbon footprint needs to be evaluated and monitored, with actionable steps put in place to make changes and improvements.
- **Social:** Buildings can be designed to promote occupant health and well-being through features such as good indoor air quality, natural lighting, and access to green spaces.
- **Governance:** Providing transparent information about a building's environmental and social impacts, as well as governance structures and practices, helps stakeholders make informed decisions and holds organizations accountable for their actions.

In particular this article will introduce RCI's Façade solar integrated system, and data collection system ECON – "your data has a better idea", which uniquely allows you to collect  data from different systems on your facility in a single application, providing insights on the operation of your entire facility, reducing costs, and allowing for further automation to increase efficiency.

## Introduction

Implementing ESG practices involves integrating these factors into various aspects of a company's operations and decision-making processes. Companies need to establish key performance indicators (KPIs) and metrics to track their progress towards environmental impact reduction, social responsibility initiatives, and governance. Regular reporting on ESG performance, usually through sustainability reports or integrated annual reports, helps stakeholders assess the company's sustainability efforts and transparency.

# Facilities

Whether choosing an existing facility as a working space or creating an entirely new facility, look out for green building certification. Here is the list of the various certification you may commonly see  in the Taiwan market and what they cover:

## Global Standards

LEED (Leadership in Energy and Environmental Design) is the most renowned and credible green building rating system globally. Advocated by the U.S. Green Building Council (USGBC), its aim is to promote the practice of sustainable design and construction standards. LEED consists of credits which earn points in several categories including: Integrative Process, Location and Transportation, Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, Innovation, and Regional Priority.

WELL is a comprehensive international certification program designed for buildings and organizations to deliver intentional spaces that enhance the health and well-being of their occupants. It is a performance-based system for measuring, certifying, and monitoring features of the built environment that impact human health and well-being by looking at ten factors, or concepts. They include: Air, Water, Nourishment, Light, Movement, Thermal Comfort, Sound, Materials, Mind, Community, and Innovation.

The UL VHB (Verified Healthy Building) program offers the real estate industry an independent source of reassurance from a respected safety science leader. It focuses on indoor air and water quality to ensure health and wellbeing of future occupants.

EARTHCHECK is a leading global certification and benchmarking program for the tourism and hospitality industry. It is designed to assist businesses, organizations, and destinations achieve sustainability goals.

## Taiwan's Standards

EEWH is Taiwan's green building certification system and focuses on enhancing the efficiency of buildings, reducing energy consumption and environmental impacts, while also providing a healthier and more comfortable indoor environment.

The goal of Taiwan's INTELLIGENT BUILDING Mark is to promote a sustainable environment, create efficient modern living spaces that reflect technological lifestyle, architectural space and cooperation between occupants.

Taiwan's LEBR (Low Embodied-carbon Building Rating System) calculates and evaluates the embodied carbon emissions of buildings, and provides hotspot diagnosis and methods for carbon reduction improvement.

BERS Taiwan's Building Energy Efficiency Rating System (BERS) primarily aims to encourage property owners and developers to design, construct, and operate buildings with higher energy efficiency.

## Green Spaces

Green spaces in the building environment play a crucial role in promoting sustainability and enhancing the quality of life for occupants. These spaces, which include gardens, green roofs, and landscaped areas, help mitigate the urban heat island effect by providing cooling through evapotranspiration and shading. This not only reduces the need for air conditioning but also lowers energy consumption and greenhouse gas emissions. Additionally, green spaces support biodiversity by offering habitats for various species, contributing to the overall ecological health of urban areas. They also improve air quality by filtering pollutants and producing oxygen, creating a healthier environment for both humans and wildlife.

For people, green spaces offer numerous physical and mental health benefits. Access to nature has been shown to reduce stress, improve mood, and enhance cognitive function. Green spaces encourage physical activity, such as walking, jogging, and cycling, which can lead to better overall health and reduced healthcare costs. Moreover, these areas provide opportunities for social interaction and community building, fostering a sense of belonging and well-being among residents. By integrating green spaces into the built environment, we can create more sustainable, livable, and resilient cities that benefit both the planet and its inhabitants.

## Waste Management

For companies with strict Environmental, Social, and Governance (ESG) policies, effective waste management in an office environment is crucial. These companies must implement comprehensive waste reduction strategies that prioritize the "waste hierarchy": reduce, reuse, and recycle. This involves minimizing waste generation through efficient resource use, encouraging the reuse of materials, and ensuring proper recycling practices. Additionally, companies should establish clear protocols for the disposal of hazardous and electronic waste to prevent environmental contamination[2]. Regular training and awareness programs for employees are essential to foster a culture of sustainability and ensure compliance with waste management policies. Monitoring and reporting on waste management performance also help in maintaining transparency and continuous improvement[1]. By adhering to these practices, companies can significantly reduce their environmental footprint and align with their ESG commitments.

Data Collection ECON is RCI's proprietary monitoring platform, designed to collect real-time data on the health and performance of your building. It enables the seamless display of data from various sources in a straightforward manner, allowing you to identify areas for improvement. By centralizing all your data—such as Indoor Air Quality (IAQ), energy usage, water consumption, and other metrics—ECON supports a wide range of monitoring devices and data protocols.

RCI offers consultation services to customize your dashboard according to your specific needs. Utilize the data collected by ECON to take control of your environment, enhance the health and well-being of occupants, reduce environmental impact, and optimize operational costs.

# Workplace Planning for Employee Well-being

## Comfort and Flexibility

The Covid-19 pandemic has irrevocably altered the landscape of work, catalyzing a widespread shift to remote working arrangements. This transition has underscored the necessity for offices to evolve, fostering environments that support both in-person and remote productivity. Businesses are now recognizing the importance of flexible workspaces that can adapt to the varying needs of their workforce. To accommodate this, offices are being redesigned to include hot-desking areas where employees can work when they choose to come into the office, as well as soundproof booths for private calls and video conferences, ensuring that remote communication is as seamless as possible.

To create such a flexible workspace, businesses can implement a variety of strategies. For instance, investing in modular furniture and movable partitions allows for the quick reconfiguration of spaces to suit different tasks and team sizes. Additionally, incorporating technology like high-speed internet, wireless charging stations, and cloud-based collaboration tools ensures that employees have the necessary resources to work efficiently, whether they are in the office or at home. By creating a dynamic and adaptable office environment, businesses can ensure that they are well-equipped to handle the evolving demands of the modern workforce.

## Indoor Environmental Quality

Another consequence of the Covid epidemic has been the increased value placed on indoor air quality and ventilation. Aside from limiting virus transmission, good indoor air quality has other benefits such as increased oxygen and reduced particulate levels in the office which will contribute to employees well-being and productivity.

Indoor air quality in office environments is a critical factor that can significantly influence employee well-being and productivity. Poor air quality can lead to a range of health issues, from headaches and dizziness to respiratory infections, which can result in increased absenteeism and reduced work performance. Contaminants like mold, dust, volatile organic compounds (VOCs), and inadequate ventilation can contribute to a decline in the cognitive functions of employees, affecting their concentration, accuracy, and speed of task completion.

Conversely, enhancing indoor air quality can lead to improved health, comfort, and work efficiency. Implementing measures such as regular maintenance of HVAC systems, use of air purifiers, introduction of indoor plants, and ensuring proper ventilation can help in reducing pollutants. This creates a healthier work environment, which can boost cognitive function, reduce sick days, and promote a more energetic and productive workforce. Ultimately, investing in better air quality is not only beneficial for employee health but also for the overall success of the organization.

RCI can carry out testing for pollutants such as volatile organic compounds (VOCs), particulate matter, carbon monoxide, carbon dioxide, and other potential contaminants.

## Smart Technology Integration

Smart technology integration in office environments has revolutionized the way we interact with our workspaces. Intelligent lighting systems, for instance, use sensors and automation to adjust brightness and color temperature throughout the day, enhancing comfort and reducing energy consumption. Climate control technologies have also become more sophisticated, with smart thermostats and HVAC systems that learn from user preferences and occupancy patterns to maintain optimal temperatures and air quality, contributing to a healthier and more productive office atmosphere.

In addition to lighting and climate, smart technology extends to various other office management needs. Advanced security systems with facial recognition and real-time monitoring ensure a safe workplace, while IoT devices streamline maintenance by predicting and addressing issues before they escalate. Meeting rooms equipped with smart booking systems and virtual assistants facilitate seamless collaboration. Overall, the integration of smart technology in offices not only boosts efficiency and sustainability but also creates a more adaptive and enjoyable work environment.

## Lighting Quality

Lighting quality in office environments significantly impacts employees' health and safety. Proper illuminance levels, typically measured in lux, are crucial for reducing eye strain, fatigue, and headaches. Insufficient lighting can lead to increased errors and accidents due to poor visibility, while excessive lighting can cause glare and discomfort. The ideal illuminance level varies depending on the task, with general office work requiring around 300-500 lux, and more detailed tasks needing up to 1000 lux. Additionally, color intensity and temperature play a vital role; cooler light (around 5000K) is often preferred for its stimulating effects, enhancing alertness and productivity, whereas warmer light (around 3000K) creates a more relaxed atmosphere.

Testing lighting quality involves several steps to ensure compliance with standards and to optimize the work environment. Light meters are used to measure illuminance levels across different areas of the office, ensuring even distribution and adequate lighting for various tasks. Color rendering index (CRI) tests assess how accurately light sources reveal the colors of objects, which is important for tasks requiring color differentiation. Regular audits and adjustments are necessary to maintain optimal lighting conditions, taking into account changes in natural light throughout the day and seasonal variations. By prioritizing proper lighting, organizations can enhance employee well-being, reduce health risks, and improve overall productivity.

RCI RCI

## Circadian Lighting

Circadian lighting is a concept that uses electric light to support human health by minimizing its impact on our circadian rhythms. It aims to mimic the natural progression of sunlight throughout the day, helping regulate our internal 24-hour clock that affects physical, mental, and behavioral changes in response to light and darkness.

Circadian lighting is an innovative approach to interior lighting design that aligns with the human body's natural 24-hour rhythm. The theory behind circadian lighting is rooted in the understanding that light is a crucial regulator of circadian rhythms, which are the physical, mental, and behavioral changes that follow a daily cycle, responding primarily to light and darkness in an organism's environment. Circadian lighting systems are designed to mimic the pattern of natural daylight, providing the right intensity and spectrum of light at different times of the day to support our internal clock. By modulating the intensity, spectrum, and color of electric light in harmony with the natural lighting cycle, circadian lighting aims to enhance comfort, productivity, and health without altering the visual appearance of the light color.

In office settings, the application of circadian lighting can have profound effects on employee well-being and productivity. Properly implemented circadian lighting can lead to better sleep quality, enhanced alertness, mood, and concentration during work hours. It can also reduce errors, accidents, and stress associated with exposure to inappropriate light levels or spectra. For instance, bright, blue-enriched light is used in the morning to suppress melatonin production and stimulate alertness, while warmer tones are employed later in the day to promote relaxation and prepare the body for rest. This synchronization of lighting with the body's natural cycle can help in regulating sleep patterns, improving overall health, and creating a more dynamic and adaptive work environment.

## Acoustics / Noise

Noise levels in office environments significantly impact employee performance and well-being. High noise levels can lead to increased stress, reduced concentration, and lower productivity. Common sources of office noise include conversations, ringing phones, office equipment, and external traffic. Open-plan offices, in particular, exacerbate these issues due to the lack of sound barriers. Studies have shown that noise distractions can increase error rates and decrease cognitive performance. Measuring noise levels typically involves using sound level meters to capture decibel readings, ensuring they remain within recommended limits for a conducive work environment.

To mitigate the negative effects of office noise, several measures can be implemented. Acoustic treatments such as sound-absorbing panels, carpets, and ceiling tiles can help reduce noise levels. Creating designated quiet zones or private workspaces allows employees to escape from noisy areas when needed. Additionally, implementing noise-canceling technologies and encouraging the use of headphones can further minimize distractions. Regularly monitoring noise levels and gathering employee feedback can help identify problem areas and ensure continuous improvement. By addressing noise issues, organizations can enhance employee satisfaction, reduce stress, and boost overall productivity.

# Planning for the Planet

## Energy Efficiency

Energy efficiency in buildings is a cornerstone of sustainable development, aiming to reduce energy consumption while maintaining or improving comfort and functionality. This can be achieved through various strategies, such as enhancing insulation, using energy-efficient windows, and incorporating advanced heating, ventilation, and air conditioning (HVAC) systems. For instance, high-performance insulation materials can significantly reduce heat loss in winter and heat gain in summer, leading to lower energy demands for heating and cooling. Additionally, energy-efficient windows with low-emissivity coatings can minimize heat transfer, further enhancing a building's thermal performance.

Moreover, integrating smart technologies can optimize energy use in buildings. Smart thermostats, for example, can learn occupants' schedules and adjust temperatures accordingly, ensuring energy is not wasted when spaces are unoccupied. Building automation systems can control lighting, HVAC, and other systems based on real-time data, improving overall energy efficiency. Implementing these technologies not only reduces energy bills but also contributes to a lower carbon footprint, supporting global efforts to combat climate change. By prioritizing energy efficiency, buildings can become more sustainable, resilient, and cost-effective in the long run.

## Renewable Energy Utilization

Taiwan is currently experiencing a renewable energy deficit, resulting in elevated prices for renewable electricity. To address this, facilities can consider several self-generation methods. Beyond the prevalent rooftop photovoltaic (PV) systems, two additional alternatives merit attention.

Firstly, Façade PV technology offers a novel approach by incorporating PV cells into the building's exterior surfaces. This is particularly advantageous for new or renovated structures, as it combines the necessity of façade cladding with energy generation, incurring only minimal extra costs. The installation process aligns with conventional construction practices, facilitating integration into new or existing buildings. Moreover, the product is offered in an extensive assortment of colors and materials, enhancing aesthetic flexibility.

Secondly, onshore wind power presents a viable solution, especially for facilities located in industrial or port areas. The feasibility of this option is contingent upon improved regulatory support, particularly from the Ministry of Transportation and Communications (MOTC) and the Ministry of Environment (MOENV). With enhanced governmental backing, onshore wind could rapidly evolve into a cost-effective self-generation avenue, boasting costs below 2NT$/kWh. The primary challenge remains navigating the governmental permitting process.

## Water Resource Management

Water resource management in buildings is essential for promoting sustainability and reducing operational costs. Effective strategies include optimizing water systems, detecting and repairing leaks, and implementing water conservation measures. For instance, installing low-flow fixtures, such as faucets and toilets, can significantly reduce water consumption. Additionally, rainwater harvesting systems can be used to collect and store rainwater for non-potable uses like irrigation and toilet flushing. These measures not only conserve water but also reduce the energy required for water heating and pumping, contributing to overall energy efficiency.

Moreover, smart water management technologies are becoming increasingly important in modern buildings. These systems use sensors and data analytics to monitor water usage in real time, identify inefficiencies, and automate water-saving actions. For example, smart irrigation systems can adjust watering schedules based on weather conditions and soil moisture levels, ensuring optimal water use. By integrating these advanced technologies, buildings can achieve higher levels of water efficiency, reduce their environmental footprint, and enhance resilience against water scarcity.

## Material Selection

Sustainable material selection in construction is a critical aspect of green building practices, aiming to minimize environmental impact and promote resource efficiency. The process involves choosing materials that have a reduced ecological footprint throughout their life cycle, from extraction to disposal. Key considerations include the material's embodied energy, recyclability, and potential for reuse. For instance, materials like bamboo, recycled steel, and reclaimed wood are favored for their low environmental impact and renewability. By prioritizing these materials, construction projects can significantly reduce carbon emissions, conserve natural resources, and minimize waste generation.

Moreover, sustainable material selection also considers the health and well-being of building occupants. Materials that emit low levels of volatile organic compounds (VOCs) and other pollutants are preferred to ensure indoor air quality. Additionally, the durability and maintenance requirements of materials are evaluated to ensure long-term sustainability. For example, high-performance insulation materials can improve energy efficiency, while durable flooring options like cork or linoleum can reduce the need for frequent replacements. By integrating these sustainable materials, the construction industry can contribute to a healthier environment and promote a more sustainable future.





## Circular Economy

The construction industry stands as a significant contributor to environmental depletion, with its extensive use of raw materials and generation of waste. Embracing the circular economy within construction is crucial for sustainable development. This approach prioritizes the reuse and recycling of materials, promotes resource efficiency, and aims to minimize waste. By considering the circular economy, construction projects can significantly reduce their environmental footprint, conserve natural resources, and create a more sustainable future.

Implementing the circular economy in construction projects requires a paradigm shift in project planning and execution. It involves designing buildings with deconstruction in mind, selecting materials based on their lifecycle and recyclability, and utilizing construction methods that allow for material recovery. Collaboration across all stakeholders, including architects, engineers, contractors, and clients, is essential to integrate circular economy principles from the project's inception. This collective effort can lead to innovative solutions that support economic, environmental, and social sustainability in the construction sector.



## Conclusion

In conclusion, creating workspaces that prioritize both employee well-being and environmental responsibility is no longer optional but essential for businesses in Taiwan. By embracing green building certifications, incorporating green spaces, prioritizing indoor environmental quality, adopting smart technologies, and implementing sustainable practices like energy efficiency, renewable energy utilization, water conservation, sustainable material selection, and circular economy principles, businesses can reap significant benefits. These benefits include enhanced employee productivity and well-being, reduced operational costs, a smaller environmental footprint, and a stronger brand reputation in an increasingly eco-conscious market.  By taking these steps, businesses can create offices that are not only aesthetically pleasing and functional but also contribute to a healthier, more sustainable, and prosperous future for all.







RCI智森

## Author

**RCI**

RCI Sustainability Solutions is a company that provides ESG strategy consulting, sustainability certification, carbon and energy reduction, testing and performance verification, and building performance monitoring service with offices in Taichung and Taipei.

RCI specializes in sustainability and ESG, aiming to decarbonize the built environment and work towards a net zero future. The team comprises professionals from engineering, architecture, construction, facility operation, and policy fields.

The company emphasizes that sustainability is a collective objective, advocating for a healthier and greener environment. It aims to make sustainable living more accessible, benefiting the areas where people live, work, and play.





# Rethinking HVAC for an Urban Net Zero Future

Cities accommodate more than half of the world's population, consume nearly 45 percent of globally available energy, and account for over 70 percent of the world's $CO_2$ emissions. With their high energy demand, city buildings are one of the primary energy consumers, with heating and cooling representing the largest share.

Buildings are responsible for over 30% of global energy consumption. To improve our living conditions, we have engineered solutions to control the temperature, humidity, and fresh air flow in buildings. Not surprisingly, heating, ventilation, and air conditioning (HVAC) consume on average about 50% of the energy used in buildings. At the same time, in large commercial buildings the equipment used to move people, like escalators and elevators, can account for 2-5% of the build-ing's energy use. Therefore, improving the energy efficiency of these systems is essential.

Systems to control different processes inside buildings have existed for decades. However, the energy efficiency of these systems has not been sufficient. The development of variable speed drive (VSD) technology has enabled us to solve many of the energy loss problems in buildings. Because building systems like HVAC run at partial loads for most of the time, variable speed drives can save energy by an average of 20 to 60% compared to traditional damper or valve control methods. Such massive energy savings are possible because drives are able to adjust the motor speed of fans, pumps and compressors directly to meet the current building needs.

Variable speed drives help save a lot of energy, but with a small investment savings can be increased further. The optimal companion to a variable speed drive is a high efficiency motor like ABB's IE5 synchronous reluctance motor (SynRM). Compared to an IE3 energy efficiency class induction motor, it offers up to 40% reduced energy losses, delivering ultra-premium energy efficiency – a new level of efficiency defined by the International Electrotechnical Commission.

This makes SynRMs the new first choice to meet the growing global demand for improved energy efficiency. Because buildings operate for most of the time at partial loads, it's important to consider a motor's partial load performance instead of just the nominal performance. Synchronous reluc-tance technology combines the performance of permanent magnet motors with the simplicity and service-friendliness of induction motors. The rotor in a synchronous reluctance motor has no mag-nets or windings and suffers virtually no power losses. It also requires less material for manufactur-ing than a traditional motor – a great bonus for sustainability.

# ABB Cooling Solutions Save Up to 30% Annual Energy Use in New Alamein City

ABB, working together with the system integrator Quasi systems, is supplying over 470 units of ACH580 drives for major buildings in the New Alamein City development, including the presidential palace, Alamein University, New Alamein City towers and a luxury hotel.

New Alamein City is a new fourth-generation coastal city in Northwest Egypt that is projected to provide housing for around 3 million residents. This new coastal city will include a range of high quality international trade centers, residential towers and luxurious resorts, along with the existing historical sites.

In addition, some of the installed drives are ultra-low harmonic, meaning they don't pollute the power network and thus ensure its stability. Ultra-low harmonics also ensures the electrical system itself does not waste energy, further contributing to the energy saving potential and sustainability of the new city's infrastructure.

With the ACH580 solution, it is expected that the building owner will be able to save 25-30% on energy use and costs annually.

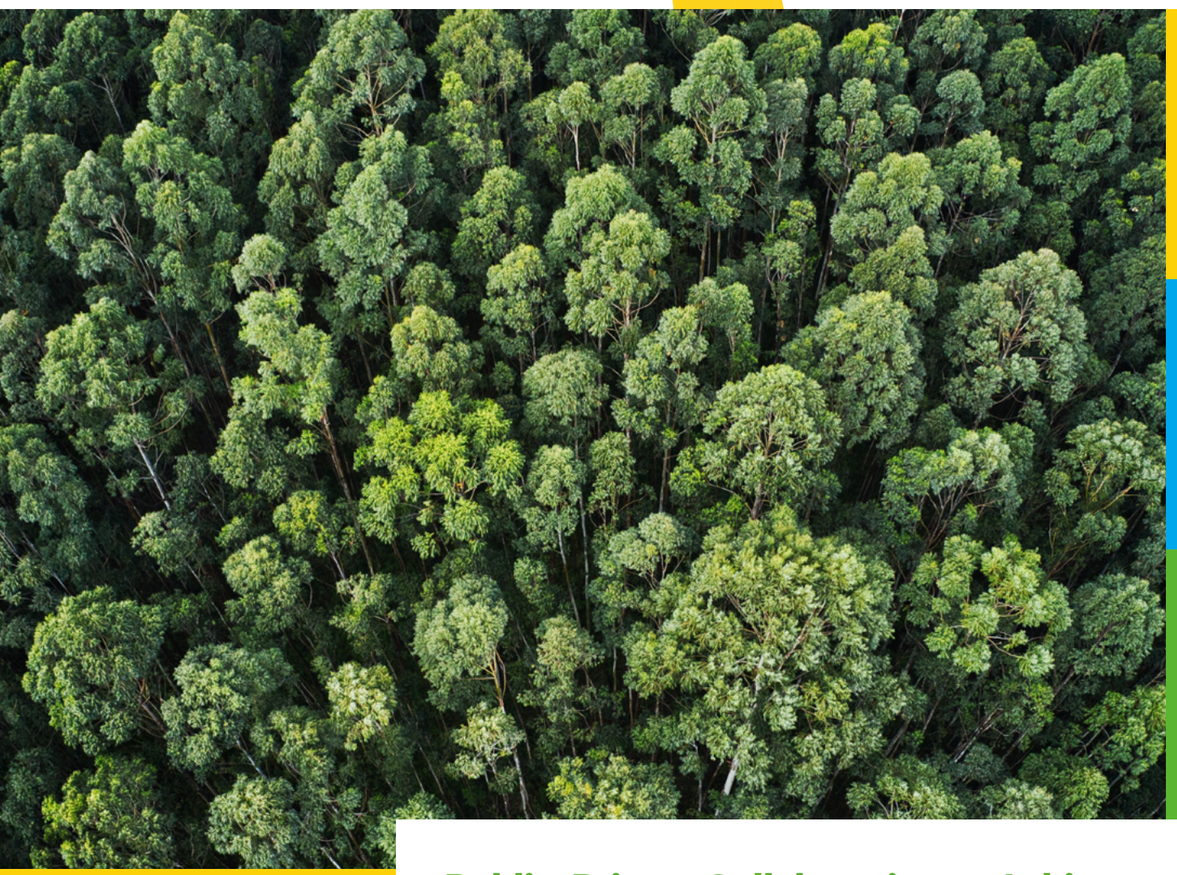


**Author**

ABB Ltd.

ABB is a technology leader in electrification and automation, enabling a more sustainable and resource-efficient future. The company's solutions connect engineering know-how and software to optimize how things are manufactured, moved, powered and operated. Building on over 140 years of excellence, ABB's more than 105,000 employees are committed to driving innovations that accelerate industrial transformation.

農業部
林業及自然保育署
Forestry and Nature Conservation Agency,
Ministry of Agriculture



# Public-Private Collaboration to Achieve Net Zero and Biodiversity Sustainability Goals

## Introduction

At the 2021 United Nations Climate Change Conference (commonly referred to as COP26), countries around the world were urged to adopt more immediate climate actions, aiming to halve global greenhouse gas emissions by 2030 and achieve net zero by 2050. These actions are essential to limit the global temperature rise to 1.5°C and address the high-risk impacts of global climate emergencies, such as forest wildfires, increased frequency of extreme rainfall, and the loss of wildlife habitats. In December 2022, the Convention on Biological Diversity adopted the Kunming-Montreal Global Biodiversity Framework (K-M GBF), with a vision for living in harmony with nature by 2050. This framework emphasizes the urgent need for all countries to halt and reverse biodiversity loss and to achieve sustainability goals aimed at restoring nature.

According to a 2020 study by the World Economic Forum, approximately half of the global GDP is highly or moderately dependent on natural resources and their services. Any damage to nature would severely impact various industries, including agriculture and forestry. As discussions on the relationship between biodiversity and business operations intensify, the United Nations, in Target 15 of the K-M GBF, clearly stated that companies should take responsibility for disclosing nature-related risks. In September 2023, the Taskforce on Nature-Related Financial Disclosures (TNFD) was officially launched, highlighting the crucial role that companies and the financial system play in global biodiversity conservation, which is essential for effectively promoting biodiversity conservation.



## Promotion of the Taiwan Ecological Network

Taiwan's unique topography and geographical conditions have nurtured rich biodiversity. Most of the forest ecosystems in the Central Mountain Range have been effectively protected through the system of protected areas. However, about 60% of protected wildlife and threatened plants are located outside of protected areas and state-owned forests. These low-elevation mountains, plains, and coastal wetlands are often close to densely populated urban environments. In the face of habitat loss and fragmentation caused by various forms of development and changes in agricultural land use, conservation efforts must move beyond the approach of in-situ conservation in protected areas. To address this, the Ministry of Agriculture, led by the Forestry and Nature Conservation Agency (FANCA) and with the support of the Executive Yuan, has implemented cross-sectoral integrated strategies since 2018 to promote the Taiwan Ecological Network, aiming to connect and restore habitats in low-elevation shallow mountains, valleys, and coasts and improve the resilience and adaptability of ecosystems and satoyama communities in these regions. As a result, with the collaboration of relevant government agencies, research units, and experts from various fields, 44 biodiversity priority areas and 45 regional conservation corridors have been identified across Taiwan. Biodiversity data-based spatial planning extends from state-owned forests and encompasses the entire national territory, aiming to connect ecosystems across shallow mountains, streams, valleys, coasts, and offshore islands, providing ecological spatial information and conservation strategies. These resources aim to serve as a guide for the restoration of ecological habitats and efforts to enhance landscape connectivity.

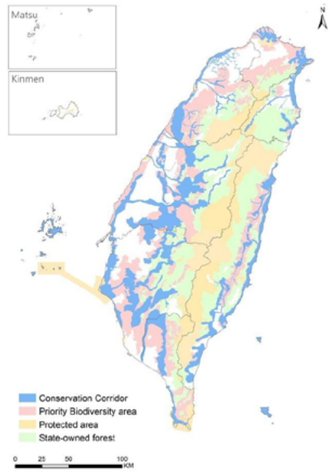
Global net zero emissions and biodiversity conservation goals can only be achieved through public-private collaboration, with government departments working hand-in-hand with the private sector and companies. FANCA is currently referencing K-M GBF and TNFD, to create a comprehensive spatial plan for Taiwan's natural environment, ecological information, and industry needs. The aim is to propose localized TNFD operational guidelines by 2025 to help companies conduct nature-related financial assessments. Under the Taiwan Ecological Network, both public and private sectors can continuously implement spatially focused actions, utilizing various policy tools such as the establishment of ecological corridors, vegetation restoration, ecosystem service payments, ecologically friendly production, and environmentally friendly governance projects to jointly promote and improve habitat restoration, connectivity, and management.

## Encouraging Companies to Take Part in ESG Projects Through Public-Private Partnerships

Meanwhile, after more than two years of planning and numerous discussions with over a hundred domestic companies, we have gathered insights to align the international trend of net zero carbon emissions with local community efforts to promote biodiversity conservation and meet corporate ESG implementation needs. This was done by establishing the Carbon Sink and Biodiversity ESG Project Matching Platform (website: https://esg.forest.gov.tw/ForestESG). The platform facilitates the matching of companies with national, public, and private landowners, encouraging them to engage in forest management or natural habitat restoration and conservation through public-private partnerships. Furthermore, we offer certifications for the outcomes of these efforts, which companies can use to demonstrate their performance in ESG sustainability reports. Through joint efforts from both public and private sectors, we aim to enhance carbon sinks, promote biodiversity conservation, and achieve sustainable development and net zero goals.

FANCA's ESG matching platform offers companies projects in two general categories: "natural environment" and "forestry, society, and culture." These include 11 project types, covering afforestation projects to increase forest carbon sinks, biodiversity projects for the conservation of wildlife and habitats, as well as social-cultural projects aimed at preserving important forestry cultural resources or indigenous peoples' knowledge of forests. The platform provides opportunities for companies to participate. FANCA also encourages enterprises to utilize their expertise and resources to proactively propose collaboration projects that positively impact biodiversity.

The results section of the ESG matching platform discloses all project information and outcomes. Companies can also use the search function on the Taiwan Ecological Network Mapping Platform to display project locations and overlay information from the Taiwan Ecological Network. This helps companies understand the ecological information near their production sites and provides spatial guidelines for ESG and biodiversity investments, allowing for more systematic spatial planning for ESG and biodiversity contributions. In addition to achieving the goal of positive change, project execution must heed the United Nations' call to prioritize the livelihoods of forest-dependent communities and the Convention on Biological Diversity's expectations for participation in decision-making by indigenous peoples and local communities (IPLCs). This includes investments from companies to provide financial resources to mountain villages and communities in the priority areas, providing residents with job opportunities to carry out afforestation, conservation monitoring, and patrol work. Alternatively, companies can host events such as employee family days and farmer markets to promote local consumption or help promote the under-forest economy or environmentally friendly agricultural products. This allows residents in forest and biodiversity regions to benefit from the ESG movement, while also ensuring project outcomes and highlighting the social benefits of ESG.




Taiwan Ecological Network

## Future Prospects

Companies are encouraged to participate in projects on FANCA's ESG matching platform through public-private collaboration, jointly fulfilling the United Nations' Sustainable Development Goals, the 2030 global biodiversity targets, and the 2050 net zero carbon emissions objective. The projects allow companies to participate in forest management, natural habitat preservation, biodiversity conservation, as well as the preservation of social and cultural forestry heritage. Moreover, companies can utilize the Taiwan Ecological Network, established as a foundation for facilitating cross-sectoral cooperation, to promote biodiversity, improve the economy of rural tribal communities, and revitalize industries, generating both environmental and social benefits. At the same time, the projects also seek to effectively address social, economic, and environmental challenges by connecting critical habitat regions of foothills and plains to realize solutions for preserving nature.

### ESG Project Types

**Natural environment (E)**

**Carbon sinks**

- New afforestation
- Reforestation
- Mid- and late-age forest tending
- Bamboo forest management
- Flatland afforestation and maintenance

**Biodiversity**

- Habitat creation
- Wildlife conservation
- Development of environmentally friendly industries

**Forestry, Society and culture (S)**

**Forestry culture**

- Preservation or adaptive use of forestry and cultural resources

**A Mountain and forest culture**

- Reconstruction and application of traditional forestry knowledge
- Expand the development of social services in mountain and forest regions





農業部
林業及自然保育署
Forestry and Nature Conservation Agency,
Ministry of Agriculture

## Author

**Forestry and Nature Conservation Agency**

The Forestry and Nature conservation Agency (FANCA) is devoted to sustainable forest management and natural conservation. Based on environment protection, economic development, and social justice, FANCA has implemented many tasks. In recent years, the agency even devotes itself to growing healthy forests, building a forest value chain, combating illegal logging, strengthening national forest management, promoting natural-reserve operations, and boosting mountain-village ecological economies.

In the face of the increasingly serious environmental problems brought about by climate change, FANCA upholds the principle of sustainable use of natural resources and continues to promote policies that take into account both ecology and industry, realizing the vision of sustainable forestry and eco-Taiwan.

國立中興大學
NATIONAL CHUNG HSING UNIVERSITY



# Biodiversity Conservation as a Critical Facet of Net Zero Best Practices

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## Net Zero Through Nature-based Solutions

As global temperatures rise and the impacts of climate change become increasingly severe, the urgency to achieve net zero greenhouse gas emissions by 2050 has intensified. Net zero has been the current focus of international climate policies to limit global warming to a target of 1.5°C through the aggregate balance of greenhouse gas emissions produced and the amount removed from the atmosphere (Figure 1). Beyond radical alteration to energy and climate policies to reduce greenhouse gas emissions from fossil fuel and intensive land use activities, there is also a need to enhance the removal of carbon through technological innovations and nature-based solutions.

**Anthropogenic carbon flows in and out of each sphere are balanced; temperature stabilized sustainably**

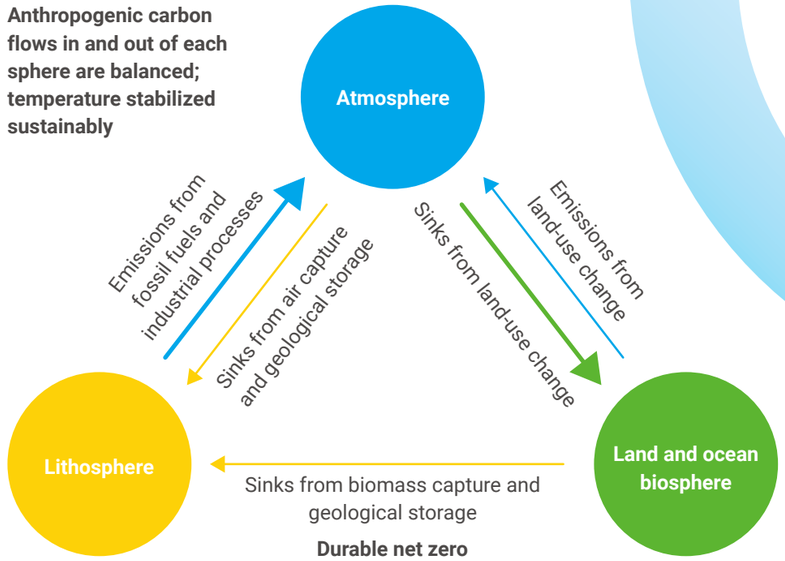



Figure 1 Framework for a durable net zero entails not only the aggregate balance of anthropogenic flows to and from the atmosphere but also the role of both biological carbon storage and longer-lived geological storage.

Source: Fankhauser et al. (2022). The meaning of net zero and how to get it right. Nature Climate Change, 12(1), 15-21.

Nature-based solutions are one of the oldest yet most reliable and efficient methods of greenhouse gas removal. Pristine natural forest ecosystems are vital carbon reservoirs, with the carbon stored within living tropical trees accounting for approximately one-third of atmospheric carbon levels. The destruction of rainforests not only releases this carbon but is also a major driver of global biodiversity loss and the decline of ecosystem services. Addressing biodiversityloss and climate change together is crucial, as they represent fundamental planetary boundaries that significantly affect the stability and functioning of our environment. These boundaries are thresholds that define the safe operating space for humanity within Earth's systems, allowing us to meet current needs without compromising the ability of future generations to meet theirs.

Climate action and biodiversity conservation measures are also closely connected and mutually reinforcing. Emphasizing net zero targets through nature-based solutions can enhance biodiversity conservation by directing more attention and funding toward reforestation, forest restoration, and forest protection. The government and private sectors worldwide have taken decisive action to allocate funds for landscape restoration, carbon sequestration, and wildlife protection. Conversely, biodiversity conservation is also a crucial aspect of achieving credible net zero targets, as it strengthens the environmental integrity of carbon offsets. Environmental integrity in the context of carbon offsets refers to the assurance that the carbon credits generated truly represent real, additional, and verifiable reductions in greenhouse gas emissions.

## Biodiversity, Ecosystem Functioning, and Carbon Sinks

Biodiversity is the cornerstone of life on Earth, and the destruction of biodiversity can lead to instability in global ecosystems. Fundamentally, biodiversity comprises a diverse set of organisms that play a crucial role in regulating the flow of carbon between the atmosphere and the biosphere through primary production and decomposition. The intricately woven web of biodiversity implies that any specific processes, such as plant growth, are ultimately influenced by a variety of other organisms. This interconnectedness means that factors such as soil microorganisms, herbivores, pollinators, and decomposers all play significant roles in supporting and enhancing plant health and productivity, and thus the capacity of nature-based solutions to contribute towards net zero.

The most common measure of biodiversity is the number of species present in a given area, and this diversity of species can have significant consequences for ecosystems by affecting their resilience and ability to provide essential services. For nature-based solutions to deliver lasting benefits to people, the ecosystems involved must be healthy and resilient, capable of resisting or recovering from disturbances. This ecological resilience is also influenced by ecosystem connectivity and the genetic, functional, and species diversity across multiple trophic levels. Highly biodiverse ecosystems are more capable of recovering from disturbances if there are multiple species with overlapping functional roles within the system. In cases where one of the species is lost, the presence of another species that could take its place allows the ecosystem to maintain key ecosystem functions necessary for natural forest regeneration, such as pollination, nutrient cycling, and seed dispersal.

Conversely, key ecosystem functions regulated by biodiversity are also threatened by climate change which has negatively impacted biodiversity. Rising temperatures, shifting precipitation patterns, and extreme weather events have altered habitats and disrupted biological rhythms. For instance, the changing microclimate has impacted the bee activity cycle and consequently led to a mismatch in pollination relationships, affecting the reproductive success of both pollinator and wild plant diversity. Plant diversity itself is an important regulator of ecosystem function and services, such as soil carbon storage. High plant diversity is associated with increased rhizosphere carbon inputs, which then interact with the soil microbial community to enhance carbon storage. Thus, as biodiversity declines, the ability of ecosystems to provide these essential services also diminishes, creating a cycle that further exacerbates the challenges posed by climate change.

## Importance of Diversity Underground

Besides the diversity of terrestrial species found above ground, underground soil microbial diversity also plays a critical role in achieving net zero targets via soil carbon sequestration. Soil carbon sequestration has become an increasingly popular and undeniably important method for the long-term capturing and storing of atmospheric carbon. At the crux of soil carbon sequestration is the community of microbial organisms that interact with soil biophysical properties to regulate carbon stocks and fluxes. While the interactions between microbial communities appear subtle and minute to the naked eye, their effects are disproportionately greater by degree of quantity and across temporal scales. Studies have demonstrated that reintroducing microbial communities to agricultural soils is essential for improving their long-term carbon storage potential and stability.

The importance of soil microbial diversity also extends beyond carbon storage. The soil microbial community contributes significantly to soil ecosystem services such as nutrient cycling by driving multiple biochemical processes such as nutrient mineralization, decomposition of soil organic matter, and nitrogen fixation. The diverse metabolic pathways of macro- and micro-organisms enable them to decompose a wide range of organic materials. This decomposition process is vital, as it transforms complex organic compounds into simpler forms, releasing nutrients that are crucial for plant growth while simultaneously converting carbon into stable forms that can be stored in the soil. Furthermore, diverse microbial communities can mitigate soil erosion and degradation, which are significant threats to carbon storage. By forming a complex network of fungal hyphae and microbial aggregates, these organisms help bind soil particles together, improving soil structure and preventing erosion. The stability and longevity of biological and geological carbon sinks are crucial for a durable net zero (Figure 1) because they ensure that carbon storage in ecosystems is sustained over the long term rather than being simply a temporary fix.

## Net Zero Best Practices Need to Consider Biodiversity

Regrettably, in the focus on carbon sinks as part of nature-based solutions for achieving net zero, biodiversity is often overlooked. This oversight limits the ecosystem co-benefits that healthy, resilient natural habitats can provide. In many instances, large-scale plantations or woodlands are established using exotic plant species or a narrow selection of fast-growing species, prioritizing the rapid creation of efficient biological sinks. This represents a significant pitfall as there are considerable trade-offs with other ecosystem services. Nature-based solutions that emphasize biodiversity-based protection, restoration, and sustainable management of native ecosystems not only preserve ecological integrity but also enhance the ecosystem's capacity to adapt to changes, resulting in more sustainable outcomes over multi-decadal timescales.

In addition to selecting plant species for natural restoration efforts, it is essential also to carefully select restoration sites that can optimize co-benefits for climate mitigation and biodiversity conservation. High-resolution regional maps on forest cover, plantation area, and aboveground carbon are examples of information that can be used to identify restoration opportunities to support decision-making for achieving net zero (Figure 2). For instance, numerous degraded forest areas within Southeast Asia present significant opportunities for restoration, particularly in heavily logged regions that are no longer financially viable for timber and are thus at risk of conversion. Additionally, there are chances to restore severely degraded forest set-asides within agricultural landscapes, such as riparian buffer zones and areas designated for High Conservation Value and High Carbon Stock within existing plantations. Restoring riparian buffer strips can create important ecological corridors that enhance connectivity for wildlife and animal-assisted seed dispersal between forest areas. Net zero best practices also need to consider the scale of restoration efforts. Large patches can mitigate detrimental edge effects that lead to high tree mortality in smaller fragments, while small forest fragments can serve as valuable stepping-stones for biodiversity.

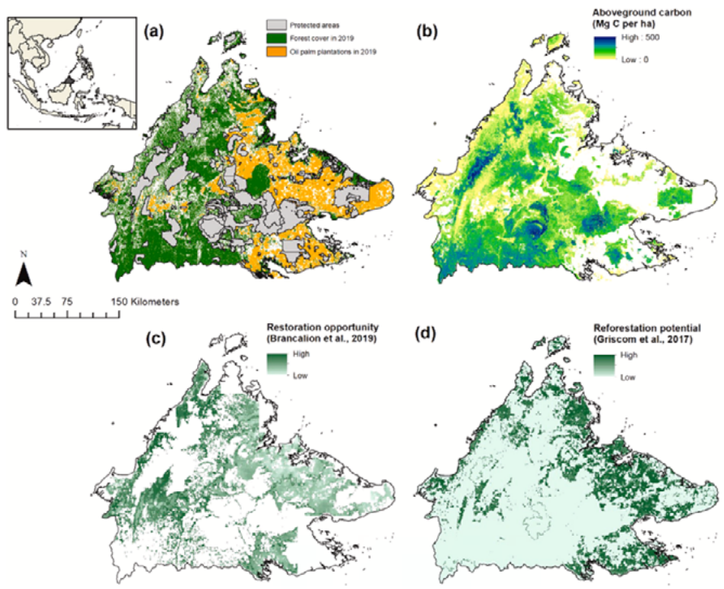



Figure 2 High-resolution regional map and information for Sabah (a-b) used to identify restoration (c) and reforestation opportunities (d).

Source: Scriven et al. (2022). Supporting decision-making by companies in delivering their climate net zero and nature recovery commitments: Synthesising current information and identifying research priorities in rainforest restoration. Global Ecology and Conservation, 40, e02305.

## Conclusion

Biodiversity conservation is a critical facet of net zero. Achieving net zero emissions requires more than reducing carbon output; it necessitates the protection and restoration of biodiversity. Biodiverse ecosystems act as natural carbon sinks, absorbing significant amounts of atmospheric carbon while providing essential ecosystem services such as pollination, climate regulation, and nutrient cycling. Ultimately, successful net zero strategies that aim to be holistic and sustainable must prioritize biodiversity within nature-based solutions. While direct evidence linking net carbon uptake to biodiversity conservation may be lacking, this article underscores the significance of biodiversity in fostering resilience and stability. Nature can serve as a powerful ally in combating climate change but misguided climate actions can harm biodiversity, potentially leading to even higher greenhouse gas emissions. It is also important to recognize that even as nature-based solutions offer numerous benefits for both the environment and communities, they are not a silver bullet for the climate crisis. As part of the formulation of best practices towards net zero, we cannot simply restore ecosystems and expect nature to handle everything on its own. Effective climate action requires significant reductions in emissions alongside the implementation of these solutions. A balanced approach is essential, recognizing that while nature can help mitigate climate change, it cannot replace the urgent need for systemic changes in our emissions practices.




## Author

### Liu Wan-Yu

**Distinguished Professor**

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Dr. Wan-Yu Liu, born in Chiayi, is currently a Distinguished Professor at National Chung Hsing University. Her expertise lies in climate change and carbon sequestration, natural carbon sinks and carbon credits, environmental and resource economics, and forest resource valuation. Passionate about solving Taiwan's environmental resource and carbon sink planning challenges, Dr. Liu integrates natural and social science methodologies to address real-world issues. Her work focuses on applying environmental economics to enhance the value of natural resources and solve pressing international environmental problems.



Photo 1 Our employees enjoying a delicious sustainable lunch

# From Table to Community: Jardine Restaurant Group's Path to Resource Circularity

**Thomas Mak**, Group Supply Chain Management and Sustainability Director, Jardine Restaurant Group

At lunchtime, laughter fills the air of offices at Devon House, Hong Kong. Employees gather around tables with Western and Asian dishes, enjoying a delightful midday break. This is part of Jardine Restaurant Group's latest initiative - Show Me Your Love - a sustainable lunch programme aimed at fostering a sustainable value chain through resource circularity, as well as giving back to the local community.

As one of the leading food and beverage groups in Asia, Jardine Restaurant Group (JRG) operates the well-known KFC and Pizza Hut brands, running over 1,000 outlets in Hong Kong, Macao, Myanmar, Taiwan and Vietnam with approximately 25,000 employees. We recognise the significant role the food and beverage industry can play, and we are committed to embedding circularity into every market and community we serve, making it a daily habit for both customers and employees.

## Sustainable Lunchbox: Starting Point for Circularity

According to the United Nations Intergovernmental Panel on Climate Change (IPCC), nearly one-third of global greenhouse gas emissions come from the catering industry. The Ellen MacArthur Foundation further highlights that food systems could reduce greenhouse gas emissions by nearly half if they embrace circular practices.



In response, JRG has been promoting reusable containers as an alternative to single-use packaging in its offices through a reusable lunchbox programme since 2022. This initiative evolved into the Show Me Your Love Sustainable Lunch Programme, which integrates food circularity and waste management with the goal of achieving zero waste across the food and beverage value chain.

In Hong Kong, we collaborate with other Jardines business units to channel food waste (e.g., eggshells, which are a good source of calcium) from our operations to local regenerative farm cooperatives, providing nutrients to these farms. The produce grown is then used as menu items for our Sustainable Lunch Programme. Each month, our chefs craft a diverse menu based on seasonal local produce, supporting the biodiversity fostered by regenerative agriculture.

Alongside with the circularity, we donate one meal to elderly or disadvantaged individuals through an NGO – Dignity Kitchen, which focuses on supporting individuals with physical disability – for every lunch being sold. Since the programme's pilot run in June 2024, over 800 meals have been delivered. Additionally, the project also plays as the source of funds to support afternoon tea at hospice care homes to both the patients and their families when the project accumulates enough love – i.e. the orders. So far, we have hosted two afternoon teas between July and September.

## Circular Innovation to Cut Emissions




Photo 2 Pizza Hut Taiwan and Vietnam redesigned the pizza boxes, reducing single-use plastic usage by more than 90% compared to 2021




Photo 3 By introducing the reusable cup service and providing washable cups in-store, KFC Taiwan has successfully reduced over 1.1 million disposable cups from in 2024

The IPCC reports that about 5% of the catering industry's greenhouse gas emissions come from food packaging. Since 2022, JRG has redesigned the pizza boxes in Pizza Hut Taiwan and Vietnam, changing them from a quadrangular shape to a more efficient hexagonal design. This design not only improves the load-bearing capacity but also increases the stability of the boxes, reducing the need for single-use plastic support stands.

By eliminating these plastic support stands, which were previously used to prevent box collapse, we have significantly reduced waste and packaging costs. Currently, except for a few limited-time products, the use of plastic support at Pizza Hut Taiwan and Vietnam has decreased by over 90% compared to 2021. JRG will continue to explore alternative solutions to reduce single-use packaging across the markets we operate.

Additionally, KFC Taiwan has launched a reusable cup service in 2022, providing customers with the option to rent cups for take-away drinks or bring their own cups. As of the end of 2024, 62 KFC Taiwan outlets offer this service.

To further reduce the use of disposable containers, KFC Taiwan has reconfigured in-store spaces to accommodate washing machines for reusable cups, giving dine-in customers the option to use sustainable cups. In 2024, KFC Taiwan has reduced the consumption of over 1.1 million disposable cups.

## Committing to Emission Reduction and Building a Circular Ecosystem

JRG has completed a Group-wide inventory of scope 1, 2, and 3 greenhouse gas emissions for the base year, committing to reduce absolute scope 1 and 2 emissions by 54.6% and absolute scope 3 emissions by 32.5% by 2033, with 2023 as the baseline. Additionally, we aim to reduce absolute scope 3 FLAG emissions by 39% within the same timeframe and achieve zero deforestation by 2025 across our primary deforestation-linked commodities.

These targets were submitted to the Science Based Targets initiative (SBTi) and officially validated in November 2024. JRG is proud to be the first operator in the "Hotels, Restaurants and Leisure, and Tourism Services" sector across our operating markets (Hong Kong, Macau, Myanmar, Taiwan, and Vietnam) to achieve this milestone.

We recognise that achieving net zero carbon emissions requires collaboration across the entire value chain. This includes engaging our employees, customers, governments, community groups, and other stakeholders to create maximum sustainable value through resource circularity. We remain committed to seeking like-minded partners to help build a sustainable food and beverage ecosystem.




## Author

**Thomas Mak**

**Group Supply Chain Management and Sustainability Director**

**Jardine Restaurant Group**


Thomas Mak is Group Supply Chain Management and Sustainability Director of Jardine Restaurant Group (JRG). He oversees the supply chain and sustainability strategies for the group across Hong Kong, Macao, Myanmar, Taiwan and Vietnam. Thomas first joined the company as Project Director in 2020 and was subsequently appointed his current role.

For more than 15 years, Thomas had worked in different capacities in the food and beverage industry across Asia, from business development to operations to marketing to supply chain – all while finding the right balance for the sustainable development of the business and the environment. Prior to joining JRG, Thomas held various management positions at Pacific Coffee, The Venetian and Café Deco Group.

Thomas holds a Bachelor of Business Administration degree and is a Certified Public Accountant. He is also a connoisseur with the Specialty Coffee Association (SCA) and the Wine & Spirit Education Trust (WSET).

DFI RETAIL GROUP
An IKEA retailer



# Radical Collaboration for Developing Circular Business Models for Taiwan's Furniture Industry

**Hugo Asplund**, Group Sustainability and Food Transformation Manager, DFI IKEA

**Angela Chao**, Sustainability Specialist, DFI IKEA

As the environmental consequences of linear production and consumption models are becoming more and more apparent, the concept of the circular economy is gaining significant traction within the business world. Circular business models focus on extending the lifecycle of products through reducing, recycling, refurbishment, and reuse, presenting an opportunity for more sustainable and resilient economic systems. Taiwan's furniture industry, valued at approximately $3 billion in 2022, is well-positioned to take a leading position in this shift. However, to successfully implement circular business models, a completely different level of collaboration among diverse stakeholders, including manufacturers, consumers, retailers, policymakers, and waste management sectors, is essential.





Taiwan is one of the more progressive countries in Asia and its manufacturing industry is known for its quality and innovative designs and its furniture sector is significant. In 2021, Taiwan exported over $1.5 billion worth of furniture, with key markets including the United States, Japan, and Europe. However, like many industries, it predominantly follows a linear "take-make-dispose" model. This model leads to significant waste, with an estimated 300,000 tonnes of furniture waste generated in Taiwan each year. The increasing consumer demand for affordable furniture has further exacerbated the problem, resulting in short product lifespans and a growing environmental footprint. In Taiwan, this figure accounts for a sizable portion of municipal waste, putting pressure on landfill capacities and waste management systems. The environmental implications are increasingly apparent, as the extraction of raw materials, energy-intensive manufacturing processes, and the disposal of furniture in landfills contribute to resource scarcity, greenhouse gas emissions, and pollution. Addressing these issues requires a fundamental change in how furniture is designed, produced, consumed, and disposed of, shifting toward a circular model that emphasizes sustainability and resource efficiency.

## The Need for Multi-Stakeholder Collaboration

For a circular furniture economy to take root in Taiwan, concerted efforts from multiple stakeholders to collaborate and find cost efficient solutions are crucial.

### 1 Furniture manufacturers

Furniture manufacturers are at the forefront of the transition to a circular economy, having the expertise to redesign products for longevity, modularity, and recyclability. By adopting sustainable materials, such as wood and innovative production techniques, manufacturers can create furniture that is easier to repair, refurbish, or recycle. However, this shift requires significant investment and development of materials and new production techniques.

The financial aspect is critical. Research indicates that the cost of transitioning to a circular model can initially be 20-30% higher than traditional production methods due to the need for new technologies, sustainable materials, and redesigning products. However the long-term savings from reduced material costs and waste disposal fees can offset these expenses and collaboration with various stakeholders can alleviate some of these challenges. Engaging already at the design stage can promote the creation of modular furniture, where components can be easily replaced or upgraded, extending the product's life. The Ellen MacArthur Foundation's research has, as one example has shown, that adopting circular principles in the furniture sector could reduce material costs by up to 30% while significantly lowering carbon emissions.

## 2 Retailers

Retailers are critical in shaping consumer perceptions and behaviors and not only serve as a conduit between manufacturers and consumers but also influence purchasing decisions through marketing, product displays, and in-store experiences. By actively promoting circular furniture options, retailers can significantly impact consumer choices and accelerate the adoption of sustainable practices.

One of the most exciting opportunities lies in the innovation of the business model, such as the furniture-as-a-service (FaaS) model, where consumers lease furniture instead of purchasing it outright, which not only provides both an affordable and flexible option for consumers but also ensures that furniture is returned to the retailer at the end of its lease term for reuse, refurbishment, resale, or recycling. In the European market, companies like IKEA have piloted such programs with positive results and similar tests have also been launched in Taiwan. An obvious area of collaboration between retailers and manufacturers is to offer take-back programs for old furniture, providing incentives like discounts or store credit to encourage consumers to return used items. This practice not only promotes recycling but also secures a steady supply of materials for manufacturers to refurbish or recycle. There are unfortunately many hurdles making this idea very impractical at the moment.



IKEA

## 3 Consumers

Consumers play a pivotal role in the success of circular business models but there is a need to raise awareness about the benefits of sustainable furniture to shift consumer behavior. In a recent survey conducted in Taiwan, 65% of respondents expressed a willingness to pay a premium for sustainable products, yet only 30% actively sought out circular or sustainable furniture. This gap indicates a need for greater consumer education and incentive structures. For example, the waste management sector must work closely with furniture manufacturers to develop efficient systems for collecting, processing, and recycling discarded furniture. Currently, only about 20% of furniture waste is recycled or repurposed, leaving a vast opportunity for improvement.

Educational campaigns, spearheaded by both the government and industry groups, can inform consumers about the environmental and economic benefits of circular furniture. Moreover, providing incentives such as buy-back programs or discounts on refurbished items can encourage consumers to participate in the circular economy. For example, IKEA's circular initiative, which includes take-back and refurbishment services, saw a 50% increase in customer engagement in regions where it was implemented. When consumers demand sustainable products, they create a market incentive for manufacturers to innovate and adopt circular practices.

## 4 Government policy

Government policy is a powerful tool for promoting circular business models but can also act as a major obstacle. The scale of the shift into a circular economy requires a clear direction and long term predictability to enable investments needed to transform business models. Government policy must provide a clear roadmap that includes an effective waste management ecosystem, setting requirements for the use of recyclable materials, providing tax incentives for companies that adopt circular practices, or implementing extended producer responsibility (EPR) schemes that make manufacturers responsible for the end-of-life management of their products.

Investing in advanced recycling technologies and infrastructure is necessary to handle the diverse materials used in furniture manufacturing. By 2025, it is estimated that the global market for recycled wood and furniture materials could reach $20 billion, indicating significant economic potential.

Taiwan has already made strides in promoting circular economy principles in other sectors. The "Resource Recycling Act" and the "4-in-1 Recycling Program" have successfully improved waste recycling rates to over 55% in Taiwan. Extending such policies to include the furniture sector could further enhance circularity. Moreover, the government can invest in research and development to support the circular economy. By funding initiatives that explore new materials and technologies for furniture production, policymakers can facilitate the transition toward a more sustainable industry. Collaborating with manufacturers and researchers can help ensure that regulations are practical and conducive to innovation.

### 5 Research institutions and non-governmental organizations (NGOs)

Research institutions and non-governmental organizations (NGOs) also play a critical role in advancing the circular economy by providing valuable insights, data, and best practices. For instance, research institutions can uncover new methods for designing, producing, and recycling furniture, while NGOs can advocate for sustainable consumption and production patterns. These organizations can act as a bridge, facilitating dialogue and knowledge exchange between manufacturers, policymakers, and consumers.

To establish a circular furniture economy, Taiwan must cultivate a collaborative ecosystem where stakeholders actively engage and support one another. This could involve forming multi-stakeholder alliances or working groups focused on circular economy initiatives within the furniture sector. Such platforms can foster dialogue, share knowledge, and identify joint projects that drive progress.

For instance, manufacturers and waste management companies could co-develop take-back programs for old furniture, ensuring that materials are recovered and reused. Policymakers, in turn, could support these initiatives through regulations that encourage participation and compliance. By involving consumers in the dialogue, these efforts can be tailored to meet market demands and preferences, ensuring widespread adoption.



IKEA



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IKEA's vision is to create a better everyday life for the many people by offering a wide range of well-designed, functional, and affordable home furnishings. To achieve this goal, IKEA's founder, Ingvar Kamprad, developed a unique business model that includes in-house design, global production, centralized procurement and distribution, and a self-serve sales system.

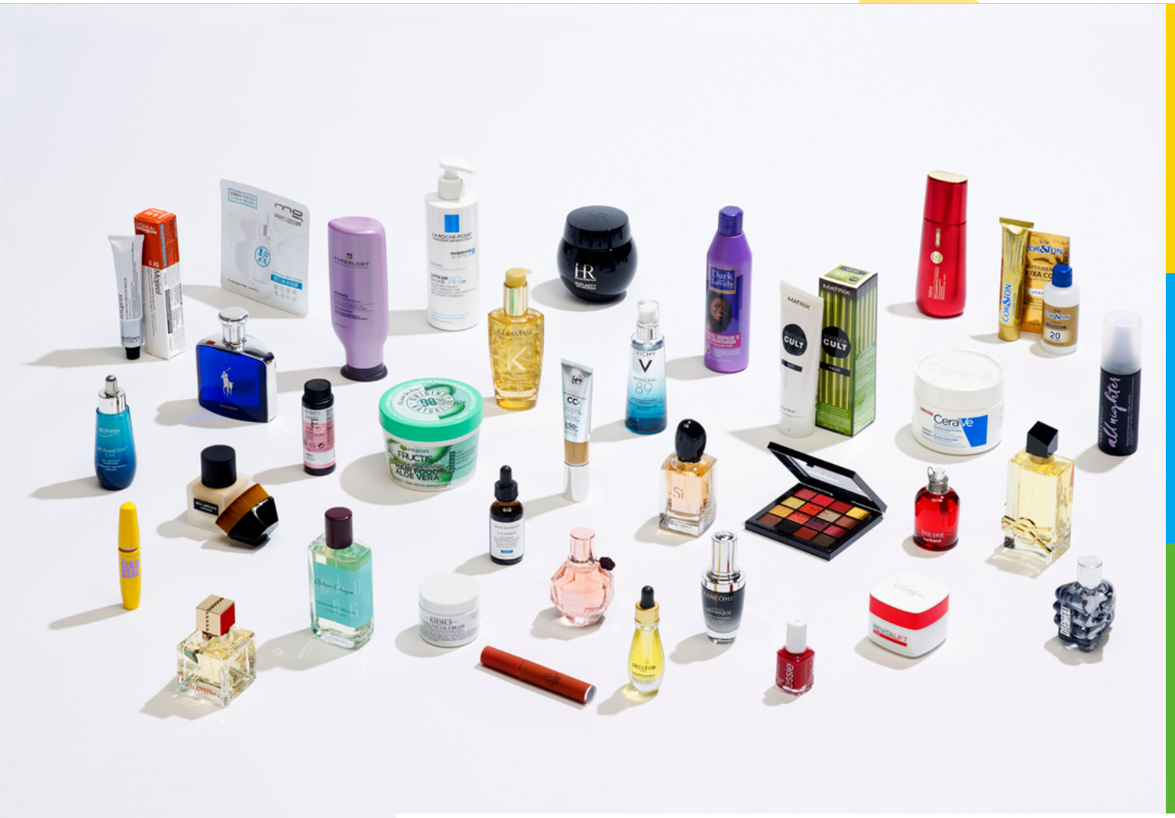
All IKEA products adhere to the principles of "democratic design," which consider five key elements: function, form, quality, sustainability, and low price. Through various innovative approaches, IKEA minimizes costs at every stage of the production process, enabling the company to provide high-quality, well-designed home goods at affordable prices.

In 2019, IKEA introduced the "IKEA Circular Design Principles" during the product design phase, aiming to transform all IKEA products into "circular economy concept products" by 2030. This initiative seeks to extend product lifespans and reduce dependence on Earth's raw materials, promoting sustainability and environmental responsibility.

IKEA's commitment to democratic design and circular economy principles allows the company to offer a wide range of stylish, practical, and affordable home furnishings to the majority of people. By continuously innovating and improving its processes, IKEA strives to create a better everyday life for its customers while minimizing its environmental impact and contributing to a more sustainable future.

IKEA

L'ORÉAL
TAIWAN



## L'Oréal's Commitment to Sustainable Packaging: Reducing Waste and Plastics

L'Oréal Group, a global leader in the beauty industry, is deeply committed to environmental sustainability. Its "L'Oréal for the Future" program, launched in 2020, outlines ambitious goals for 2030, focusing on transforming business activities to minimize environmental impact, empowering its business ecosystem, and addressing global environmental and social challenges. This commitment extends beyond simply reducing the company's direct environmental footprint to encompass its indirect impact across the entire supply chain and product lifecycle. This article will highlight L'Oréal's global initiatives and the specific contributions of L'Oréal Taiwan in reducing plastic waste and heading circular economy visions.

## L'Oréal's Global Sustainability Targets

The core of L'Oréal's sustainability strategy is aligned with planetary boundaries, ensuring its operations are compatible with a resource-constrained planet. Key targets under "L'Oréal for the Future" include:

- **By 2025:** 100% of plastic packaging will be refillable, recyclable, reusable, or compostable.
- **By 2030:** 100% of the plastic used in packaging will be recycled or bio-based (50% by 2025).
- **By 2030:** A 20% reduction in the intensity of packaging used, compared to 2019.

These targets drive a three-pronged eco-design policy implemented since 2007: **Reduce**, **Replace**, **Recycle**.

1 **Reduce:** L'Oréal is actively minimizing raw material usage through packaging size reduction, weight optimization (achieving a 3% reduction in 2022 compared to 2019), and innovative packaging designs that utilize less plastic. The company is also expanding its range of reusable and refillable products, such as fragrance fountains and a series of refillable make-up product cases and refills (also launched in Taiwan), to further reduce overall packaging quantity.

2 **Replace:** Innovation is key to replacing high-impact materials. L'Oréal is substituting virgin plastic with recycled alternatives, as seen in some Kérastase and Elvive shampoos using 100% recycled PET. Cardboard replacements for plastic are also being implemented, as exemplified by Garnier's solid shampoo bars. Collaborations with partners like Albéa have led to the development of cardboard-based tubes, significantly reducing plastic content, as showcased by La Roche-Posay's Anthelios products which are also imported in Taiwan.

3 **Recycle:** Strategic partnerships are vital to developing a circular economy. L'Oréal actively participates in initiatives like the Ellen MacArthur Foundation's New Plastics Economy and the Sustainable Packaging Initiative for Cosmetics (SPICE), fostering collaboration within the beauty industry. The Circular Innovation Fund, established in 2022 with a €50 million investment, further supports scaling up circular economy solutions. In 2017, L'Oréal co-founded a consortium with Carbios to develop an enzymatic plastic recycling process that produces virgin-like quality recycled PET, resulting in the world's first beauty product bottle made from 100% bio-recycled PET.

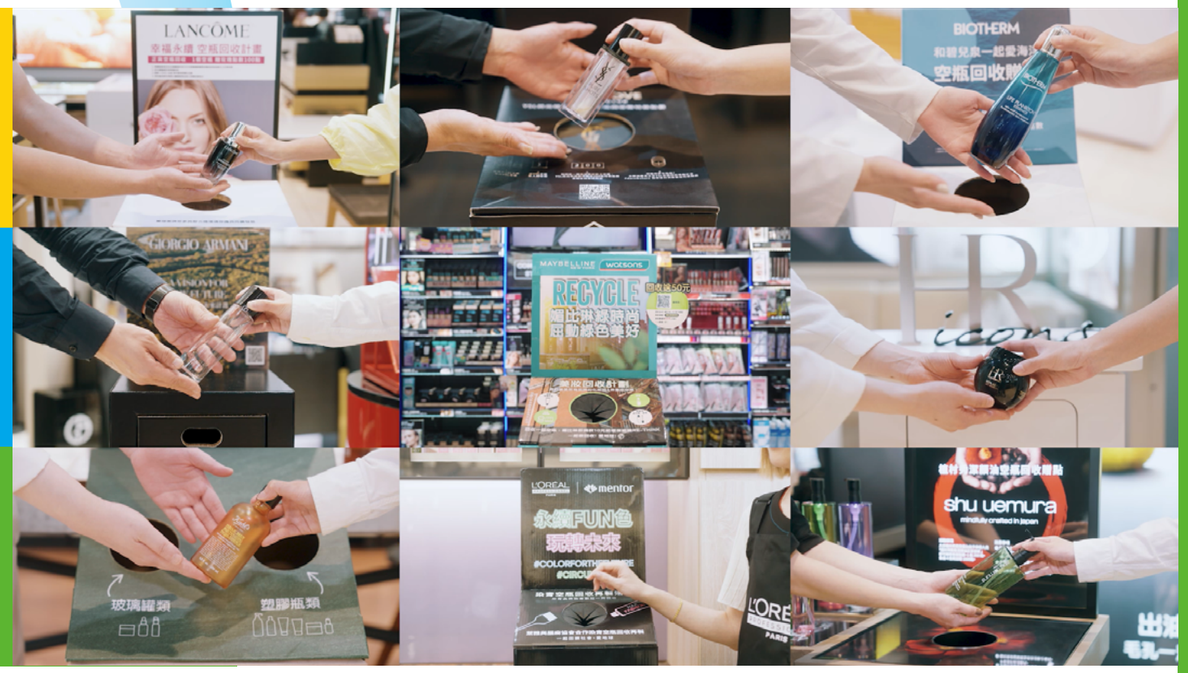
## L'Oréal Taiwan's CircuLove Initiative




L'Oréal Taiwan demonstrates a strong commitment to sustainable practices through its unique "CircuLove" program. L'Oreal CircuLove is launched in 2022. The background of the program stems from the fact that Taiwan has a good recycling model, but consumers need more education on properly recycling beauty product packages that are often designed with more complex materials and avoid resulting in waste. To simplify the complexity of cleaning and segregating elements of beauty product packages and encourage consumers to recycle empty beauty packages, the "CircuLove" package recycling program facilitates recycling by allowing consumers to send back the empty packages to the brand counters at the department stores and Watsons.

This initiative goes beyond simple collection; it actively involves disadvantaged groups in the pre-cleaning and sorting of recycled materials, creating a socially responsible element. Partnering with FNG, the recycled packages are processed into reusable materials used to create upcycled products like aprons, towels, bags, and phone accessories. To date, nine L'Oréal Taiwan brands have participated in this year-round program, demonstrating a company-wide commitment to this program.

The CircuLove program not only facilitates effective resource recycling but also fosters a more sustainable consumer behavior and creates a positive social impact. Through CircuLove, L'Oréal Taiwan is setting a benchmark for sustainable practices within the Taiwanese beauty industry, showcasing a model of impactful waste reduction through recycling and upcycling.








At L'Oréal, we aim to manage our consumption of natural resources to ensure that our activities are compatible with a resource-constrained planet. We promote the use of renewable raw materials that are sustainably sourced or derived from green chemistry. We are also working on solutions that allow for more recycling and promote the development of the circular economy. Please see more L'Oreal sustainability info at loreal.com.

L'ORÉAL
TAIWAN

**Author**

**L'Oréal Groupe**

For 115 years, L'Oréal, the world's leading beauty player, has devoted itself to one thing only: fulfilling the beauty aspirations of consumers around the world. Our purpose, to create the beauty that moves the world, defines our approach to beauty as essential, inclusive, ethical, generous and committed to social and environmental sustainability. With our broad portfolio of 37 international brands and ambitious sustainability commitments in our L'Oréal for the Future programme, we offer each and every person around the world the best in terms of quality, efficacy, safety, sincerity and responsibility, while celebrating beauty in its infinite plurality.

With more than 90,000 committed employees, a balanced geographical footprint and sales across all distribution networks (e-commerce, mass market, department stores, pharmacies,perfumeries, hair salons, branded and travel retail), in 2023 theGroup generated sales amounting to 41.18 billion euros. With 20 research centers across 11 countries around the world and a dedicated Research and Innovation team of over 4,000 scientists and 6,400 Digital talents, L'Oréal is focused on inventing the future of beauty and becoming a Beauty Tech powerhouse.

More information on https://www.loreal.com/en/mediaroom

雀巢 Nestlé Good food, Good life




## ECCT Net Zero By 2050

## Nestle's Drive Towards Zero Emissions Circular Goods

**Josephine Lo**, Chairman and General Manager, Nestlé Taiwan





## Design and Manufacturing

### Nestlé Good Coffee- Pioneering sustainable hand-brewed coffee! Nestle Taiwan partners with MIT Supply Chain to launch ‘Nestle’s Good Coffee,’ showcasing Taiwan’s boundless creativity to the world.

Nestlé, a global leader in the food industry, embraces the philosophy of ‘creating shared value’ and consistently fosters innovation from the global stage to local communities. Nestlé Taiwan, with a 40-year presence in the country, collaborated with real estate experts and supply chain partners over 15 months to design, develop, and manufacture the world’s first ‘Nestlé’s Good Coffee.’ This innovative product is not only easy to carry and use but also simplifies disposable consumables, allowing you to enjoy a great cup of coffee anytime, anywhere. It redefines the sustainable value of hand-brewed coffee and has been recognized by the prestigious German iF Design Award, showcasing Taiwan’s creativity in sustainable development to the world.”

### The group’s strategy is executed at the local level. Nestlé Taiwan employs the four BEST sustainability pillars to develop ‘Nestlé’s Good Coffee.

Josephine Lo, Chairman and General Manager of Nestlé Taiwan, stated: “Nestlé upholds the core principle of ‘Good Food, Good Life’ and firmly believes in the power of a good cup of coffee. Globally, Nestlé has implemented the ‘Nescafé Plan 2030,’ which encompasses everything from land and planting to coffee bean harvesting and packaging. We collaborate with value chain partners to build a more resilient coffee industry. In Taiwan, Nestlé continues to advance the four BEST sustainability actions through ‘Nestlé’s Good Coffee.’ achieving business sustainability. Simultaneously, we aim to positively impact the global environment, Taiwanese society, and local talent, embodying our business philosophy of creating shared value with the local supply chain, academia, and consumers.”





Nestlé Taiwan has partnered with National Cheng Kung University to foster innovative ideas from talented local designers. Collaborating with the MIT supply chain, they have turned these ideas into reality, creating ‘Nestlé Good Coffee’ that benefits both people and the planet. They have also adopted the 5R concept—Rethink, Redesign, Reuse, Reduce, and Recycle—to redefine the sustainable appearance of hand-brewed coffee. This includes portable and reusable stainless steel drinking cups, hand-brewed pots, and filter cups. Additionally, disposable carbon paper, filter ear bags, and the outer packaging of the entire carton and coffee filter grounds are 100% recyclable, significantly reducing carbon emissions and the use of virgin plastic.



### Nestlé collaborates with sustainable partners to achieve mutual benefits, and the initial batch of 5,000 sets of ‘Nestlé’s Good Coffee’ has sold out.

Nestlé Taiwan has united efforts to create ‘Nestlé’s Good Coffee.’ which is “Good for you Good for the planet”. With the support of Nestlé’s sustainable partners, the initial batch of 5,000 sets sold out immediately upon launch. This achievement not only showcases Taiwan’s exceptional design, production, and manufacturing capabilities to the world but also aims to inspire various sectors to reconsider the limitless possibilities of sustainability through the power of a good cup of coffee.”

## Consumer Behavior and Education

### Nestle for Healthier Kids (N4HK)- Collaborate with local partners to nurture a healthier future generation







Nestlé Taiwan has long been committed to addressing food literacy and environmental sustainability. In 2010, it introduced the globally recognized ‘Nestle for Healthier Kids (N4HK)’ to Taiwan. Partnering with the John Tung  Foundation, the program has reached elementary schools across Taiwan to promote balanced diets. It encourages children to drink ‘two cups of milk a day,’ ‘eat more whole grains, vegetables, and fruits,’ ‘have a healthy breakfast every day,’ and ‘exercise regularly.’ To date, the program has been implemented in over 1,000 primary schools, training approximately 4,800 seed teachers and benefiting more than 150,000 school children.”

Starting in 2022, Nestlé has combined nutrition knowledge with sustainability by partnering with Taiwan’s largest digital learning platform, Jun-Yi Education Platform, to develop a series of courses on ‘New Literacy in Sustainable Food Generation.’ So far, five videos have been released, accumulating 78,000 views on the Jun-Yi platform and 110,000 views on YouTube, with an average rating of 4.5 stars (above the platform average of 4.2 stars). In 2024, the latest sustainable food videos will be launched, and six additional videos will be integrated into the curriculum of elementary and middle schools. These resources aim to guide teachers, students, and parents in embedding sustainability more comprehensively into their lives. Nestlé and Jun-Yi will continue to develop comprehensive and open digital curriculum resources to expand their audience and enhance the teaching and independent learning motivation of teachers, parents, and school children.





## About Nestlé

The world’s leading food company, Nestlé was founded in Switzerland and dedicated to providing everyone “Good Food, Good Life.” With more than 2,000 brands in nearly 180 countries around the world, Nestlé is part of billions of people’s daily lives. **Unlocking the power of food to enhance quality of life for everyone, today and for generations to come—that is our brand purpose.** To fulfill it, Nestlé carries out various actions centering sustainability. Nestlé has been deeply involved in Taiwan for over 40 years, and we continue to accelerate sustainability initiatives in four dimensions of BEST, including

1. **Business:** continue to bring nutritious and sustainable products and services to Taiwan to take care of Taiwanese family and their pets;
2. **Environment:** Join hands with local value chain partners to fully promote food packaging transformation and Taiwan's local circular economy.
3. **Society:** to address social gaps, use Nestlé's advantages of nutrition and sustainability to create shared value with stakeholders to nurture a healthier next generation;
4. **Talent:** connecting with international career opportunities to empower young.



**Author**

**Josephine Lo**

**Chairman and General Manager**

**Nestlé Taiwan**

Nestlé Taiwan Chairman and General Manager Josephine Lo is the group’s first local chief executive since Nestlé opened its doors in Taiwan 40 years ago. Since taking the helm, Josephine has promoted “One Nestlé One Life,” integrating business units, promoting cross-brand collaboration, increasing the group's overall operating efficiency, continuing to cultivate a deep-set connection with Taiwanese society, and driving business growth.




MICHELIN VISION CONCEPT, an illustration of Michelin's sustainable development model

More than a futuristic vision of the sustainable mobility of tomorrow, the VISION concept represents a road map that is already inspiring Michelin Group's entire innovative ecosystem in order to focus its research and develop new solutions.

## Michelin and the "All Sustainable" Tyre

As the world is facing numerous challenges, massive and urgent, environmental, and societal, in a context where the global population is predicted to reach more than 9 billion in 2050, the planet is in a state of emergency and certain critical thresholds have already been crossed. Michelin is well aware that the future of humankind depends on protecting our planet and conserving its resources and has adopted a holistic approach to reduce its environmental footprint, doing its utmost to operate within the limits of our planet.

## 100% Sustainable Tyre Challenges

When we consider tyres, our thoughts may gravitate towards a straightforward black rubber object, everywhere in our everyday lives. However, a deeper examination reveals that tyres are far more complex than they first appear. They are intricate technological marvels composed of over 200 components. These components must work together harmoniously to create a product that meets rigorous performance standards.

The assembly of a tyre is a long and meticulous process, involving various stages such as curing and quality control. In this intricate dance of engineering, a tyre must perform a multitude of functions: it must grip the road effectively, provide durability, and exhibit resilience across diverse weather conditions and terrains. The tyre's performance is not merely a matter of physical attributes; it encompasses a balance of opposing forces—grip versus wear, flexibility versus sturdiness.

Environmental considerations add another layer of complexity to tyre design. In an era where sustainability is paramount, the industry faces the challenge of creating tyres that not only perform well but also minimize resource consumption and reduce carbon emissions. The concept of sustainable materials in tyre production is not just a trend but a necessity. The aspiration for a 100% sustainable tyre is no longer a distant dream but a tangible goal that the industry is actively pursuing.

## Are Sustainable Materials in Tyre Production Possible?

Creating a fully sustainable tyre is technically feasible; however, the challenge lies in sourcing materials that meet stringent sustainability criteria. The term "green materials" is often used, but it can be misleading and vague, leaving room for misinterpretation. For instance, while sand is a natural resource, its extraction for silica used in tyres is not renewable, as once it is depleted, it cannot be replaced. Thus, it fails to meet the requirements of sustainability.

On the other hand, materials derived from citrus fruits represent a more promising avenue. These bio-based materials are renewable and can be repurposed from waste, such as citrus peels, thus supporting the circular economy without impacting food supply. It is critical to ensure that any bio-based materials used in tyre production do not compete with food resources.



Sustainable Materials

At the end of 2022, Michelin presented car and bus tyres homologated for road use containing 45% and 58% renewable and recycled materials respectively. The technology used will be transposed onto the tyres arriving on the market in 2025.



MOTORSPORT TYRE : 71% RENEWABLE AND RECYCLED MATERIALS

The Mission H24 hydrogen prototype and the Porsche GT4 ePerformance were fitted with tires containing 71% renewable and recycled materials, in 2024 Le Mans 24 hours race.

In addition to bio-based options, the tyre industry can also utilize recycled materials. While not all materials are inherently sustainable, the ability to recycle them contributes to a more circular approach. In short, the two pivotal rules for sustainable tyre production: materials must either be renewable, and non-food related or derived from recycled sources.

To date, there are no guidelines or regulations governing the term "sustainable material". In order to place the environmental cursor as high as possible, Michelin considers that a material is only truly sustainable if it is recycled or renewable over a human lifetime.

One of the major challenges is to find alternatives to the components currently used in tyres, which do not impair tyre quality or performance, particularly in terms of safety. Michelin can leverage its extensive know-how in high-tech materials (3,678 material-related patents filed at the end of 2021). The Group is also investing in startups and concluding multiple partnerships with innovative companies: Pyrowave (r-styrene), Carbios (r-PET), Enviro (rCB etc.) in order to accelerate disruptive technology. Michelin pays close attention to its sourcing and has been evaluating supplier CSR performance for more than ten years now. At the end of 2022, 87% of its main suppliers were in compliance with the standards laid down by the Group.

Renewable or recycled materials, according to Michelin:

- **Recycled materials:** styrene regenerated from waste polystyrene (yoghurt pots, food trays, packaging, etc.), textiles regenerated from PET[1] waste (plastic bottles, dispensers, etc.), carbon black recycled from end-of-life tyres.
- **Renewable materials:** natural rubber from a responsible industry, butadiene (or bio-butadiene), products made from biomass (plant waste).

At the end of 2022, Michelin presented car and bus tyres homologated for road use containing 45% and 58% renewable and recycled materials respectively. The technology used will be transposed onto the tyres arriving on the market in 2025.

For the 2023 season, Michelin supplied tyres for the world MotoE™ championship containing 52% of renewable and recycled materials and capable of reaching track speeds of 250 km/h. Another example is the Mission H24 hydrogen prototype and the Porsche GT4 ePerformance fitted with tyres containing 71% renewable and recycled materials, in 2024 Le Mans 24 hours race.

To achieve truly sustainable tyres, the entire lifecycle must be considered. Beside 100% sustainable materials in tyre production, it's essential to account for entire lifecycle of the tyre. This includes ensuring that the energy used in manufacturing and transportation is derived from sustainable sources. The challenge is significant, but advancements in technology, such as enzyme treatment and pyrolysis, provide hope for future innovations in recycling and material recovery.

## From Lifecycle Assessment to an "All Sustainable" Tyre

For Michelin, using sustainable - recycled or renewable bio-based - materials in its tyres still does not make them all sustainable; tyres **need to have as little impact as possible on the environment throughout their entire lifecycle.** All sustainable tyres must be designed for long-lasting performance from the first mile until the tread wear limit to use less materials and energy and avoid having to replace tyres too early. All sustainable tyres must offer the same - if not better - safety performance than today's tyres.




Life Cycle Assessment

For Michelin, using sustainable - recycled or renewable bio-based - materials in its tyres still does not make them all sustainable; tyres need to have as little impact as possible on the environment throughout their entire lifecycle.

In the **design** stage, Michelin uses virtual testing to speed up tyre development. A pioneer in modeling and simulation systems, Michelin is capable of simulating tyre behavior in the most extreme situations. This means fewer prototypes and tests, thereby saving on $CO_2$ emissions. Michelin used simulation technology to develop certain recent lines (Pilot Super Sport, Pilot Sport Cup) for manufacturers like Ferrari, AMG, Porsche, Corvette, Lexus, Ford Performance, and more.

As for **manufacturing**, Michelin has pledged to reduce the environmental impact of its sites and, by 2050, is aiming to achieve net zero $CO_2$ emissions for all its plants, zero impact on water availability in the areas where it operates and the total elimination of solvents in the tyre production process.

Better and alternative **transportation** is another commitment made by the Group which aims to slash $CO_2$ emissions in logistics by 15% by 2030 compared to 2018. To achieve this, Michelin will rely on a local-to-local production strategy.

The lifecycle assessment reflected that 75-90% of the environmental impact of tyres occurs during the **usage** phase.

Supplying tyres which offer top performance from the first mile to the tread wear limit is part of Michelin's DNA and is one of its competitive advantages thanks to its know-how in materials and tread design. In Europe alone, 128 million[2] tyres and 6.6 million[2] tonnes of CO2 emissions would be saved if all tyres were used right down to the legal wear limit of 1.6 mm[3].

In fact, for more than 30 years now, Michelin has been systematically improving the rolling resistance of its tyres, making a major contribution to saving energy and money. Tyre rolling resistance accounts for the equivalent of one full tank of fuel out of five.

Michelin is investing in regenerating the materials used in tyres and re-injecting them into new tyre production by actively contributing to developing the **recycling** sector and fostering the emergence of disruptive technologies in collaboration with various partners.

Lastly, all sustainable tyres must be suitable for mass production, not just available in small quantities or in particular models. Michelin factors in the environmental impact of its tyres at each stage of their lifecycle but also ensures that industrialization can be scaled-up so that everyone can benefit. The idea is not to make a splash with a show tyre.

## Michelin's Holistic Environmental Approach

Today, Michelin Group is accelerating its efforts to fulfill by 2050 its "All-Sustainable" vision and "net zero emissions" commitments, deploying a master concept for environmental stewardship informed particularly by the idea of a circular economy. Respect for the environment is one of the Michelin Group's core values. Due to the Group's longstanding commitment to reduce its environmental footprint and follow the precepts of the circular economy, it has been able to develop efficient analytical tools. It leverages its unique innovative power as well as technological partnerships to reduce its impact on our planet.

Michelin has defined a three-pronged holistic approach:

### 1. An environmental footprint analysis is carried out through the life cycle assessment

Michelin analyses the environmental footprint at each stage of the life cycle of a product or service based on sixteen environmental impacts in four main areas: health, climate change, use of fossil-based resources and biodiversity.

Tyres are not biodegradable - at least, not yet.  Tyre's grip on the road, which is essential for safe driving, generates wear particles. Tyre manufacturing consumes resources such as energy and water and emits $CO_2$ as does tyre transportation, use and end-of-life disposal.

Reducing a tyre's environmental impact requires precise data. Michelin utilizes Life Cycle Assessment (LCA), a powerful tool which evaluates each stage in a product's life cycle from design through to disposal (raw materials, transportation, manufacture, use and end-of-life processing) based on the sixteen environmental impacts laid down in the method defined by the European Commission (EU2021/2279).

Delivered by the LCA, the environmental footprint evaluation clearly maps the environmental impact of a product, service, or activity at each stage of its life cycle; this makes it possible to prioritize actionable solutions already during the study and design phase. This is where there is scope for action: 80% of a project's environmental impact is determined upon conception.

This approach will be applied to all product and service ranges marketed in 2030. In fact, half of all new tyre projects were already subject to LCA at the end of 2021. And since 2023 it has been the case for all new projects to keep their environmental impact in check.

### 2. An eco-design concept applied to the Group's innovation strategy

The French Ministry of Energy Transition gives the following definition:

"Eco-design is a methodology for designing goods and services that considers environmental outcomes during the design process right from the beginning. It seeks to reduce the environmental impact of products at each stage of their life cycle. It is a multi-step and multidimensional approach taking into account each stage of the life cycle and the various contributing factors (material and energy consumption, release into the natural environment, impact on the climate and biodiversity)."

Eco-design is rooted in the Group's innovation strategy. Michelin considers eco-design to be an excellent framework for innovation providing a driving purpose and logic when seeking environmentally friendly solutions.

The Life Cycle Assessment (LCA) articulates with great precision the environmental impact of a tyre, a service or an activity. The eco-design approach, which is an integral part of the Group's strategy, aims to mitigate a tyre's negative aspects while preserving its qualities and ensuring long lasting performance. The quest to reduce any negative environmental impact is factored in throughout the entire life cycle of a product or service, not only during design or manufacturing.

Eco-design considerations include material and energy consumption, release into the natural environment, climate effects as well as impacts on biodiversity. All negative impacts of the products are carefully studied with a view to finding solutions to mitigate them.

Such an approach may seem rather abstract with its share of graphs, eco-design strategy wheels, percentages, and micro-economic data. But the effects are real and significantly contribute to protecting the environment. The main idea is to design products which have a lower environmental impact with the same performance and without any impact transfer, i.e., improvement on one side, degradation on the other. This can be verified by conducting a comparative environmental analysis between the conventional product or service and the eco-designed equivalent.

At Michelin, the eco-design process is multi-step, multidimensional and multidisciplinary as many different métiers in the company join forces to improve the design of a product or service.

Michelin's goal is for **all its products and solutions to be eco-designed by 2030**. The Group has defined a framework in the form of an eco-design charter which has been in force in all its companies since 30 June 2022.

Let's take the example of a MICHELIN PRIMACY 4 tire manufactured in Europe. We have determined that its "use" phase accounts for 84% of its overall environmental impact. Thanks to eco-design tools and data, engineers have singled out three actionable drivers to reduce this figure and boost the energy efficiency of the product, namely optimizing rolling resistance, increasing lifespan, and reducing the rate of wear (abrasion).




MICHELIN PRIMACY 4

Let's take the example of a MICHELIN PRIMACY 4 tyre manufactured in Europe. We have determined that its "use" phase accounts for 84% of its overall environmental impact. Thanks to eco-design tools and data, engineers have singled out three actionable drivers to reduce this figure and boost the energy efficiency of the product, namely optimizing rolling resistance, increasing lifespan, and reducing the rate of wear (abrasion).

“Raw materials” account for 13% of the environmental impact. What solutions do we have? Reducing the tyre’s weight, substituting recycled or renewable materials for fossil-based raw materials, using low-carbon raw materials and components as well as increasing lifespan and ensuring tyres are easier to repair.

## 3. Tangible action and clear commitments for 2030 or 2050



The Michelin Group is also continuing and strengthening its commitment to biodiversity alongside the act4nature international organization to reduce the pressures exerted on nature by its activities and its entire value chain.

Michelin’s holistic approach goes even further. It makes it possible to identify the Group’s main environmental impacts and translate them into tangible and ambitious goals for 2030 and beyond. These include global warming, the use of fossil-based resources and the protection of biodiversity.

Michelin combats global warming by setting itself the goal of net zero emissions by 2050 and contributing to low-carbon mobility. The growing use of renewable and recycled materials in tires is another challenge to tackle for the Group to conserve natural resources.

The Michelin Group is also continuing and strengthening its commitment to biodiversity alongside the act4nature international organization to reduce the pressures exerted on nature by its activities and its entire value chain.

Michelin is one the world’s largest purchasers of natural rubber and is aware that rising global demand can lead to detrimental practices. The Group is therefore working to promote a fair and eco-responsible rubber industry, with the ambition of zero deforestation by bringing the main operators in the sector on board.

In 2030, all Michelin Group production facilities will uphold their commitment not to use pesticides or herbicides in groundskeeping operations.

Lastly, Michelin is seeking to reduce the impact of its manufacturing sites through five priority programs: water withdrawal, the use of organic solvents, the amount of waste generated, energy consumption and $CO_2$ emissions. Since 2005, manufacturing facilities have been evaluating water consumption in the same way as energy consumption or $CO_2$ emissions.

In 15 years, Michelin has cut water withdrawal by 43% which represents a saving of 178 million cubic meters, equivalent to the annual household water consumption of 3.3 million people in a country like France. Between 2019 and 2030, Michelin plans to further reduce its water withdrawal by 33%, based on a water stress coefficient for each production site.

The Group’s strategy and initiatives are aligned with international environmental principles such as the 2015 Paris Accord and it is a signatory of the United Nations Global Compact as well as various calls to step up the fight against global warming. Michelin has joined the Race to Zero campaign and is in favor of the European Green Deal as well as EU regulations on deforestation-free products.

[1] PET : Polyéthylène Téréphtalate

[2] Data taken from an Ernst & Young report “Planned obsolescence is not inevitable” - May 2017

[3] conditional upon uniform tyre wear and compliance with tyre manufacturers’ and automotive manufacturers’ recommendations. If in doubt, consulted a specialist. Ministerial order of 18/09/1991 amending the order of 29/07/1970 regarding the characteristics and conditions of use of vehicles and their trailers, Official Journal of 08/10/1991.

**Author**

**Michelin**

## About Michelin

Michelin is building a world-leading manufacturer of life-changing composites and experiences. Pioneering engineered materials for more than 130 years, Michelin is uniquely positioned to make decisive contributions to human progress and to a more sustainable world.

Drawing on its deep know-how in polymer composites, Michelin is constantly innovating to manufacture high-quality tires and components for critical applications in demanding fields as varied as mobility, construction, aeronautics, low-carbon energies, and healthcare.

The care placed in its products and deep customer knowledge inspire Michelin to offer the finest experiences. This spans from providing data and AIbased connected solutions for professional fleets to recommending outstanding restaurants and hotels curated by the MICHELIN Guide.

## About Michelin Taiwan

Michelin Group officially entered the Taiwan market in 1972. The company is located in Xizhi District, New Taipei City. Its business in Taiwan includes Michelin Group's passenger car tires, light truck tires, truck and bus tires, metro tires, earthmover tires, agricultural tires, and the marketing of bicycle and moto tires. (For more details, please visit www.michelin.com.tw)

EY安永 Shape the future with confidence



# From Vision to Reality: Shaping Taiwan's Sustainable Future

Ernst & Young, Taiwan

Jeffrey D. Sachs, the world-renowned economist and leader in sustainable development, stated that sustainable development tries to make sense of the interactions of three complex systems: the world economy, the global society, and the Earth's physical environment (Jeffrey D. Sachs, 2015). He posed questions such as: What happens when billions of people are interconnected through markets, technology, finance, and social networks? How does a global society of such inequality of income, wealth, and power function? What occurs when the world economy conflicts with the physical environment?

To explore human sustainable development, we must examine the connections between the environment, society, and economy. While achieving net zero emissions is a core environmental goal, it must be pursued alongside other sustainability issues, such as economic prosperity and social equity. However, as the world advances sustainability initiatives, have we considered the potential crises lurking beneath?

**"Sustainable development has set massive gears in motion over the past few years, but the scale and speed are still insufficient to address the crises we face. Fundamentally, we remain entrenched in an unsustainable system... endlessly touting sustainable transformation!"**

The 2024 EY report "A New Economy" highlights that the world currently faces a polycrisis comprising three major systemic crises: ecological, social, and geoeconomic. The interplay of these crises is pushing the global economic system toward instability, triggering multiple cascading global crises. We have transgressed six of the nine planetary boundaries essential for life, with the consequences of climate change and biodiversity loss becoming increasingly irreversible and severe. Moreover, the COVID-19 pandemic, energy crises, and geopolitical tensions between nations have exacerbated global inequalities and vulnerabilities.

## Reflecting Taiwan's Current State Through the Polycrisis?

### 1. Ecological System Crisis

- Global temperatures have risen by 1.2°C, marking the hottest decade on record. According to Taiwan's Central Weather Bureau, the average temperature in Taiwan has increased by approximately 1.6°C since 1911, surpassing the global average rise of 1.2°C.
- Wildlife populations have declined by 69% globally since 1970. Taiwan's biodiversity has also been significantly impacted. For example, the population of Taiwan's endemic leopard cat has decreased by over 70% since the 1970s, with fewer than 500 remaining. Many bird and amphibian species, such as the Taiwan Blue Magpie and Suzuki's Tree Frog, have also drastically declined.
- One-tenth of the global population has experienced unprecedented heatwaves. In 2022, northern Taiwan faced over 20 days of extreme heat exceeding 37°C. Heat-related illnesses and mortality rates have been rising annually in Taiwan.
- In 2022, climate change led to a global GDP loss of 1.8%. Greenpeace estimates that by 2030, extreme sea-level rise and storms could affect populations, land, and GDP in seven coastal cities in Asia, including Taipei, where 430,000 residents could be impacted, and 24% of the city's GDP could be at risk.

## 2. Social System Crisis

- Globally, one in eight people suffers from mental health issues. According to Taiwan's Ministry of Health and Welfare, approximately 15% of Taiwan's population experiences mental health problems, such as depression or anxiety, during their lifetime. Mental health-related outpatient visits have increased by about 20% since the COVID-19 pandemic, with a record-high number of long-term leave requests due to mental health issues in 2022.
- Surveys across 45 countries show that 30-35% of young people take leave due to stress. In Taiwan, a survey by a local job bank found that 33% of young workers (aged 18-34) took leave due to psychological stress or burnout in 2022. Major sources of stress included overwork, salary pressures, and promotion bottlenecks. About 40% of respondents reported that psychological stress affected their work performance, but only 25% sought professional help.
- Loneliness affects 20-34% of elderly populations in China, India, the US, Europe, and Latin America. In Taiwan, loneliness among the elderly is also a severe issue. According to the United Nations' 2019 World Population Ageing report, Taiwan ranks third globally, after South Korea and Singapore, in terms of the fastest-growing proportion of elderly populations from 2019 to 2050. In 2023, Taiwan's Ministry of Health and Welfare conducted 620,000 screenings for elderly depression, referring thousands to medical or psychological services, contributing to the first recorded decline in elderly suicide rates.

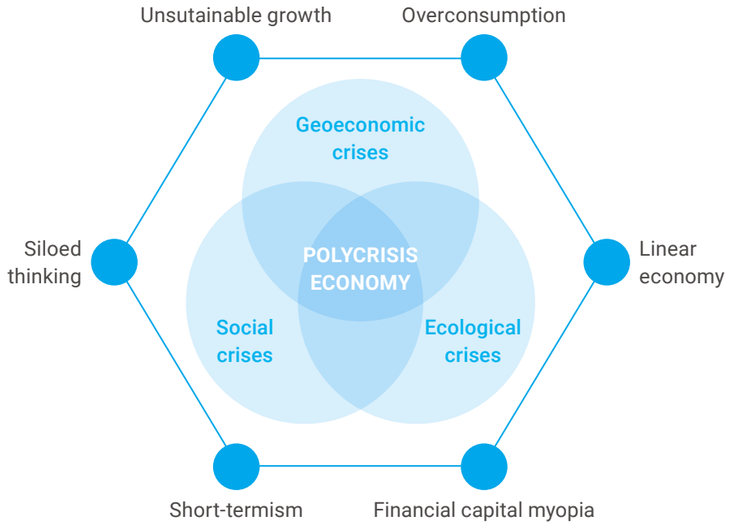
## 3. Geoeconomic Crisis

- COVID-19 death rates in low-income countries are four times higher than in wealthy countries. While Taiwan's COVID-19 death rate is much lower, low-income households have faced greater medical and economic burdens. Vaccine shortages during the initial global rollout left some high-risk groups in Taiwan unprotected.
- Over 30% of new diseases since 1960 are linked to land-use changes. Urbanization and agricultural land development in Taiwan have led to frequent outbreaks of mosquito-borne diseases such as dengue fever in southern regions. Habitat destruction has increased contact between humans and wildlife, raising the risk of zoonotic diseases.
- Since 2008, 376 million people globally have been displaced by natural disasters and ecological threats. By 2050, this number is expected to reach 1.2 billion. Taiwan's unique geography exposes it to frequent natural disasters, such as typhoons and earthquakes. For example, Typhoon Morakot in 2009 displaced 1,177 households. The escalating impacts of climate change could further increase displacement risks.
- The World Economic Forum's 2024 Global Risks Report lists interstate armed conflict as the fifth largest risk. As a tech hub, Taiwan faces challenges in three key areas: the technology sector, energy security, and ESG policies. Geopolitical risks threaten supply chain stability and energy imports, underscoring the need for accelerated ESG policy implementation, energy transition, and self-sufficiency.

# Addressing the Root Causes of the Polycrisis

EY's observations highlight six entrenched systemic flaws:

1. **Unsustainable growth:** Economic outcomes are unevenly distributed, exacerbating inequalities. Economic growth raises living standards but also drives energy and resource demand at a severe ecological cost.
2. **Short-termism:** Policies, business plans, and investments prioritize immediate concerns, disregarding long-term impacts. This mindset shifts burdens onto future generations.
3. **Siloed thinking:** Fragmenting complex challenges into smaller parts impairs understanding of systemic interdependencies, missing opportunities for transformative change.
4. **Overconsumption:** At current consumption rates, we would need two Earths by 2030 and three by 2050. Wealthy segments overconsume while the poorest struggle to meet basic needs.
5. **Linear economy:** Limited progress in circularity intensifies resource competition, price volatility, supply chain instability, and potential human rights abuses.
6. **Financial capital myopia:** Overemphasis on short-term financial returns undervalues other essential capitals (e.g., natural, human, and social), distorting true value assessments.

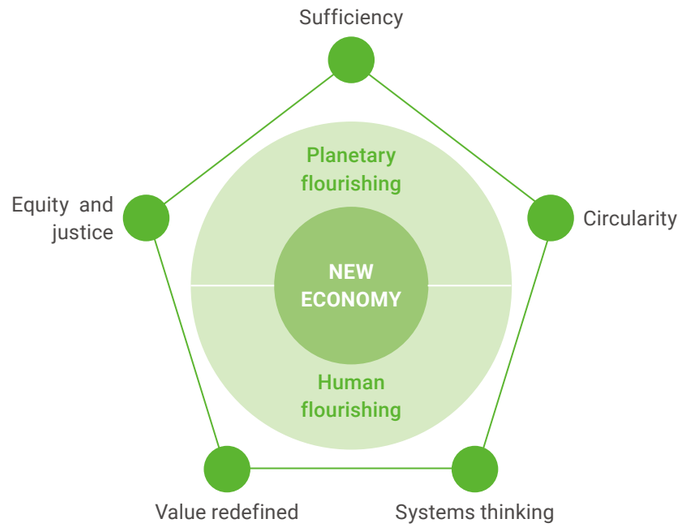



Resource: Regenerative principles to unlock a sustainable future, 2024, EY Global

## EY's New Economic Framework

To transform crises into actionable outcomes, governments and businesses must collaborate to dismantle structural barriers and create favorable conditions for a sustainable economy that ensures human and planetary prosperity. EY proposes five principles to accelerate this transformation:

1. **Redefine value:** Prioritize human and planetary well-being in value creation. Policymakers, standard setters, and businesses must redefine societal values that cannot be priced.
2. **Equity and justice:** Equitable responsibility-sharing is essential for sustainable prosperity. Businesses can promote fairness across value chains, fostering climate and social justice.
3. **Systems thinking:** Focus on interconnections to catalyze systemic change. Identify key leverage points for comprehensive transformation.
4. **Circularity:** Align production and consumption with nature. Produce only what is necessary, ensure durability, and retain material value through safe reuse or recycling.
5. **Sufficiency:** Consume within ecological and social limits. Prioritize essential needs over servicing inequitable and excessive markets.




Resource: Regenerative principles to unlock a sustainable future, 2024, EY Global

## Taiwan's Net Zero Policies

Facing global and local challenges, Taiwan's government proposed the 2050 Net Zero Emissions Target and its roadmap in 2021. In 2024, President Lai Ching-te further introduced the "National Hope Project" with five key strategies:

1. **Secondary energy transition:** Accelerate renewable energy development, optimize grid infrastructure, improve energy efficiency and storage, and phase out coal-fired power.
2. **Dual-axis transformation of digital and green industries:** Leverage green finance to support R&D in smart and net zero technologies, promote carbon pricing and market mechanisms, and encourage sustainable agricultural transformation.
3. **Net zero sustainable living:** Advocate energy-saving actions, increase public low-carbon transport usage, and promote smart living and low-carbon diets.
4. **Government as the strongest support for net zero transition:** Establish technical service teams across industries, periodically release action guidelines, and strengthen related oversight mechanisms.
5. **Just transition without exclusion:** Develop mechanisms to address disputes in the net zero transition, turning climate challenges into opportunities for regional development to create a fair and green future.

Taiwan's Financial Supervisory Commission also announced the "Green and Transition Finance Action Plan" in the same year, emphasizing the pivotal role of finance in the National Hope Project. Businesses must disclose transition plans, fund allocation, and emission reduction progress to ensure proper use of capital and mitigate greenwashing risks. EY's 2024 Global Climate Action Barometer shows that only 41% of businesses globally have transition plans, while 21% have yet to formulate one. Companies with transition plans typically have higher quality climate-related disclosures.

EY urges businesses to act immediately, warning that if climate actions remain stagnant, the average GDP of 51 surveyed countries (including Taiwan) is expected to drop by 35% by 2100.

## Six Core Actions to Accelerate Change

1. **Make transition planning a core business issue:** Set science-based targets for Scopes 1, 2, and 3 emissions with clear short-, medium-, and long-term goals. Plans should include rigorous scenario analysis and supply chain decarbonization strategies.
2. **Incorporate climate risks into financial reporting and explore opportunities:** Assess climate-related risks and opportunities to align with financial reporting. Quantify financial risks of climate transitions and explore new business models.
3. **Leverage data disclosure for climate action:** Collect and utilize sustainability-related data to support decision-making. Reporting under TCFD's four pillars can help companies address future climate challenges.
4. **Allocate sufficient resources to sustainability teams:** Equip teams to manage compliance, lead overall sustainability strategies, and conduct in-depth analyses of climate risks to integrate sustainability across business units.
5. **Ensure board members understand climate risks:** Provide training and recruit experts to integrate climate-related performance into executive compensation, aligning goals with decision-making and daily operations.
6. **Explore cross-sector collaboration:** Create unique value benefiting diverse stakeholders by aligning with regulatory frameworks, enhancing transparency, and advocating sustainable policies.

These actions provide a concrete roadmap for businesses and a strategic guide for Taiwan's role in global climate governance. As a highly export-driven economy, Taiwan should share green technology expertise and actively engage in international climate governance to foster low-carbon economic development in the region.

## From Vision to Reality

While global systemic crises pose significant challenges to current economic systems, they also present opportunities to redefine value. EY's five principles—redefining value, equity and justice, systems thinking, circularity, and sufficiency—offer direction for sustainable and low-carbon transitions.

In Taiwan, net zero transition is not merely an environmental goal but an opportunity to reshape economic core values. By integrating policy and business innovation, Taiwan can achieve energy transition, resource circularity, and social equity. This vision concerns not only the nation's future but also the sustainable development of the global community.

Future economic transformation requires collective societal effort. We must ask ourselves: What legacy do we wish to leave for future generations? What roles do we play in this process? Driven by these questions, let us work together to turn vision into achievable goals, shaping a more sustainable and prosperous future for Taiwan.

Disclaimer: The views reflected in this article are the views of the author and do not necessarily reflect the views of the global EY organization or its member firms.



EUROPEAN CHAMBER OF COMMERCE TAIWAN
歐洲在臺商務協會

# European Chamber of Commerce Taiwan

## About the European Chamber of Commerce Taiwan (ECCT)

With over €70 billion in direct foreign investments, European businesses are collectively the largest group of foreign investors in Taiwan. The European Chamber of Commerce Taiwan is the principal organisation representing and promoting European business interests in Taiwan. The chamber represents over 1,000 members from over 450 companies and organisations. Through a network of 29 industry committees along with 2 platforms, the ECCT has been successful in addressing specific concerns and providing concrete recommendations to all levels of government to facilitate improving the business environment. The ECCT produces annual position papers that comprise issues identified by its committees as hindering the further development of their respective industries and provide recommendations to the government of Taiwan for improvement of the business environment on general issues as well as industry-specific problems. They also serve to keep the European Commission and parliament as well as the governments of individual European countries informed about Taiwan's business environment.

## About ECCT's Low Carbon Initiative (LCI) Platform

The ECCT Low Carbon Initiative (LCI) was established in June 2012 as a cross-industry, cross-ECCT committee best practice platform to showcase best international practices and low carbon solutions from Europe in alignment with ECCT committee priority advocacy issues. The LCI is supported by companies and institutions that are members of the ECCT and membership in the LCI is open to any ECCT member who is willing to support the initiative.

The ECCT LCI's aim is to enhance recognition of the importance of sustainability and promote the implementation of low carbon solutions, thereby helping Taiwan to reduce its carbon emissions and reach its goal of net zero emissions by 2050.

The ECCT LCI creates opportunities for member companies to share their best practices on the platform, raise awareness of sustainable development and the circular economy by sharing resources through independent and co-branded events and networking opportunities in partnership with European representative offices, the Taiwan government, industry, and non-governmental organisations.

## Special Thanks to the Report Contributors

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EUROPEAN CHAMBER OF COMMERCE TAIWAN
歐洲在臺商務協會

# 序言



張瀚書
歐洲在臺商務協會理事長

臺灣與歐洲在實現淨零未來的願景與承諾上，有著共同的目標。儘管在邁向這一願景的過程中，已取得進展，但距離目標實現僅剩 25 年，若缺乏一致的行動，不僅中期目標難以達成，長期目標也將變得遙不可及。

歐洲企業是台灣最大的外資來源，同時也是台灣風能產業的最大投資者。如本報告所述，歐洲在臺商務協會 (ECCT) 的會員企業，擁有創新技術與解決方案，致力於推動 2050 年淨零排放目標的實現。其中，多項解決方案對達成此目標至關重要，每一項都在減少碳足跡和促進環境永續上，發揮獨特且關鍵的作用。例如，替代能源，包括風能、太陽能、地熱、水力和海洋能，是從化石燃料轉型為更清潔的可再生能源的基石。同樣地，清潔氫能和生物基燃料等替代原料，為電力、交通、農業、製造業及化工業等行業提供可持續的解決方案，有效取代高碳排放的原料。

金融業在為綠色技術和專案融資方面，發揮著關鍵作用。政策、激勵措施及對清潔能源基礎設施的投資，是擴大解決方案規模並加速低碳經濟轉型的必要條件。制定適切的金融策略，將確保企業與政府能夠推動創新，支持能源轉型專案，並促進永續發展實踐。

工業與交通運輸中的永續實踐，包括能源高效的製造流程、電動車的採用及智慧交通系統的推行，能顯著減少排放。這些措施還可促進綠色技術創新，推動工業採用更清潔的替代方案。此外，低碳及節能建築對於減少能源消耗及排放至關重要。透過整合先進的隔熱技術、智慧科技及可再生能源系統，建築物能有效減少其對環境的影響。

生物科技與自然解決方案，例如生態復育、生物多樣性保育及智慧農業，提供了創新方法來強化生態系統、減少排放並提升碳封存能力。此外，零排放的循環產品設計，專注於商品的重複利用、回收或重新賦予其用途，不僅能有效減少廢棄物，還能在產品全生命周期中，顯著降低碳排放。

本報告中所概述的解決方案，將協助台灣加速邁向實現淨零願景的步伐。若能與歐洲在臺商務協會 (ECCT) 的會員企業合作推動，這一轉型將更加順利，並為台灣的經濟與環境帶來雙重益處，進一步鞏固台灣作為環境治理模範與淨零倡議領導者的國際形象。



EY安永 Shape the future with confidence

# 序言



傅文芳

安永聯合會計師事務所所長

## 預測未來最好的方法就是自信地創造未來

當今世界，氣候變遷已不再是一個遙遠的威脅，而是我們必須立即因應的艱鉅挑戰。作為全球供應鏈的重要樞紐，臺灣在淨零轉型的旅程中，不僅肩負國際責任，也面臨著重塑經濟、社會與環境的歷史機遇。

在此背景下，我們很榮幸與歐洲在臺商務協會（EUROPEAN CHAMBER OF COMMERCE TAIWAN, ECCT）攜手，共同發行《淨零實踐報告書》。這份報告集結了淨零最佳實踐與專業見解，期許為政府與企業提供一帖淨零良方，推動臺灣在 2050 年前達成淨零目標。

## 全球視野中的臺灣角色

臺灣是全球半導體產業的領導者，也是許多高科技產業與製造業供應鏈的關鍵環節。這樣的角色為我們帶來了獨特的優勢，也賦予更大的責任。在全球能源轉型與淨零目標的推動下，臺灣必須在以下三個方面展現領導力：

1. **創新驅動的產業轉型：**透過技術創新，推動高碳排產業邁向低碳轉型，並在國際市場中樹立綠色製造的標竿。
2. **能源結構的根本性改變：**發展再生能源，實現能源自主與穩定，將是臺灣淨零的首要關鍵。
3. **社會共融的公平轉型：**在推動淨零的同時，我們必須確保弱勢族群不會因轉型而被邊緣化，創造更公平的發展環境。

## 安永全球戰略：All In

我們也意識到會計師在永續與淨零趨勢下將面臨 3 大新挑戰，包括如何衡量永續相關資訊的不確定性？如何為企業進行時間跨度更長、更完善的財務評估？以及財務報表如何呈現整體價值鏈的永續相關風險？

作為全球專業服務機構，安永始終將推動永續發展作為核心使命。我們推出了全新的全球戰略 -All In，展現大膽的雄心壯志，為客戶、員工和利害關係人創造全新的價值。

All In 不僅僅是一種商業策略，更展現 40 萬安永員工的工作態度及多元專業，以預測和駕馭不斷變化的世界，協助政府與企業能夠自信地塑造未來。

## 共同的責任與願景

此次在報告中匯聚安永與 ECCT 企業會員的專業智慧，內容涵蓋全球趨勢、產業轉型案例與科技創新方向。我們深信，成功的淨零轉型需要政府、企業與社會各界的協同努力。

尤其淨零的實現不僅關乎碳排放的減少，更關乎經濟結構的轉型、社會公平的提升，以及我們對下一代的承諾。安永將以全球視野結合在地洞察，繼續攜手 ECCT 共同支持政府與企業在淨零旅程中的每一步。

我們期待，本報告書能成為政策制定者與產業領袖的重要參考，幫助臺灣在全球淨零競賽中走在前列。也期待與各界攜手，為臺灣與世界共創永續的未來。

傅文芳

經濟部
Ministry of Economic Affairs

# 序言



郭智輝
經濟部部長

隨著氣候變遷造成的衝擊日益增加，應對氣候危機的迫切性已成為各國面對的共同課題，驅使各國積極推展永續行動，實踐淨零碳排綠色轉型。歐盟是全球淨零轉型的先驅，率先承諾於 2050 年實現氣候中和，所提出之《歐洲綠色新政》(The European Green Deal)，涵蓋能源、經濟、建築、運輸、農業、生態、環境等廣泛層面，亦為台灣與其他國家參考效法的標竿。

歐洲在臺商務協會長期關注並積極參與臺灣能源建設計畫，於 2011 年成立低碳倡議行動 (Low Carbon Initiative，LCI)，長期與我國政府及產業界分享歐洲最佳低碳方案與規範，促進臺歐雙方在低碳永續領域協同發展，是臺灣落實淨零轉型的重要夥伴。此次歐洲商會透過《從理想到實踐，擘劃未來淨零藍圖》報告書，深入探討臺歐能源轉型路徑，並分享歐盟在能源轉型過程中的產業解決方案與實踐案例，內容涵蓋再生能源、綠色金融、永續消費、運輸建築、自然生態等跨域主題，非常值得我國淨零轉型政策參考。

臺歐雙方不僅貿易關係緊密，綠色轉型理念也十分相近，自 2016 年能源轉型以來，歐洲即為臺灣重要的綠能技術來源與投資夥伴。許多歐洲企業已在我國推動能源轉型過程中扮演關鍵角色。臺灣目前已啟動第 2 次能源轉型，透過多元綠能及深度節能等面向，確保能源穩定供應，強化能源自主，未來也期盼臺歐雙方能在地熱、海洋能等新興能源發展方面深化合作，強化夥伴關係。

2050 淨零轉型是一項跨世代、跨領域、跨區域之全球大型轉型工程，需要各個國家共同合作及經驗分享。臺灣具備全球優勢的半導體及資通訊產業，也擁有健全的科技及傳產供應鏈，而歐盟在再生能源或氫能等潔淨能源技術、綠色金融及法規配套規劃等領域亦居於世界領先地位，期待臺灣與歐盟未來能持續合作，共同投入低 ( 無 ) 碳技術研發與商業應用，一同為全球淨零貢獻心力。



環境部
Ministry of Environment

# 序言



彭啓明
環境部部長

隨著全球氣候變遷的加劇，淨零減碳已成為國際社會共同努力的關鍵目標。臺灣身為全球經濟鏈中的重要一環，不僅積極追求淨零排放目標，並且在此過程中與全球夥伴密切合作。

歐洲長期以來是全球氣候政策的領導者，無論是在創新技術、政策規劃還是社會共識的建立上，皆走在世界前列。臺灣深受啟發，並積極與歐洲合作，學習其成功經驗，並將其融入本地實踐。透過歐洲在臺商務協會的支持，雙邊合作關係得以進一步鞏固，不僅促進了技術和資源的共享，也提升了雙方的經濟和環境價值。

臺灣自 2021 年宣示 2050 淨零排放目標以來，在淨零減碳的進展上已取得顯著進展，除了逐步推動一系列政策，並在能源轉型、產業減碳及交通運輸方面取得積極成果。具體來看，我們已經在 2023 年成功降低了全國溫室氣體排放量約 3%，尤其是在電力及工業部門的排放控制上成效顯著。此外，臺灣在推動再生能源發展方面也陸續到位，截至 2024 年中，太陽能裝置容量已達 12 GW，風力發電容量超過 3.01 GW，這些成果標誌著台灣邁向低碳社會的堅實步伐。

2024 年，臺灣邁出了淨零之路上的關鍵一步，宣布了碳費制度的正式實施。在過去數個月間，環境部全力推動碳費法規的制定與執行，進行了多次公聽會及與業界的諮詢，並根據各行業的不同需求與特性調整具體措施，確保法規的可操作性與公平性。碳費制度不僅為台灣實現減碳目標奠定了基礎，也標誌著朝向低碳經濟邁進的重要里程碑。

臺灣碳費制度以溫室氣體排放為計價基礎。在設計此制度時，特別考慮了企業的不同需求，確保該制度不是經濟懲罰措施，更是能實質推動企業創新和調整的機制。在法規實施的前三個月，政府與超過 100 家企業簽訂了減碳目標承諾，並推動相關技術支持及資金補助計劃，協助企業逐步適應新政策。

碳費法規的全面實施，預計將在未來五年內使臺灣全國溫室氣體排放量大幅減少，這對於如期實現 2050 淨零目標至關重要。碳費制度的推出不僅表明臺灣對減碳的堅定承諾，也為企業提供了清晰的政策指引，促使各行業加速調整運營模式，適應低碳經濟需求。

臺灣與歐洲在推動淨零減碳的合作，不僅限於政策層面，還體現在技術創新及產業鏈的綠色轉型上。臺灣的高科技產業與歐洲的先進技術供應商緊密合作，雙方在智慧電網、能源儲存、再生能源技術及電動車領域的協同發展上創造了豐富的合作機會。這些合作不僅加速臺灣內部的綠色轉型，也使臺灣成為歐洲企業拓展亞太市場的重要夥伴。透過這些跨國合作，雙方共同應對氣候變遷挑戰，並促進全球經濟的可持續發展。

臺灣政府對於淨零排放的願景是長期且系統性的。實現淨零目標不僅是單一國家的責任，更是全球性的挑戰。展望未來，實現淨零排放的路途仍然充滿挑戰，無論是在技術突破還是社會共識的建立，都需要持續投入資源與智慧。然而，透過臺灣與全球夥伴的共同努力，這些挑戰終將被克服，氣候目標將得以實現，並為後代創造一個更加美好的地球。

Chi-Ming Peng

# 序言



谷力哲

歐洲經貿辦事處處長

氣候變化威脅的不僅是珊瑚礁、沿海城市以及數百萬人的生計，更威脅著我們賴以維生的星球。

如果全球暖化超過 1.5° C，調適的成本將遠超過在損害不可逆轉之前，轉向低污染能源的成本，這凸顯了迅速實現經濟脫碳的迫切性。

為了達成 2030 年減少 55% 排放、2040 年減少 90% 排放，以及 2050 年實現氣候中和的目標，歐盟近年來推出了一系列重大政策，並已開始見到成效。2022 年，歐盟的太陽能和風能發電量超過了天然氣發電量；而到 2023 年，再生能源佔總能源結構約四分之一，是過去十五年的兩倍。這是歐盟持續邁向更永續生產和消費模式轉型的一部分，同時也在與工業界、社會夥伴及所有利益團體合作的基礎上，擴大並且優先展開對清潔能源基礎設施與技術的投資。

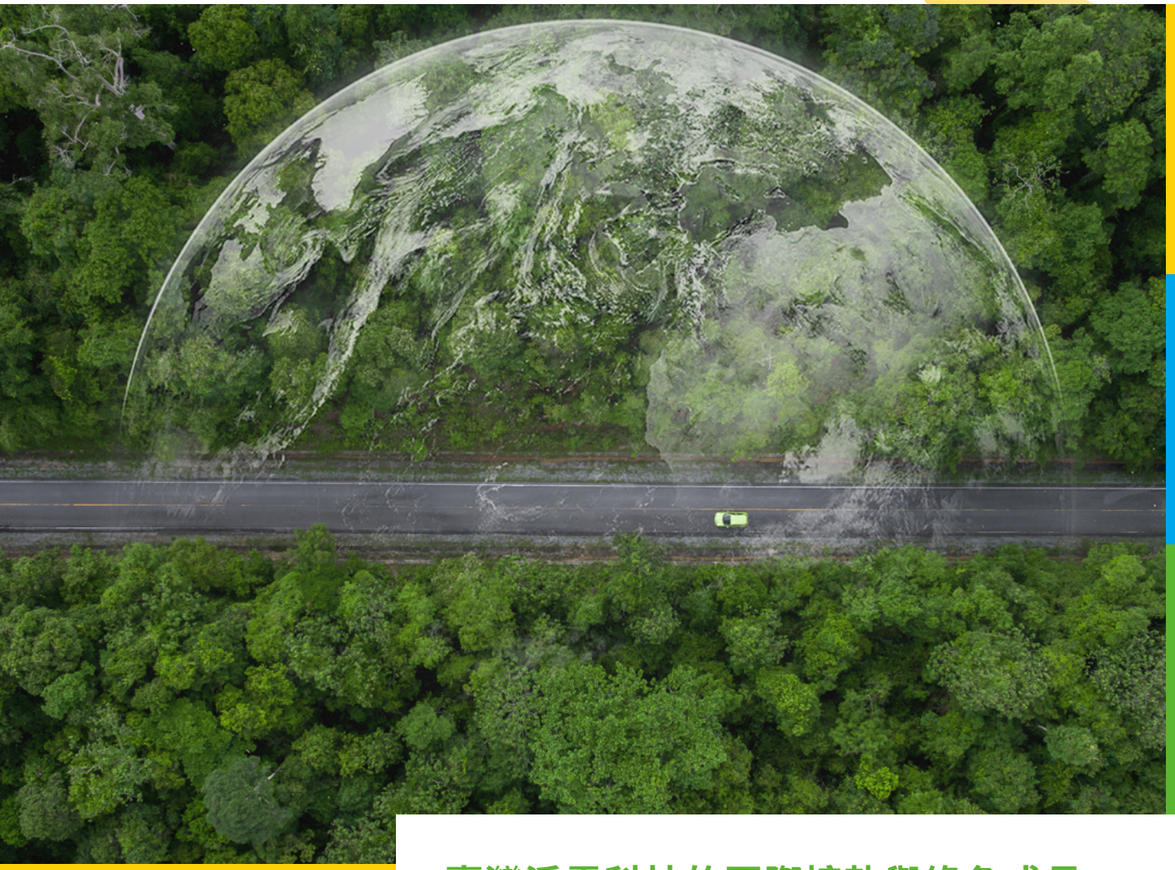
然而，我們必須承認，歐盟的二氧化碳排放量不到全球總排放的 10%，因此無法單獨應對氣候變遷帶來的挑戰。顧名思義，全球暖化是全球性問題，必須依賴全球的參與和解決方案。為了實現這些解決方案，歐盟能做的是以身作則，甚至引領通往綠色經濟的成功道路。

同樣承諾在 2050 年之前實現碳中和的台灣，正在面對日益嚴重的洪水泛濫、致命熱浪，以及更頻繁和強烈的颱風。台灣選擇加入這一時代最具意義的挑戰，與志同道合的夥伴共同努力。歐盟希望加強與台灣在這一領域的夥伴關係，不只是鼓勵歐商投資台灣的離岸風電項目，還有與台灣在甲烷排放、碳定價和全球再生能源目標等歐盟最新的倡議展開合作。

讓我們抓住這個機會，共同邁向一個更加綠色和安全的未來。



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# 臺灣淨零科技的國際接軌與綠色成長

**曾于哲** 安永聯合會計師事務所 氣候變遷、永續發展與 ESG 諮詢服務負責人暨審計服務部執業會計師

**林宜賢** 安永聯合會計師事務所 氣候變遷、永續發展與 ESG 諮詢服務副理

我國為實現2050年淨零排放目標，基於《氣候變遷因應法》及淨零轉型四大策略（能源、產業、生活、社會），行政院於 2023 年 1 月核定公布《淨零排放路徑 112-115 綱要計畫》（以下簡稱淨零綱要計畫）之具體行動方案，以確保能源轉型、減碳政策及產業升級能有效推進。淨零綱要計畫中針對建築、運輸、工業、電力及負碳技術等 5 大部門提出 2050 淨零路徑規劃。報告中指出，當前我國最具減排潛力的能源轉型技術包含地熱、氫能、智慧電網、離岸風電、海洋能等低碳技術。

安永為協助進一步辨認適合於國內並有開發與發展條件的淨零技術，同時探討低碳轉型計畫所伴隨的潛在風險與機會，將借鏡國際能源署（IEA）所定期更新發布之 IEA Clean Energy Technology Guide（以下簡稱 ETP 科技指南），以其公布之 597 項淨零科技相關之「技術成熟度」、「減碳潛力」及「法規標準」三項指標，針對我國淨零綱要計畫中所提及的減碳技術進行比對與分析。

IEA ETP 科技指南是一項工具，設計用於幫助決策者、企業和研究人員深入了解清潔能源技術的現狀、潛力及應用場景。屬於 IEA 的 Energy Technology Perspectives（ETP）系列，其中涵蓋多項清潔能源技術的詳細資訊，包括其發展階段、市場應用、成本趨勢，以及對減少碳排放的貢獻。技術範疇涵蓋能源生產、轉化、儲存和使用的所有主要技術，包括：可再生能源（太陽能、風能、水能、地熱能等）、能源儲存（電池、氫能等）、能源效率（建築、工業、運輸技術）、碳捕捉與封存（CCUS）與低碳燃料（綠色氫、合成燃料、生物能源）。

### 1. 技術成熟度

ETP 科技指南根據每種技術的發展階段將其分類：
(1) 研究與發展階段（R&D）：仍需進一步研究和試驗。
(2) 示範階段：正在測試或試運行。
(3) 早期部署階段：開始在特定市場應用。
(4) 商業化階段：已經普遍應用並具成本競爭力。

### 2. 減排潛力

評估每種技術在 2030 年和 2050 年對全球減碳的貢獻潛力，以及提供技術在實現淨零目標中的必要部署規模。

### 3. 法規標準

如何加速技術發展和應用的政策，例如：(1) 政府支持研發計畫、(2) 建立市場激勵機制（如碳價和補貼）以及 (3) 推動國際合作和技術轉移。

相對於 IEA ETP 科技指南，我國於能源及運輸部門較有完整之改善規劃及具體的技術路徑。淨零綱要計畫針對於**能源領域**提出諸多改善規劃，內容包含地熱、氫能、電網、離岸風電、海洋能等各領域，顯示於推動能源轉型具有較具體技術路徑。初估我國參採大約**20%**的IEA ETP科技指南所提出的能源領域技術項目數量，但例如：永續燃油、甲烷重組等技術，亦或尚未具備成熟的條件而未列入政策。

**運輸部門**則已對於電動車電動機車、公超電氣化多有說明。初估我國參採大約 10% 的 IEA ETP 科技指南所提出的運輸部門技術項目數量，但例如：氫或氨的添加或儲存的基礎設施、燃料電池等，未有明確或具體的政策描述。

另外，淨零綱要計畫針對**工業部門**或**建築部門**，主要僅提供政策說明或法規因應，參採 IEA ETP 科技指南項目數量的程度大約分別為 **3%** 及 **1%**。工業部門並未提及已如 IEA ETP 科技指南詳實程度的具體產業技術推動計畫，大部分規劃僅說明最佳可行技術（BAT），例如：建立低碳製程解決方案、能源轉換應用、設備效能提升，但與發展淨零技術的關聯性偏低。即便我國的鋼鐵、水泥產業等指標性公司皆個別提出相關的減碳或 2050 淨零計畫，但淨零綱要計畫並未提及相關的政策敘述，亦未指明永續金融行動方案將如何能夠提供工業轉型所需的足夠資金或投資。另外，建築部門在淨零綱要計畫內容偏向政策、配套措施因應，具體技術規劃尚未清楚定義未來技術走向，整體淨零建築推動尚處於非常初期的階段，尚未提及例如：製冷的控制系統、熱效率、照明標準、低碳材料或材料生命週期（之延長或循環經濟）等，或是近零碳建築的通風或是建築外殼技術標準等，未有明確或具體的政策描述。

安永認為，我國宜持續廣泛的研究和借鏡歐洲或其他國際間標竿的淨零技術藍圖，除可行性應全面且完整的持續評估外，還需要將永續金融如何得以協助產業綠色成長的經濟產業政策整合，以嶄新的思維重新打造淨零技術脈絡。淨零目標並非是2030 的目標，而是 2050 的目標。除了現有的永續經濟活動分類原則，得參考歐盟綠色新政再列入轉型經濟活動（Transition Activities）與賦能經濟活動（Enabling Activities），必要時引進國外相關淨零技術以縮短產業的學習曲線，導引資金共同投入低碳綠色、轉型和賦能等三方面的經濟活動而不偏廢，我國的淨零目標方能真正的提升國家、企業和社會的整體競爭力！

Disclaimer: The views reflected in this article are the views of the author and do not necessarily reflect the views of the global EY organization or its member firms.



## 作者

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**氣候變遷、永續發展與 ESG 諮詢服務負責人暨審計服務部執業會計師**

曾于哲為氣候變遷、永續發展與 ESG 諮詢服務負責人，擁有豐富的企業永續及審計經驗，為安永在永續相關領域協會組織的代表。取得臺北大學自然資源與環境管理博士及東吳大學會計碩士。

主要負責業務包括氣候相關財務報導、永續報告書諮詢及確信、國際永續指數、社區投資、影響力評估、綠色金融、碳定價及策略等永續服務。

協助公司及組織鑑別短、中、長期的永續發展關鍵議題、制定永續發展策略，並導入財務及非財務、利害關係人管理制度，循序建構涵蓋治理、管理、風險管理及指標和目標的永續藍圖。



## 作者

### 林宜賢

**氣候變遷、永續發展與 ESG 諮詢服務副理**

宜賢目前為安永氣候變遷、永續發展與 ESG 諮詢服務副理，主要協助業務包含氣候與自然相關財務報導、永續報告書諮詢、國際永續揭露、ISO 準則導入及水回收查驗等永續服務。為成功大學環境工程學士與碩士。

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# 借鑒歐洲，臺灣綠電交易市場將加速發展

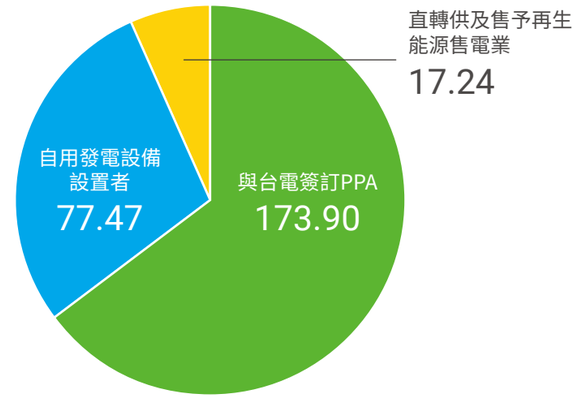
**吳培源** 安永財務管理諮詢服務股份有限公司 執行副總經理

**朱忠熠** 安永財務管理諮詢服務股份有限公司 副理

## 再生能源政策鬆綁，太陽光電直轉供度數成長，擴充綠電供給市場

根據安永聯合會計師事務所（以下簡稱安永）統計，臺灣 2023 年共發電 2,821 億度，其中 9.5% 來自再生能源，約 268.6 億度。再生能源的發電量裡，台電躉購約 173.9 億度；直轉供及售予再生能源售電業（以下簡稱直轉供交易市場）則為 17.3 億度，僅占總發電量的 6%；剩餘 77.47 億度的自用設備發電量則未進入再生能源交易市場。

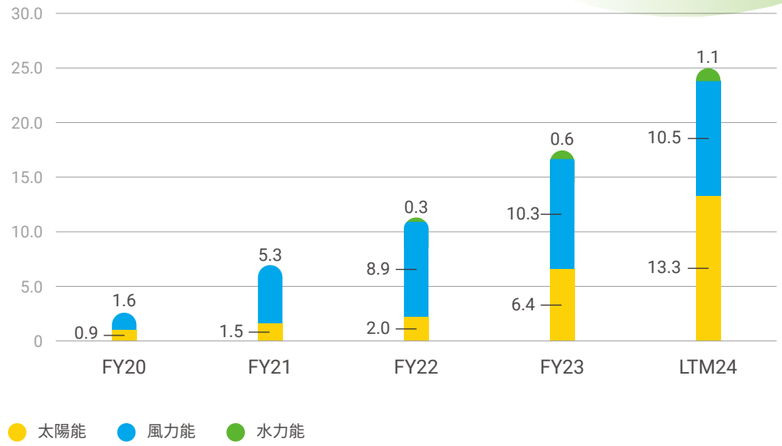
### 2023 臺灣再生能源交易分佈（單位：億度）




考量國內產業日益增長的綠電需求，經濟部能源署於 2023 年進一步放寬「三轉一」法規，開放自發自用型案場（太陽光電第二、三型）產生的再生能源可直接賣給再生能源售電業，供給綠電市場；另外，台電的統計資料顯示，自直轉供開放、2020 年 5 月首次受理業者轉供案件以來，截至 2024 年 9 月底，累計直轉供交易量約達 56.1 億度。

安永統計 2024 年近 12 個月的綠電直轉供量可達約 24.9 億度，相較 2023 年的 17.3 億度，成長四成以上；其中太陽光電增加至 13.3 億度，和 2023 年的 6.4 億度成交量相比，增長超過九成。自 2017 年 1 月 26 日《電業法》修正案公布、推動綠電自由化以來，如下圖所示，我國再生能源售電業正以平均每年約五成的速度成長。經濟部也預估，由於法規放寬，2024 年自用設備發電者有 86 億度綠電可進入直轉供交易市場。

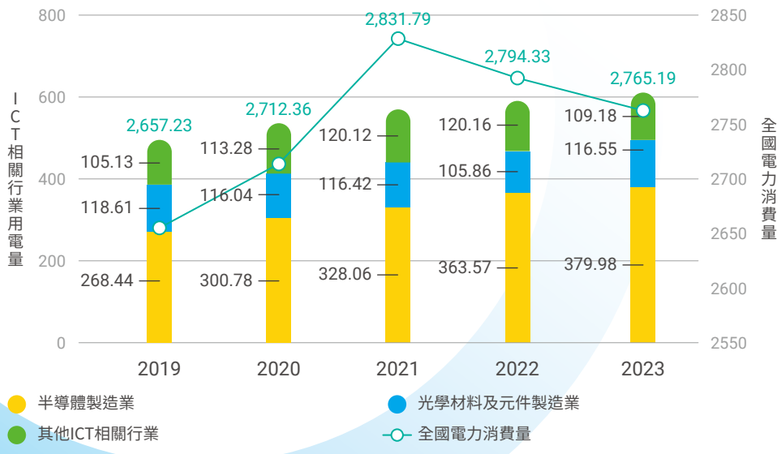
### 2020-2024 年直轉供及售予再生能源售電業交易量 ( 單位：億度)




## ICT 相關行業用電量日益增加，綠電仍供不應求

安永表示，臺灣在全球 AI 運算系統供應鏈扮演舉足輕重角色，伴隨大型科技公司共同響應政府「2050 淨零排放」的政策、自主跟進承擔「RE100 倡議」與企業社會責任，科技業者對於綠電需求持續上升。台電的數據顯示，2023 年較 2022 年的全國電力消費量減少了 29.1 億度，但隨著新興科技應用不斷擴展、數位轉型、全球半導體晶圓代工產量增加，2023 年半導體製造業用電較 2022 年增加 16.4 億度（成長 4.5%）。由於半導體先進製程產能逐年增加，預計未來臺灣半導體產業用電量可能增長超過三倍；另外，2024 至 2028 年國際大廠也陸續在臺增設 AI 伺服器及資料中心，兩者合計至 2030 年用電需求可能大增。

### 2019-2023 年全國電力消費量與 ICT 相關行業用電量 ( 單位：億度)

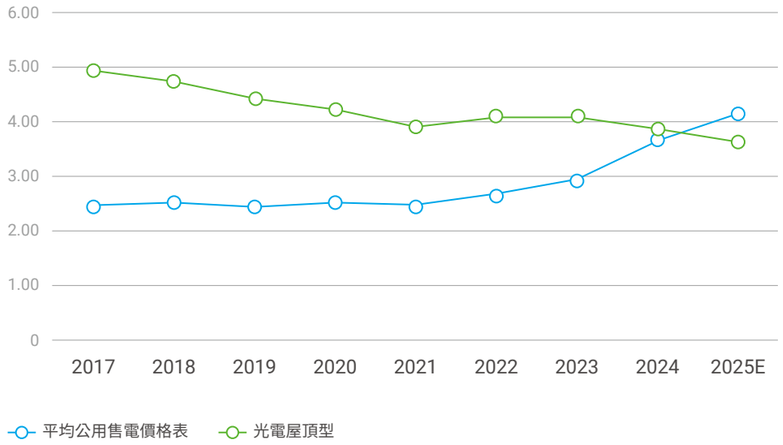



## 躉購 (Feed-in Tariffs, FiT) 價格逐年縮減、用電價格調漲，未來綠電交易將更活躍

隨著太陽能發展越來越成熟，2024 年臺灣太陽能屋頂型第二期上限 FiT 約落在新臺幣 4.37 元／度，八年間收購費率減少 12.2%。未來發電業者與台電簽訂長期購電合約的獲利空間將日益縮減，在能源市場交易的效益將逐漸高於售回國家電網的效益。

台電於 2024 年 9 月進行電價費率審議會，為避免加劇財務危機，決議調漲產業電價平均調幅 12.1%，調價後產業用電均價為 4.27 元／度。以此趨勢預估，未來躉購價格甚至會低於產業平均用電價格，並於 2025 年出現黃金交叉。因此，在 FiT 逐漸退場的同時，非常有利於綠電交易市場的發展。

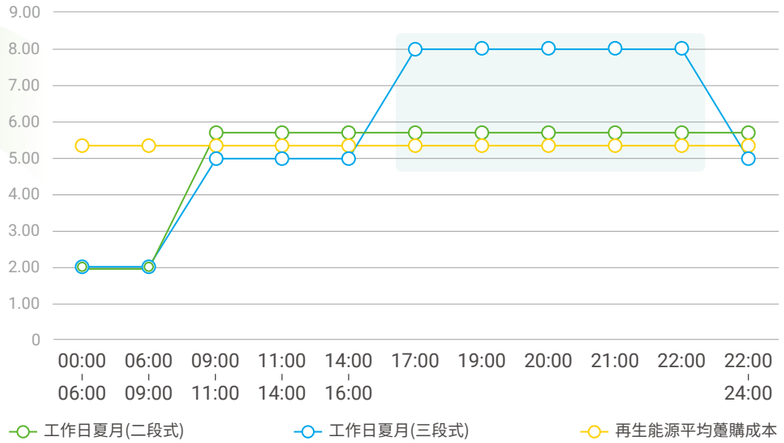
### 光電屋頂型 FiT 價格 vs. 平均產業電價 ( 單位：新臺幣 / 度)




## 時間電價制度及表後儲能建置將促使尖離峰價差套利

就國內綠電市場來說，大企業（2B 企業用戶為主）可以與第一型再生能源電廠或售電業者，按照固定費率簽訂長期的企業購電協定（Corporate Power Purchase Agreement，CPPA）。然而，對國內住商及中小企業 （2C 零售）來說，綠電目前仍是稀缺資源，未來更傾向與台電申請二段式、三段式簡易型時間電價來實現「淨消費」，即把離峰時段低價購買或多發的電儲存起來，在尖峰時段自用或售出，以獲取更好的價格進行套利。依經濟部能源署統計，目前符合申辦條件的中小企業（每月用電逾 5,000 度）約 50 萬戶、小型商家（每月用電逾 1,500 度）約 100 萬戶、家庭用戶（每月用電逾 800 度）約 200 萬戶；然而實際申請比例仍不足 3%。安永預估，上述符合申辦條件的用戶，若後續能配合申請離尖峰電價差的方案，每年預計需採購大量的綠電來實現套利，這將推動表後儲能市場的發展。

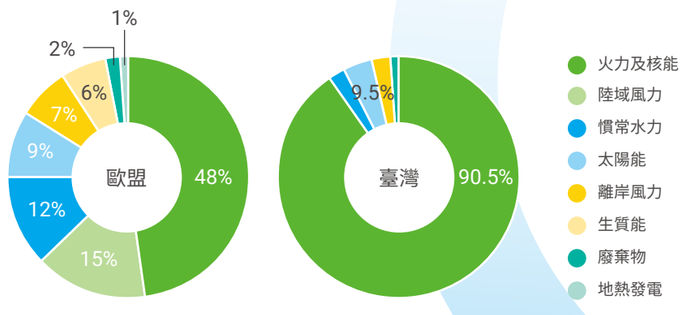
### 2024 年度標準型表燈時間電價 vs. 再生能源平均躉購成本（單位：新臺幣 / 度）




## 歐盟 2023 年再生能源發電已過半，CPPA 簽署容量持續增長

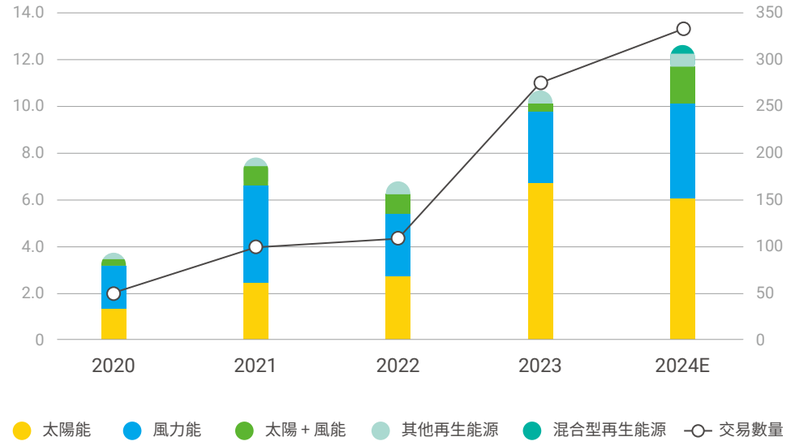
為了環境保護及永續發展，歐盟可再生能源發電能力正以前所未有的速度增長。根據國際能源署（International Energy Agency，IEA）的年度報告，2023 年再生能源占歐盟總能源生產的 51.7%。相比之下，臺灣再生能源僅占比 9.5%，產量遠低於國內所需的能源。長遠來看，氫能、天然氣以及碳捕捉技術仍需依賴進口，而歐盟可能成為臺灣潛在重要的合作夥伴之一。

### 2023 年歐盟與臺灣能源產量分布及占比（單位： %）




依布魯塞爾的能源交易平臺 RE-Source 統計，歐洲（包括英國）2024 上半年已簽署 145 筆企業購電協定，創下了成交數量的新紀錄，較 2023 年同期的 94 筆增長 54%，相當於簽署了 10.6 GW 的裝置容量。其中，太陽能成交量為陸域與離岸風能的兩倍，大約 5.9 GW。安永統計，2024 年近 12 個月歐洲簽約的 PPA 數量不包含公用事業購電交易可達 323 筆，裝置容量超過 12 GW 。

### 歐洲 26 國 2020 至 2024 年（預計）簽署的裝置容量（單位：GW）

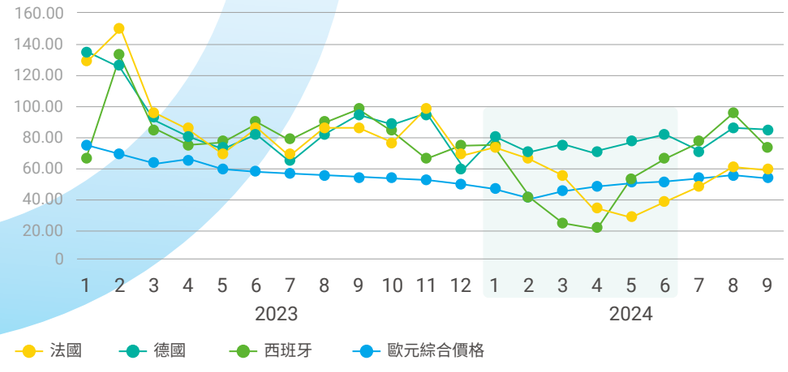



## 再生能源間歇性過剩，歐洲綠電批發頻繁出現「負電價」

由於再生能源電力過剩，歐洲電力供需的不平衡程度逐漸提高，德國、西班牙和法國在 2024 上半年分別出現長達 142 小時、160 小時和 233 小時的負電價。其中，西班牙即時用電批發均價跌至每兆瓦時（Megawatt hour，MWh）40 歐元以下，較去年同期下降 56%，達到歷史最低，德國和法國也呈現相同的趨勢。

歐盟報導指出，為了減少依賴俄羅斯天然氣，歐洲大量投資綠色基礎設施。2024 上半年較去年同期風能和太陽能總發電量增加約 12.7%；截至 2023 年，太陽能已安裝的裝置容量則達 256 GW，較 2022 年 206 GW 增加 24.6%。由於部分時段電力的生產超過消耗，歐盟 CPPA 市場經歷了劇烈的價格波動，無疑增加了簽署長期購電協議的風險。相較之下，臺灣 CPPA 市場發展較為初期，售電業者仍面臨供應短缺、大額資本支出以及高於市場的融資利率等挑戰，但歐洲持續波動的綠電價格仍可作為對臺灣市場的警示，並彰顯出儲能對穩定綠電價格的重要性。

### 2023-2024 年 9 月即時用電批發均價 vs. 歐元綜合再生能源價格



## 結論

臺灣再生能源起步較晚，但產業發展快速，使得綠電需求日益增加，因此企業購電需求（CPPA）依舊相當熱絡，只是考量未來綠電市場的波動問題，中短期 CPPA 將更受歡迎。同時，政府為彌補低電價導致的虧損而於 2024 年調升用電價格、逐年降低綠電收購價格，並同時鬆綁太陽能供給相關法規，導致表後綠電交易及各種儲能套利的商業模式勢必加速開展。

由於歐洲綠電滲透率已經過半，為了管理買賣雙方潔淨能源的交易風險，長遠來看，需要建立更穩定、波動性較低的定價機制，預期未來短期 CPPA 的比例將增加。此外，長期儲能技術（如氫能） 結合風能或太陽能混合型 PPA（Hybrid PPA）將有助於解決電價波動的問題。歐洲的綠電交易發展歷程及模式可以作為臺灣的借鑑。

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安永能源與基礎建設產業成員，執業會計師及財政部促進民間參與公共建設專業人員資格。擔任企業財務顧問協助其進行投資與併購交易長達十年以上經驗，曾協助各類再生能源與儲能專案的投資評估。





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於安永財務交易支援服務部門曾參與投資併購各類再生能源與儲能專案。 加入財務管理諮詢服務前，曾於知名會計師事務所審計部門服務，擁有協助跨國企業於紐約證券交易所上市的經驗。

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# 綠色金融的浪潮：再生能源專案融資的挑戰與機遇

**馮熾煒** 安永財務管理諮詢服務股份有限公司 執行副總經理

**王紹安** 安永財務管理諮詢服務股份有限公司 協理

現今極端氣候事件正以驚人的頻率和強度席捲全球，從歐洲的熱浪到亞洲的洪水，無不昭示氣候變遷已成為人類須共同面對的嚴峻挑戰。科學家亦警告，如不採取緊急行動，氣候變遷將對人類社會和生態系統造成不可逆的損害。為了遏止全球暖化，減緩氣候變遷的衝擊，國際社會達成共識，必須加速能源轉型，並將經濟發展模式轉向低碳、永續的方向。

面對迫在眉睫的氣候危機，全球各國紛紛將目光投向能源轉型。傳統化石燃料所引發的溫室氣體排放是導致氣候變遷的元凶，因此，擺脫對化石燃料的依賴成為當務之急。在這場能源革命中，再生能源不僅因其潔淨、永續且具有分散式發電的潛力，能有效地大幅減少溫室氣體排放，更能進一步創造就業機會，刺激經濟成長，並提升能源供應的穩定性。隨著技術的進步和資金的投入，再生能源的競爭力日益提升，逐漸成為全球能源供應的主流。隨處可見的太陽能板、在廣袤的草原或海上轉動的風力渦輪機，這些景象正逐漸改變我們對能源的傳統認知。

## 臺歐攜手，共創綠色未來

臺灣與歐洲在再生能源領域的合作日益密切。歐洲作為全球再生能源發展的領頭羊，其豐富的經驗、先進的技術以及完善的產業鏈，為臺灣的能源轉型提供了寶貴的借鏡。而臺灣為了達到 2050 年淨零排放及碳中和的目標，政府也致力於加速發展淨零與能源轉型，為全球的綠色發展貢獻一份力量。

例如，丹麥的風力發電技術世界聞名，臺灣在引進丹麥的技術與經驗的同時，也積極培育本土的風電產業鏈，並在歐洲開發業者的協助下，成為亞洲離岸風電發展的領先國家之一，近年日韓相繼來台取經。此外，2024 年德國慕尼黑的歐洲智慧能源展（The Smarter E Europe 2024）中的 Intersolar Europe 太陽光電展會上，亦有臺歐業者簽署合作備忘錄，共同發展儲能與太陽能光電。透過與歐洲合作，臺灣不僅能獲得先進的技術，也能成為全球綠色供應鏈的一員。

## 再生能源的專案融資：挑戰與機遇並存

開發再生能源需要大量資金投入，以專案融資的方式向銀行貸款是籌措資金常見的方式。然而，再生能源的專案融資與傳統產業的融資相比，有其特別之處。

- **專案的特性**

  再生能源專案通常具有投資金額高、建設週期長、技術面複雜等特點；例如，一座大型離岸風電場的投資金額往往高達數百億元，且建設週期長達數年。此外，再生能源的發電量受自然條件影響較大，收益也相對較不穩定。這些特性都增加了還本付息的不確定性。

- **銀行的考量**

  而銀行在評估再生能源的專案融資時，除了關注專案的經濟效益外，還需要評估以下四個面向：

  » **開發商實力：**開發商的技術能力、財務狀況以及過往的開發經驗是銀行考量的重要因素。一個經驗豐富、財務穩健的開發商，更容易獲得銀行的信任。

  » **技術可行性：**專案的技術方案是否成熟、設備供應是否穩定、施工是否順利、專案的建造成本是否與原本預估相當，或發電效率及發電量是否有符合預期等，都直接影響專案的成功與否。

  » **政策風險：**政府的能源政策、補助政策等，都可能對專案的經濟效益產生影響。例如，躉購費率的調整、稅收政策的變化，都可能影響專案的收益。

  » **市場風險：**電力市場的波動可能導致電價下跌，影響專案的收益。例如，如果傳統能源價格大幅下降，再生能源的競爭力將受到挑戰；或市場短時間內新增太多參與者，收購報價可能因此下降。

- **銀行的因應措施**

  為了因應這些挑戰，銀行通常會採取以下措施：

  » **風險分擔：**與專案開發商、政府，或多家銀行共同承擔專案風險。例如，銀行可以要求專案開發商提供一定比率的自有資金、同時尋求多間融資銀行共同聯貸，或設定資金動用限制與要求備償專戶等。

  » **財務可行性評估：**針對不同類型的專案融資計畫，尋求第三方獨立機構如財務顧問公司建置財務模型，檢視專案的償債保障比率（Debt Service Coverage Ratio，DSCR）、利息保障倍數（Times Interest Earned，TIE），或試算不同參數情境下的還本付息結果等。藉由外部顧問的財務模型試算，可進一步提高銀行對於專案融資可行性的掌握。

  » **信用增強：**要求專案開發商提供信用增強措施，以提高專案的信用等級。例如，開發商可以提供抵押品或找母集團公司進行連帶保證擔保等方式。

## 政府的角色與支持

除了開發商和銀行，政府的角色也同等重要。政府的支持政策，如提供穩定的躉購費率、融資保證、稅務優惠等，能有效降低專案的投資風險，吸引更多資金投入再生能源產業。此外，政府還能藉由制定相關法規，完善市場機制，為再生能源產業的發展創造良好的經商環境。

## 未來展望

隨著全球對綠色能源的需求日益增長，以及各國政府對再生能源的支持力度不斷加大，再生能源產業將迎來前所未有的發展機遇。

- **技術面：**相關技術持續改良與突破，將可降低再生能源的成本，提高其競爭力。
- **金融面：**金融機構將開發更多適合再生能源專案的金融產品，以滿足不同投資者的需求。
- **執行面：**更多國際合作將促進再生能源技術的轉移和共享，加速全球能源轉型的步伐。

在這個綠色轉型的時代，臺灣與歐洲合作將為雙方帶來更多機會與益處。透過技術交流、資金合作，相信再生能源產業將成為引領未來發展的重要引擎。

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熾煒目前為安永台灣能源與資源產業負責人，多年來在美國、中國、臺灣為客戶提供一系列的評價諮詢與模型建構服務，其中涵蓋併購交易、財務報導、財務可行、銀行融資、專案投標等相關用途。熾煒同時為臺灣評價準則委員會委員，具備特許金融分析師（CFA）及美國鑑價師協會頒發的資深鑑價師（ASA）資格。




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紹安於安永台灣擔任企業財務顧問超過七年，擁有為大型和中型跨國企業客戶提供財務盡職調查、評價、模型與經濟諮詢服務的豐富經驗；這些客戶涵蓋可再生能源、綜合電信服務、金融服務、製造業、科技、化學、保險和消費品等行業。紹安亦曾協助包含太陽能與儲能等再生能源專案之投資評估以及專案融資。

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# 臺灣未來永續綠色稅制政策的發展與產業應有的因應策略

**林宜賢** 安永聯合會計師事務所 國際及併購重組稅務諮詢 移轉訂價及供應鏈稅務諮詢服務 執業會計師

綠色稅制政策是影響企業永續發展策略的政府財政引擎，包括租稅優惠和租稅成本兩個面向，租稅優惠主要在鼓勵綠色投資行為以及綠色產品、生產流程和技術的創新，租稅成本則是基於「污染者付費原則」，讓環境污染成本由污染者承擔，並反映在其商品和服務的價格中污染者因受到懲罰造成其獲利能力降低，而碳費或碳稅就是綠色租稅成本的一種類型。隨著世界各國政府致力於減少排放和環境影響，他們越來越多地轉向財政政策來激勵實現這些目標的進展，這些稅制政策的目的不僅是為了阻止對環境有害的實務行為，而且是為了產生可再投資於永續措施和達成政策目標的收入。

世界各國政府陸續承諾於 2025 年達到淨零碳排的目標時，如何制定「綠色稅制」以鼓勵產業投資於節能減碳技術與新能源開發，已經是最重要的產業發展政策，讓達成淨零碳排目標的手段不僅處罰高碳排的企業，也應採用鼓勵方式讓企業投資節能減碳技術與開發新能源。應該以政府公定碳價來課徵「碳費」或「碳稅」？或者建立適當的「碳排交易平臺」用市場機制來決定碳價？甚至是否對高碳排的進口貨品課徵「碳關稅」？這些都是在設計綠色稅制政策的重要課題。

收取碳稅的國家包含了法國、愛爾蘭、加拿大、新加坡、日本、北歐五國等，這些國家同時也有碳排交易系統以市場機制決定碳價，屬於碳稅（懲罰性政策）與碳權（鼓勵性政策）雙軌制，實行碳稅的政府多由財政部負責執行，全國統一課徵稅收與統籌分配運用財政收入，包含稽徵程序、稅負減免優惠、設置各種節能減碳與綠電發展的基礎建設基金等。

臺灣的永續綠色稅收政策仍在不斷發展當中，而《氣候變遷因應法》於 2023 年 2 月 15 日頒布。該法案最關鍵的政策是徵收「碳費」，由環境部向高碳排的企業收取碳費並成立氣候基金，用於發展節能減碳設施、開發綠能、補助產業轉型為低碳排製程等措施上。

此外，臺灣碳權交易所於 2023 年 8 月 7 日成立，旨在提供碳諮詢服務和碳交易平臺。由於臺灣政府尚未完成強制性總量管制與交易（Cap and Trade）以產生碳權，但依據「溫室氣體自願排放減量專案管理辦法」，企業可在此平臺申請碳權認證或刊登碳權交易資訊，凡通過相關機構認證的碳權，即可在臺灣碳權交易所上進行交易或進行碳費抵換（Carbon Fee Offset）。

環境部於 2024 年 10 月 7 日召開碳費審議委員會，將每噸碳價格定為新臺幣 300 元，將來會分階段逐步調升，符合「自主減量計畫」的企業可以適用優惠費率 A 案新臺幣 50 元或 B 案新臺幣 100 元，根據《碳費收費辦法》第 3 條規定：碳費徵收對象之排放源為「全場之直接排放」（範疇一）及使用「電力之間接排放」（範疇二），初步徵收對象將涵蓋年排放量超過 2 萬 5 千公噸 $CO_2$ 當量以上的電力業、燃氣供應業和製造業，受到碳費徵收的企業將於 2026 年 5 月正式申報支付於 2025 年碳排量的碳費，但是企業必須從 2025 年開始每月將應付碳排負債準備提列入帳，因此其財務報表獲利表現從 2025 年期初就開始受到衝擊。

臺灣政府有關租稅優惠的法規制定在產業創新條例，第 10 條之 1 投資抵減已於 2024 年 12 月 31 日屆期，為利產業因應全球淨零排放趨勢，促進投資新創事業，強化公司關鍵技術，經濟部產業發展署於 2024 年 10 月 5 日起預告產業創新條例部分條文修正草案。為配合全球減碳趨勢與我國 2050 淨零排放目標，第 10 條之 1 增訂節能減碳項目，運用租稅優惠促進積極投資綠色產業，將現行適用投資支出金額上限新臺幣 10 億元提高至 18 億元，以期產業多投資節能減碳設備，加速數位與淨零雙軸轉型，施行期限延長至 2029 年 12 月 31 日。而此修正草案在 2024 年底尚未被國會（立法院）通過。

永續性綠色稅制的模式既多樣化又快速發展，反映了每個司法管轄區獨特的環境優先事項和經濟條件。這種多樣性為跨多個地區營運的企業帶來了重大挑戰，因為它們必須因應一系列複雜且不斷變化的租稅優惠、處罰和報告義務。因此臺灣政府在制定「綠色租稅政策」的範圍，不應該只限於碳定價機制，例如：碳費、碳稅、碳權與碳排交易系統，或僅提供資本支出的投資抵減，而必須更廣泛設計各種「綠色課稅措施」與「綠色租稅優惠」。

綠色課稅措施就是政府以綠色稅收作為財政收入來源，同時也是一項工具性政策，對各種產品、服務和流程徵稅以鼓勵或抑制消費。同時，政府對某些符合條件的產品、用途或納稅人提供此類稅收的豁免，例如以下所列示：

- 能源－對傳統電力、化石燃料和天然氣課稅
- 水資源－對用水量和排放量課稅
- 污染－對空氣、化學物質、土壤和廢水課稅
- 塑膠和包裝－擴大生產者被徵稅的義務
- 循環經濟－提供電子廢棄物的掩埋、回收和返回的稅負減免或退稅

綠色租稅優惠是推動永續綠色產業投資的重要政府計畫，一般可分為以下三類：

1. 減少能源消耗－投資節能製造設備和綠色建築物
2. 使用替代或再生資源－永續性研發活動、電動車和充電基礎設施、碳捕獲和儲存
3. 鼓勵科技創新－新技術、減排與能源節約

許多計畫包含多種要素，並且是三種類型的混合，例如稅額扣抵、現金補助和綠色貸款，均是常用的措施。

隨著綠色租稅政策格局的不斷擴大和進化，公司稅務職能部門和財務、法務顧問、採購、供應鏈等其他職能部門的利益相關者密切合作，將扮演相當重要的角色以確保其公司不僅遵守新法規，而且也利用法規來推動永續發展目的，並實現淨零排放和其他環境目標。

臺灣跨國企業在受到國內碳費以及國外碳關稅與各種綠色稅制的多重壓力下，建議必須建立以下八項因應策略：

### 1. 資訊蒐集

開始搜集的資訊包括各國市場碳價格、產品碳排含量、產品重量、關務資訊（原產地、稅則分類、完稅價格）。

### 2. 內外部利益相關者參與

公司內部組織的利益相關者應該合作，例如稅務、財務、法務、採購、關務與永續發展部門，而且合作範圍要需要涵蓋外部多元的供應商與客戶。

### 3. 組織與流程改造

企業必須重新建立部門與功能以及相關的作業流程，並且各自負責應執行的資訊蒐集與進行交換，企業各部門應積極和環境保護主管機關、稅務機關與進出口海關溝通。

### 4. 製造成本與產品定價

當和供應商與客戶進行採購與銷售價格談判時，必須考慮額外的綠色租稅成本，碳費與碳關稅的成本勢必嚴重影響供應鏈結構、商業活動及投資決策。

### 5. 遵循法規之合約擬定

為了處理碳費與碳關稅申報納稅，資訊提供以及額外成本資料搜集工作將面臨很大的挑戰，而且與供應商及客戶商業合約條件必須重新協商。

### 6. 風險管理

廣泛而巨額的碳費與碳關稅可預期會導致供應鏈中的貿易商從事低報逃漏碳費或碳關稅的風險，企業必須提升風險管理的層級，並對供應商與客戶進行盡職調查。

### 7. 企業營運模式的調整

企業的營運模式將受到額外應考慮議題的影響，例如歐盟碳邊境調整機制、森林砍伐、出口管制以及國際運輸安全等議題，因此必須修改現行經營模式，以調適隨時變動的供應鏈。

### 8. 申報資料的正確性

應繳納碳費或碳關稅或各種綠色稅負的企業必須遵行法規，正確申報相關資料，並從可信賴的供應商取得正確的資訊，以提交申報與繳納碳關稅，例如：原產地、稅則分類、碳含量、產品價值與重量、以及在其他管轄區之供應商已支付碳稅金額等。

企業在面臨淨零碳排時代的來臨，若能妥善計畫與執行以上八項因應策略，企業將能夠在全球供應鏈快速變革下維持競爭力並永續發展。

Disclaimer: The views reflected in this article are the views of the author and do not necessarily reflect the views of the global EY organization or its member firms.



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林宜賢為安永台灣國際及併購重組稅務諮詢服務、移轉訂價服務負責人，為臺灣大學會計學士，並取得美國紐約大學管理碩士及荷蘭萊登大學法學院國際租稅進階碩士。其專業經驗不但用於為企業進行國際稅務諮詢，亦於國稅局、大學院校和跨國企業教授國際稅收和移轉訂價，並負責國際財政文獻局的編輯及臺灣稅法發展動向報導。

他運用稅務相關的經驗，發表許多與國際租稅及反避稅條款有關之學術論文與專案報告，分享個人洞悉，促進業界對全球稅法的認識及瞭解。亦為財政部培訓學院的國際稅務講師，並擔任中華經濟研究院專案研究顧問。

EU ropean Economic & Trade OFFICE 歐洲經貿辦事處



# 「Fit for 55 」套案

## 歐盟如何推動再生能源的發展

**古力哲** 歐洲經貿辦事處 處長

隨著全球面臨前所未有的氣候變遷，其對生物多樣性、人類健康及經濟活動的影響日益嚴重，歐盟將綠色轉型列為核心優先事項之一，並計畫在全球其他地區之前實現氣候中和目標。為確保到 2050 年歐盟排放的溫室氣體（GHG）少於其吸收量，歐盟於 2020 年通過了《歐洲綠色政綱》，並在此框架下制定了一系列政策措施。這些舉措使歐盟成為全球綠色轉型的領導者之一。

為進一步實現其環保承諾，歐洲議會及理事會於 2023 年通過了“Fit for 55”立法套案（名稱源自於歐盟 2030 年前溫室氣體排放減少至少 55% 的目標）。此套案不僅將更高的減排目標納入法律，還明確規劃了行動重點，包括：改革碳排放交易系統（ETS）；降低運輸和建築領域的排放；改善土地使用與林業管理目標；通過碳邊境調整機制（CBAM）處理境外碳排放問題；設立社會氣候基金以協助最脆弱群體；促進航空及海運業採用更清潔的燃料；減少甲烷排放；提升汽車二氧化碳排放標準；修訂能源稅制；提高能源效率，並為再生能源的使用設立具體行業目標。

“Fit for 55”套案預計將大幅促進歐洲及其他地區再生能源的部署與發展。以下是該政策中主要元素如何推動再生能源進步的具體闡述：

### 1. 排放交易系統（ETS）

歐盟碳排放交易系統（ETS）自 2005 年啟動，是一個基於限額與交易的碳市場，也是歐盟減少排放的關鍵工具。透過設置溫室氣體排放總量的上限，並逐年降低此限額，歐盟得以有效控制並減少排放量。企業可獲得或購買排放配額，並可自由交易，而價格則透過「市場穩定儲備」進行調控。“Fit for 55”不僅進一步降低排放上限，還逐步取消對部分行業的免費配額，並擴展 ETS 適用範圍至海運、公路和航空運輸等領域。這些改革將使碳排放成本提高，相對降低再生能源的價格，進一步激勵採用再生能源。

### 2. 社會氣候基金（SCF）

SCF 的設立主要在於緩解綠色轉型對弱勢家庭、小型企業和交通用戶的社會影響。同時，基金也間接促進了再生能源的普及。歐盟鼓勵各成員國利用該基金，投資於提高能源效率及翻新建築，從而直接促進清潔能源的採用，例如潔淨供暖系統和低排放交通工具。

### 3. 碳邊境調整機制（CBAM）

CBAM 旨在防止因歐盟減排努力，而出現生產外移至環保政策相對寬鬆的國家，或進口高碳排產品增加的情況。該機制鼓勵企業投資於再生能源，避免生產外移；同時促使出口至歐盟的國家採用低碳生產方式。更重要的是，CBAM 可激勵非歐盟國家制定支持再生能源的政策，以降低 CBAM 帶來的額外成本。

### 4. 土地使用、土地變更與林業（LULUCF）

LULUCF 法規要求歐盟減少土地與林業相關的碳排放並增加碳吸收。此政策在“Fit for 55”中進一步強化，透過鼓勵永續林業發展，不僅增加碳封存，還有助於提供生物質等可再生能源來源。該法規也保護碳封存潛力高的地區，推動再生能源在環境衝擊較低的土地上的部署。

### 5. 汽車與貨車

歐盟道路運輸占其運輸排放的 71%。新法規要求 2030 年及以後逐步降低汽車和貨車的排放量，並設置 2035 年新車零排放目標。同時，規定主要道路每 60 公里需安裝充電站，這將直接提升電動車等再生能源驅動車輛的需求。

### 6. 甲烷排放

甲烷排放占全球總排放量的 19%（按質量計算，僅次於二氧化碳），其中 19% 源於能源產業，特別是化石燃料的燃燒。根據“Fit for 55”法案的新規定，自 2024 年 5 月起，歐盟要求能源行業必須監測並報告其甲烷排放，且需由獨立機構進行審查。此外，還規定必須立即實施強制性洩漏檢測及減排措施，以有效降低甲烷排放量。這些政策將顯著增加化石燃料發電設施的運營成本，從而推動能源產業向再生能源的方向轉型。

### 7. ReFuelEU 法規

航空和海運分別占歐盟運輸排放的 14.4% 和 13.5%。為應對這一挑戰，ReFuelEU 法規要求歐盟機場的航空燃料供應商逐步提高永續燃料的使用比例，目標是在 2030 年達到 6%，到 2050 年提升至至少 70%。此外，該法規規定歐盟機場需配備必要的基礎設施，以支持永續燃料的供應、儲存和補充。同時，歐洲港口靠泊的總噸位超過 5,000 噸的船舶，需在 2025 年前減少 2% 的溫室氣體排放，在 2040 年前減少 31%，並在 2050 年前實現 80% 的減排目標。此外，停泊船舶必須連接岸電系統以減少污染物排放。ReFuelEU 法規不僅為歐盟居民提供更加環保的交通選擇，還將促進創新和投資，推動永續燃料（包括再生燃料）的生產和應用，從而加速能源系統的綠色轉型。

### 8. 能源稅收（ETD）

“Fit for 55”法案還涵蓋了能源稅收指令（ETD）的修訂，旨在讓不同能源產品的稅率更準確地反映其對環境的影響，從而有效引導企業選擇更環保的再生能源，助力實現綠色轉型目標。

### 9. 綠色建築

建築物約占歐盟能源相關溫室氣體排放的 36%。為提升建築的永續性，歐盟規定住宅和非住宅建築須在 2035 年前將主要能源消耗減少至少 20%。此外，新法規要求在適當且可行的情況下，所有建築必須安裝太陽能系統，並配備充電設施。這一政策將大幅推動再生能源的應用，特別是太陽能的普及與發展。

## 歐盟與台灣的合作契機

歐盟的“Fit for 55”不僅間接推動了再生能源的部署與發展，還明確設定了目標，要求 2030 年前歐盟能源組合中的再生能源比例提升至 42.5%。再生能源被歐盟視為“重大公共利益”，未來將加速再生能源項目的許可程序，涵蓋範圍包括生物燃料、熱泵、太陽能、水力、風能、潮汐能以及地熱能等多種形式。歐盟堅信，向更清潔能源的過渡是實現氣候中和的關鍵前提，這對於減緩全球暖化及其可能帶來的災難性後果至關重要。

台灣是歐盟實現碳中和目標的重要夥伴。與歐盟相似，台灣也深刻認識到立即採取行動的必要性，並積極實施相關政策以兌現氣候承諾。目前，歐盟已成為台灣最大的外國直接投資來源，投資重點主要集中於離岸風電領域。台灣與歐盟在再生能源領域的合作潛力正處於高峰。抓住這一機遇，深化雙方在再生能源應用與減排方面的合作，不僅有助於強化彼此間的夥伴關係，更能為遏制地球快速暖化作出積極貢獻。







## 作者

### 谷力哲

**歐洲經貿辦事處處長**

谷力哲（Lutz Güllner）先生於 2024 年 9 月 1 日就任歐洲經貿辦事處處長。谷處長為歐盟外交機構歐盟對外事務部（EEAS）資深職業外交官，專精於經貿易關係以及安全議題。

在擔任現職前，谷處長為歐盟對外事務部資訊完整與對抗外來資訊操縱和干擾處處長，負責處理虛假訊息與外來資訊操縱和干擾（FIMI）相關的議題。

從 2003 至 2017 年間，谷處長於歐盟執委會貿易總署擔任多項職務，負責歐盟與美國以及歐盟與俄羅斯的雙邊關係、溝通交流與貿易政策規劃等事務。

在 2009 至 2010 年間，谷處長擔任歐盟外交與安全政策高級代表艾希頓（Catherine Ashton）女士的發言人。

在 2003 年進入歐盟執委會任職前，谷處長在比利時布魯塞爾擔任公共事務顧問。

谷處長於柏林自由大學與巴黎政治學院取得政治科學與國際關係學位，並曾在多所大學教授歐盟外交事務，包含位於比利時布魯日的歐洲學院和東京大學。

谷處長 1971 年出生於德國慕尼黑，他已婚並育有三個孩子。



# 建構臺灣的離岸風電標準 — 以驗證穩固再生能源系統

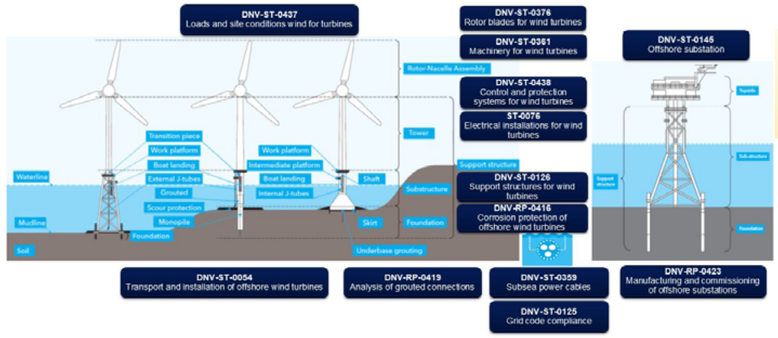
**Mark Richmond** DNV 臺灣區域總經理

根據 DNV 的《2023 年能源轉型展望》[1]，全球的風電裝置容量有望從 2022 年的 950 GW 增至本世紀中葉的 6500 GW。這一增幅匯集了各國所新增的裝置容量目標—而臺灣近期之目標是到 2025 年實現 5.6 GW 的裝置容量，並預計在 2035 年達到 20.6 GW。然而，要擴大離岸風電的規模，我們必須確保風電技術設計、製造、安裝和營運的穩固和安全。

DNV 自成立之始即與客戶合作並幫助技術發展，我們編制和定義新的標準，並先後發表了超過 40 份服務文件（包括服務規範、標準和推薦作法），涵蓋離岸風電、陸域風電、潮汐發電和太陽能等。

DNV 參與了幾乎所有台灣離岸風場的專案驗證，憑藉我們在離岸風電專案驗證方面的豐富經驗，持續與開發商合作確保離岸風場的安全和營運品質。我們針對離岸風場的開發有專案驗證 DNV-SE-0190[2]，其中涵蓋了一系列的具體技術審核與驗證，包括：

- 特定場址的環境條件驗證
- 設計基礎驗證
- 綜合結構系統的設計驗證
- 支撐結構、變電站、電力電纜和風力發電機的製造檢驗
- 運輸和安裝檢驗
- 試運轉見證




DNV 的固定式風機的標準與建議實務做法

DNV 針對風場中的資產，包括風機、水下基礎、變電站、電纜和控制站，提供嚴謹且全面的審查，其中考慮了如土壤條件、海氣象等所有相關因素。對於希望在這快速成長的市場中取得領先地位的再生能源公司，驗證是一項關鍵性工具，獲得驗證不僅顯現開發商努力解決影響其專案的挑戰因素的意願，亦有助於證明自身能力及鞏固利害關係人的信心。

## DNV 在台的專案驗證經驗

自 2020 年以來，DNV 團隊在裝置容量共 1.2GW 的海龍離岸風電專案的開發方面扮演了重要角色， 我們從最初的設計基礎階段到製造流程皆參與其中，目前，DNV 專家正針對海上運輸和安裝的複雜環節進行嚴謹的審查。

在整個專案中，DNV 團隊提供的獨立審查協助確保該專案符合所有必要的安全、績效和監管標準，並能克服一系列可能延緩或阻礙專案進度的技術和運輸障礙，而這對於開發商的融資來說至關重要，也是保障資金到位和推進建設的關鍵。

除了海龍專案外，DNV 亦正在進行風睿能源（SRE）旗下位於苗栗海上的海盛 4（Formosa 4）專案驗證，當前的驗證階段位於設計基礎和設計審查，而我們對設計的全面審查可確保 SRE 在開發流程的早期鑑別並解決任何潛在的風險或工程挑戰，為專案的長遠發展奠定基礎，而我們也將持續在往後的開發階段提供專業知識和支援，確保風場在各方面都得到了品質、安全和效率的提升。

## 工廠製造驗證

除了專案驗證之外，DNV 與開發商及台灣本土供應商合作，根據再生能源工廠製造評估標準 DNV-SE-0436[3] 來提升本土供應商的製造品質，以支持政府的國產化和供應鏈發展目標。此服務主要是向供應商提供資格驗證，向利害關係人證明此供應商具備製造風機水下基礎和變電站所需材料的能力。此驗證除可顯著提高當地製造商在全球市場上的知名度和競爭力，亦能增強開發商對當地製造商品質的信心。

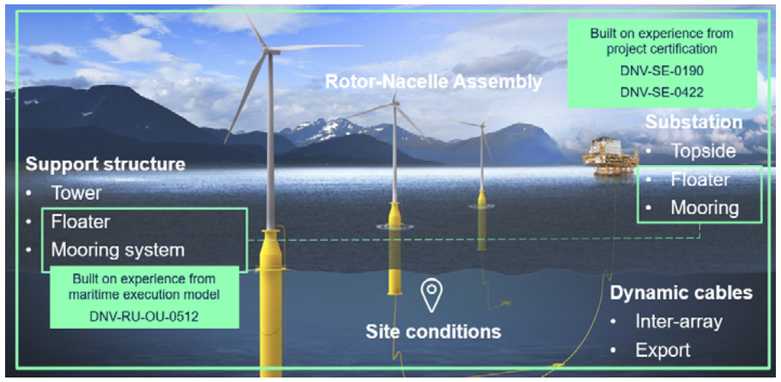
DNV 與臺灣本土供應商合作開展現場檢驗和文件審查，以確保其達到作為離岸風電產業供應鏈一環的要求，並針對需要改善的方面提出建議。對於有經驗的供應商，DNV 將根據 DNV-SE-0436 中規定的程序提出改進建議，並將協助其獲得驗證，增強該供應商在全球供應鏈中的競爭力；對於經驗不足的供應商，DNV 將為其建立進入供應鏈所需的能力提供指導，主要著重於製造品質管理和國際標準合規方面，而這將有助於這些供應商逐步滿足離岸風電專案的各項要求。

2024 年，DNV 首次核發工廠製造證書，認可四家台灣本土製造工廠在離岸風機水下基礎及鋼結構產品製造方面的能力。這四家工廠通過了依據 DNV-SE-0436: 2022-09 進行的品質管理檢查、文件審查及現場稽核，證實其能夠符合 DNV 標準中嚴格的要求、認證規範以及作業指導。

## 新興浮式風電的機會

在首批浮式離岸風電的示範專案獲得成功後，全球的浮式離岸風電產業正趨於商用化，據 DNV 分析師預測，到 2050 年，浮式風電的總裝置容量將達到 270 GW。

目前臺灣除固定式離岸風場持續增長外，也將逐步開發新興的浮式離岸風電市場。DNV 在浮式風電發展初期就積極投入技術研究，我們在浮式離岸風電的專業知識包括制訂技術要求及發佈全球首個浮式離岸風電標準，同時 DNV 團隊亦於全球完成了約 50 個浮式離岸風場的專案驗證，我們的 DNV-SE-0422[4] 標準為浮式離岸風電專案提供完整的驗證服務，涵蓋專案完整生命週期，包括概念設計、基本設計、營運中驗證，以及浮式風機、浮式風場和相關組件（如船體、系泊纜繩和壓載系統）的原型和型式驗證。




DNV 提供從葉片到整體浮式結構的驗證服務並涵蓋整個生命週期

## 未來展望與實踐

臺灣目前擁有多個離岸風場，而這些專案對於臺灣實現各種再生能源目標來說至關重要，包括 2050 年淨零排放、在 2026 年至 2035 年期間新增 15GW 的海上風電裝置容量，及為實現到 2030 年 40% 的出口產品由綠色能源驅動的政策目標。在此背景下，臺灣必須加強綠色能源的供應，且正如經濟部所說，須確保離岸風場按計劃併網，而嚴謹的專案驗證流程將能協助開發商應對臺灣獨特環境下固定和浮式離岸風電專案的挑戰，且 DNV 的工廠驗證亦將成為臺灣達成再生能源目標的一大利器，除能提高本土製造商的製造能力外，也能確保他們為參與全球競爭做好準備。

在計畫於 2050 年達成 40 GW 到 55 GW 的風電裝置容量的目標下，開發商、本土供應商與國際專業機構如 DNV 的合作對於克服臺灣離岸風場的挑戰尤為重要。作為穩固再生能源系統的基礎，未來 DNV 將持續提供驗證服務及技術支援，以支持臺灣滿足未來綠電的高需求。

[1] https://www.dnv.com/energy/standards-guidelines/dnv-se-0190-project-certification-of-wind-power-plants/
[2] https://www.dnv.com/energy-transition-outlook/
[3] https://www.dnv.com/energy/standards-guidelines/dnv-se-0436-shop-approval-in-renewable-energy/
[4] https://www.dnv.com/energy/standards-guidelines/dnv-se-0422-certification-of-floating-wind-turbines/










## 作者

Mark Richmond

**DNV**

**臺灣區域總經理**


作為 DNV 臺灣區域總經理，Mark 在臺北的 DNV 再生能源驗證團隊中發揮著不可或缺的作用。在 DNV 任職期間，他參與了多個離岸風電專案的管理工作，其中包括臺灣的兩個大型海上風電場。他在海洋氣象和載重方面也擁有豐富的經驗，審查了臺灣絕大多數的海洋氣象條件，並為 DNV 在該地的專案進行獨立載重評估。

### 教育背景

University of Strathclyde/Cranfield University - EngD, Renewable Energy Marine Structures CDT

Swansea University - MSc, Mechanical Engineering, and Bachelor of Engineering (B.Eng.), Aerospace, Aeronautical and Astronautical Engineering

Hitachi Energy



## 日立能源的太陽能創新方案：推動台灣邁向可持續能源的未來

台灣是一個資源有限且人口密度高的島嶼國家，其能源需求複雜且面臨重大挑戰。為了減少碳排放並逐步淘汰核能發電，台灣優先發展可再生能源，尤其是太陽能方面。政府設定了到 2025 年將太陽能發電能力從 2020 年的 5.8 GW 提升至 20 GW 的目標，顯示了台灣對再生能源轉型的承諾。太陽能預計將成為台灣能源結構的重要組成部分，使台灣成為全球可持續能源實踐的領先者。這一轉變符合全球向淨零排放的趨勢，台灣希望透過再生能源實現能源自給自足的目標。

作為全球能源領域的領導者，日立能源通過其在電網整合和能源基礎設施方面的創新與專業知識，在台灣的再生能源轉型中成為關鍵之一的角色。日立能源在幫助台灣實現其太陽能目標的同時，還有效解決了有限土地資源和極端天氣等獨特挑戰。其中 Grid-eXpand ™ Connect 系統已成為確保太陽能電站電力能高效併入電網的關鍵解決方案，提供模組化、可擴展的設計，滿足台灣快速增長的太陽能市場需求。

## 日立能源 Grid-eXpand ™ 技術在太陽能整合中的角色

日立能源推出的核心創新技術之一是 Grid-eXpand ™系統，該系統專注於模組化變電站，能夠從可再生能源中可靠地輸送和分配電力。這一系統的靈活性使其能夠整合各類型的太陽能專案，包含屋頂太陽能裝置乃至大型太陽能電站，同時最大限度地減少對大規模土木工程的需求。

傳統變電站需要大量的現場建設，這通常會導致項目延誤和成本增加。相比之下，日立能源的 Grid-eXpand ™系統提供了預製化和模組化變電站，顯著減少了安裝時間和土木工程成本高達 50%。該系統的標準化模組設計確保了更快的部署速度，使太陽能項目比傳統設置更快上線。此外，系統中的 170 kV 氣體絕緣開關設備（GIS）將變電站的佔地面積減少了 25%，這使得它成為台灣魚塭和屋頂太陽能裝置等空間有限環境中的理想解決方案。



## 打造更智慧、更環保、更強大的電網

Grid-eXpand ™ Connect 系統是一種模組化設計，專門用來簡化太陽能板與現有電網之間的連接。它提供了管理可再生能源流的完整解決方案，確保太陽能所產生的電力能夠高效且穩定的傳輸到電網。在土地資源有限的台灣市場，這項技術顯得尤為重要。Grid-eXpand ™ Connect 系統的最大優勢之一在於，它能簡化從設計到調整的整個週期。系統的模組化和預製化設計支援快速部署和建設，大幅提升可再生能源的併網效率。此外，該系統的資產管理功能使其成為適合各種太陽能裝置的多功能解決方案。Grid-eXpand ™ Connect 系統還具有高度的適應性，在各種環境下提供全面保護，使其成為應對台灣多樣地理和環境挑戰的理想選擇。Grid-eXpand ™ Connect 系統旨在容納各種太陽能能量收集和傳輸配置，為台灣快速擴張的太陽能產業提供靈活解決方案。

## 向陽漁電共生的成功案例

作為台灣水產養殖業的領先企業之一，Sunny Rich 向陽集團與日立能源合作，將光伏（PV）能量發電技術整合到其漁場運營中。傳統上，台灣的魚場，特別是蝦養殖場，嚴重依賴進口水產品，但對本地生產的水產品需求不斷增長。小型家庭經營的魚場一直在努力滿足這一需求，但他們面臨著高昂的能源成本和有限的土地資源等挑戰，這限制了生產的增長。為了解決這些挑戰，向陽集團採用了創新的做法，將光伏發電整合到其養殖場運營中。透過採用日立能源的 Grid-eXpand ™ Connect 系統，該公司能夠安裝類似溫室的結構，這些結構不僅保護養殖場免受極端天氣的影響，還能支撐太陽能板的安裝。這種雙重用途的結構允許向陽在繼續進行水產養殖的同時，生產太陽能電力。所產生的能源可以用於養殖場的運營，從而降低能源成本，而多餘的能源可以出售給台灣電力公司，為公司帶來額外的收入 。

這一項目的成功促使向陽將這一配置進行擴大，該公司現在成為台灣其他漁場的模範。Grid-eXpand ™技術的整合使得向陽能夠更加可持續地運營，幫助台灣實現再生能源目標，同時支持本地食品生產。這種太陽能與水產養殖的協同效應展示了日立能源解決方案的多功能性和適應性 。



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## 數位化轉型與智能電網

除了實體解決方案外，日立能源還是數位電網技術的領導者。隨著台灣太陽能發電能力的增長，智能電網變得至關重要。智能電網利用數據優化能源分配，確保太陽能能高效地從發電場傳輸到需求量最大的地區。日立能源的數位變電站自動化系統（SAS）能夠即時監控和管理電網性能，增強了太陽能發電的可靠性，並減少了運營中的停機時間 。

這種數位化轉型還延伸至預測性維護，即對太陽能基礎設施進行持續監控，以預防故障的發生。預測性維護能夠降低長期運營成本，讓可再生能源與傳統性能源更具競爭力 。

## 日立能源於太陽能市場影響與未來發展方向

日立能源在台灣太陽能市場的參與是其全球策略的一部分。隨著全球各國制定更具侵略性的碳減排目標，對於可擴展且高效的太陽能解決方案的需求將持續增加。日立能源憑藉其在模組化變電站和智能電網技術方面的創新技術，處於引領這一趨勢的有利位置 。這些技術在台灣的成功應用為其他面臨土地資源限制的島國或地區提供了再生能源轉型的典範。

隨著台灣朝著 2025 年達成 20 GW 太陽能發電容量的目標邁進，日立能源始終站在前沿，提供解決方案應對台灣面臨的獨特能源挑戰。憑藉其模組化 Grid-eXpand ™ Connect 技術方案、智能電網解決方案及在可再生能源整合方面的專業知識，日立能源不僅是產品方案提供者，更是台灣邁向可持續能源未來的戰略合作夥伴。隨著全球太陽能市場的不斷擴展，台灣所學到的經驗與發展的技術將成為其他地區向可再生能源過渡的藍圖。日立能源對創新與可持續性的承諾確保了其將在未來多年內繼續作為再生能源行業的重要參與者 。





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台灣日立
永續能源

前身為 ABB Power Grids 電網事業群，ABB 於 1988 年在台灣成立，三十餘年不斷創新、精進。2020 年 7 月 1 日，日立集團和 ABB 共同成立新合資公司「日立 ABB 電網」，延續電網業務的營運成績，並做為台灣企業與日立 ABB 集團全球資源的連接橋樑，為客戶、員工和社會創造更多的價值，從 2021 年 12 月 1 日起正式更名為「台灣日立永續能源」。目前，全台約 132 位員工，營運據點分佈台北、台中、高雄。

憑藉在電力領域超過百年的經驗，日立永續能源擁有領先業界的技術，能滿足各產業的電力需求。我們為台灣產業，如半導體、電子、石化、電力、風力發電、再生能源、鋼鐵、造紙、營建等，提供穩健的軟、硬體技術對策。解決方案包含：電網系統自動化、電網整合、變壓器產品與高壓產品暨服務、離岸風電、太陽能、儲能解決方案。

日立永續能源是台灣企業的長期事業夥伴，以高效完善的營運系統，為客戶提供高品質服務並贏得信賴。專業、熱情、積極的工作態度，使我們成為客戶的最佳選擇與策略夥伴。日立永續能源陪伴客戶成長，協助客戶在競爭激烈的國際舞台上保有競爭優勢。在台灣，有專屬的日立永續能源專業工程師隨時待命，為客戶提供無微不至的技術服務，確保客戶端的產線運作不間斷。



# 電池儲能系統是電力系統效率和彈性的關鍵

在大多數現代電力系統中，要實現我們的淨零排放目標，就需要大幅增加再生能源（主要是風能和太陽能）的使用。台灣的 2050 年淨零排放路徑和戰略目標是 40-80 GW 太陽能和 50 GW 離岸風電裝置容量，這將相當於 2023 年全部發電量（in TWh）和當前發電量（in GW）的兩倍。間歇性的、不可調度的可再生能源發電的日益普及，不僅增加了對系統靈活性的需求，以平衡供需的變化，還增加了對容量儲備的需求，以確保持續幾個小時的供應安全，特別是在需求高峰或突發事件的情況下。此外，它對我們的電網在運作管理和電網穩定性方面都帶來了一些挑戰。簡而言之，由於再生能源的可預測性和可調度性較低，對靈活性和容量儲備的需求都增加了。

傳統上，靈活性和容量儲備是由 CCGT 複循環機組等快速反應資源提供的。

電池儲能系統 (BESS) 為這種基於化石燃料的資源提供了選擇性的替代品。雖然早期它們的作用主要集中在輔助服務，但如今先進的 BESS 旨在在不同的時間常數上堆疊多種功能，從而幫助

1. 平衡供需，
2. 確保供應安全，以及
3. 優化電網管理，保障電網容量和穩定性。

當我們所有人都在努力實現淨零排放時，它們在獲取和評估寶貴的零碳電力方面發揮著關鍵作用，否則這些電力將面臨被削減的風險（以經濟和環境成本為代價），並替代重要但目前基於化石燃料的靈活性和容量資源。

BESS 正在變得越來越有競爭力，以與天然氣調峰類似的成本提供峰值功率。在美國，招標上已經使用 ESS 而不是天然氣調峰。在歐盟，由於能源成本增加，任何基於電池儲存的功能現在都比以前更有利可圖。

在台灣，Saft 在營運或正在建造的 10 個公用事業規模項目中最大的安裝項目是位於宜蘭並由 Foxwell 營運的 172 MWh 電池儲能。該系統提供動態調節儲備（dReg），提供短時間的功率突發以穩定電網。它還支援其他頻率應用和可再生能源的整合。

## 透過 ESS 進行能量轉移

儲存的主要作用包括吸收超出消耗或超出電網傳輸能力的再生能源，並在需要時將這些能量注入電網。該功能在技術上被描述為“能量轉移”，通常透過 2 小時至 4 小時的儲存系統來實現，並具有更長放電持續時間的趨勢。大多數系統都按照日常充電 / 放電方案運作（例如，在白天對太陽能充電，在晚上進行放電），但有些系統每天會進行相當於兩個放電週期的操作。

BESS 的主要報酬模式是在生產充足和市場價格較低的時期儲存電力，並在價格較高時（通常是在傍晚高峰期）出售電力。該業務可以直接與風力或太陽能相結合，在這種情況下，營運商只需推遲將其部分產品出售到市場價格較高的時期即可——這是美國普遍的營運和創收模式，由美國政府設定的稅收激勵措施所驅動。BESS 也可以作為「獨立」資產運行，從電網吸收和儲存能量並將能量重新注入電網。在這種情況下，套利通常與其他輔助服務（即初級和次級頻率調節）相結合——這是歐洲主要的報酬模式。

在避免限電方面，價值創造得到了增強：不僅能源按市場價格定價而不是損失，而且透過避免替代成本以及可能的電網增強而實現了額外的節省。目前，我們看到再生能源的削減量正在穩步增加，而社會損失的再生能源的經濟和環境成本相對較高且不斷增加。

然而，這種補償機制是基於商業市場，因此面臨市場價格波動的風險，從投資者的角度來看，風險相對較高。

## 供應安全

特別在歐洲，最近的能源危機暴露了電力系統在限制時期的脆弱性，這與其對（通常是進口的）天然氣的依賴有關。我們現在看到許多國家正在建立容量市場，以確保即使在罕見的高峰期（例如寒冷的冬季夜晚）和緊急情況下也能以可承受的成本獲得電力。容量市場所需的典型持續時間為 2 小時，而且時間週期有增加的趨勢。

對於儲存營運商來說，容量市場是一個有趣的收入增加因素，因為合約是多年期的，價格通常穩定，確保投資者獲得安全和可預測的收入。

## 電網服務

除了供電功能的平衡和安全外，BESS 在調頻和電壓支援輔助服務方面的貢獻和競爭力也已確立，並被輸配電網營運商視為確保電力系統電壓和頻率穩定的生命線。BESS 在多個國家的頻率調節市場上佔據了相當大的份額。

然而，變動再生能源（風能、太陽能）的不斷普及給電網營運商帶來了新的挑戰，特別是電網擁塞問題。它們與風力和太陽能發電機的不同位置分佈有關，與傳統發電廠相比，它們的分佈更加分散，但再生能源發電的「熱點」位於電網拓撲中未預見到的地方。一個突出的例子是德國北部沿海地區風能的大量發電，這使得電網營運商面臨著將能源輸送到大多數耗電產業所在的南部地區的挑戰。從短期來看，這種情況會導致限電，並增加調度管理和饋電管理的成本。例如，在過去幾年中，它們增加了 1 倍。從長遠來看，對電網基礎設施的投資不可避免，從而增加了社區的整體能源成本。

最先進的 BESS 提供技術上可靠的解決方案，可透過單一解決方案解決各種問題。它們可以透過在電網瓶頸之前儲存能量來暫時緩解輸電線路的壓力，從而避免限電。更重要的是，它們可以減少或推遲用於電網強固和電網穩定性的基礎設施之密集資本支出，例如現有線路的重新佈線或對新線路和其他慣性支撐的投資。

## ESS 最新進展

目前，我們看到能量密度、系統架構和數位化的趨勢不斷增強。

如今，運行兩小時 (200 MWh) 或四小時 (400 MWh) 的 100 MW 系統已很常見，我們開始看到 GW 級別的單機安裝。為了適應這一點，需要更多的 ESS 機櫃。因此，安裝空間正成為越來越大的挑戰，因為電池機櫃需要連接到電力轉換系統 (PCS) 和變壓器，並安裝在安全距離處，以便進行維護。那麼，我們如何考慮節省空間的需要，同時確保最高等級的安全性？

自 2012 年第一個鋰離子電池貨櫃離開 Saft 工廠以來，單一 20 呎貨櫃的能量密度已增加 6 倍，從 500 kWh 增至如今的 3.3 MWh，到 2026 年將達到 5.1 MWh。雖然更大尺寸和密度的鋰離子電池正在實現這樣的密度，但工程方面的挑戰在於開發和鑑定高性能電池系統解決方案，這些解決方案可以運送到世界上任何地方，並保證可以達到 15 到 20 年的內部可靠運作。

Saft 最新一代的鋰離子 BESS，稱為 Intensium ® Shift+，在標準 ISO 20 呎貨櫃中提供 3.3 MWh 的儲存容量。該產品在 Saft 工廠嚴格的品質控制下製造，並由內部工程團隊開發、測試和鑑定，以整合

- 從模組級到系統級的專有控制電子設備，
- 專利的空氣冷卻系統可確保所有 136 個電池模組在極端環境條件下的溫度均勻性，並具有高能源效率，即 HVAC 的低消耗，
- 基於風險分析的安全方法，在多個層面實施冗餘、電子和實體安全屏障，以管理火災和爆炸等風險。Saft 的安全方法是全面性的，在產品層面、現場安裝層面以及操作人員和消防員方面都已設想最壞的情境下來考量。

完整 BESS 的佔地面積也受到將多個機櫃的直流電轉換為交流電所需的電源轉換系統 (PCS) 的尺寸和數量的影響。Saft 的控制系統可準確管理多達 8 個平行貨櫃，即單一 PCS 上可連接超過 25 MWh 的電量。這允許基於市場上最大的、成本優化的 PCS 系統來設計系統架構。

貨櫃構件能量密度的提高，與先進的控制、先進的安全功能和節省空間的即插即用安裝相結合，正在改變遊戲規則。總而言之，這意味著該行業現在可以提供公用事業規模的 BESS，進行長達 8 小時的能量轉移，同時將佔地面積和安裝時間減半。

## 提高數位化程度

現代 BESS 也變得越來越數位化，支援即時系統管理以及人工智慧和機器學習的使用。這提高了效率，同時減少了停機時間和維護成本。與雲端的資料介面可遠端監控關鍵績效指標 (KPIs) 並控制系統的所有運作參數。

例如，借助 Saft 的 I-Sight 系統，數位雲端連接平台可以即時監控效能，以確保 BESS 交付符合合約指定的 KPI。該平台將警告任何偏差，以便立即採取行動。人工智慧可以實現預測性維護功能，透過對系統收集和儲存的大量資料中的微弱訊號進行檢測和徹底解釋，進一步減少停機時間、成本和安全風險。

借助遠端診斷和重新配置工具，現在無需人員親至現場處理即可解決大多數問題。

## 結論

現在潮流正在轉變。根據台灣 2050 年淨零排放路徑與策略，電能儲存將是實施低碳能源的必要項目之一。隨著我們整合越來越多的再生能源，電池儲能系統不僅是基於石化基的靈活性的有效替代品，而且是在需要時捕獲、儲存和部署能源的關鍵推動者。否則，我們就有浪費能源的風險——而能源是當今世界日益寶貴的資源。

Saft 在全球範圍內安裝或規劃的 BESS 容量超過 4.5 GWh，其中重要項目位於台灣、菲律賓、澳大利亞和紐西蘭，Saft 為項目開發商提供從案件啟動到安裝和使用壽命結束的電池儲能系統專業知識。我們的品牌代表著可靠、保證的高性能產品解決方案、卓越的專案執行和數十年的可靠服務，從而確保長壽命電池資產的投資回報。




## 作者

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Saft 致力於為相關工業提供技術領先的電池解決方案，從設計開發到生產、定制和服務提供。一個世紀以來，使用壽命不斷延長的 Saft 電池和系統為我們的客戶提供了關鍵安全應用、備用電源和推進功能。我們技術具有創新、安全、可靠的特點，在海陸空和太空領域展現了卓越性能。Saft 為各行業和智能城市提供動力，與此同時，亦提供關鍵備用功能在北極圈和撒哈拉沙漠這種偏遠和惡劣的環境中發揮作用。Saft 是 TotalEnergies 的全資子公司，TotalEnergies 是一家在全球生產和銷售能源的綜合能源公司：石油和生物燃料、天然氣和綠色氣體、再生能源和電力。

我們為世界提供動力。 www.saft.com




## ABB 助攻綠氫價值鏈推動永續未來

國際能源總署（IEA）將綠氫視為全球能源轉型難題的重要關鍵。隨著公司和政府尋求可擴展的解決方案來應對氣候變化，綠氫的需求正在逐漸擴大。

## 優化綠氫生產的電力

電解是一個能源密集的過程。電解槽將水和電能轉化為氫氣的效率直接影響綠色氫氣生產的整體成本和永續性。電解槽需要直流電源才能運作，然而太陽能和風能等再生能源產生的電力通常是交流電。整流器技術透過將波動的電網電壓和頻率轉換為穩定的直流電源來彌補中間的差距，確保向電解槽提供一致、高效的電力。

由此產生的氫氣可以以液化形式的壓縮氫氣形式有效儲存，或轉化為氨或甲醇，以便稍後使用，例如在再生能源不可用時用於提供電力的燃料電池。從本質上講，綠氫能充當一種電池，儲存再生能源，並透過清潔能源的高滲透率實現電網穩定。

除了整流器之外，變速驅動器在綠色氫氣生產中也發揮著重要作用，可以為水處理廠中的幫浦提供動力，將超純水輸送到電解槽陣列並控制集中式水冷卻系統。它們也用於高效運行壓縮機，製冷和液化產生的氫氣。

現今的驅動技術提供精確的扭矩和速度控制，以優化馬達的性能和效率，並具有消除電源波動的能力，並有助於克服太陽能或風力發電電網的間歇性。

有了整流器和變速驅動器支援的綠氫，再生能源採用的最大障礙之一 — 間歇性 — 就變得更容易管理。因此，綠氫不僅是一種儲存和移動能源的機制，而且是再生能源起飛的驅動力。



## 全球實際案例

ABB 正在為 HyPilot 計畫提供關鍵電力技術，該專案是位於挪威羅加蘭，由 Gassco 營運的 Kårstø 天然氣加工廠所正在進行的綠氫試點計畫。 ABB 為其 1 兆瓦貨櫃式 PEM 電解槽提供關鍵的供電技術，包括低諧波絕緣柵雙極電晶體整流器和 DC-DC 轉換器將調節電解槽的電力供應，確保電力穩定且有效率地流向電解槽。

ABB 綠氫專案協作的另一個例子來自瑞典的 SoutH2Port 設施。 ABB 與 Skyborn 和 Lhyfe 合作，致力於在這個大型綠氫生產計畫中將前者的離岸風電場與後者的陸上電解槽連接起來。此次合作凸顯了 ABB 對清潔能源整合的承諾，確保再生能源發電和綠色氫氣生產之間建立可靠、高效的連接。

另一個案例為 ABB 向日本長崎碳中和園區提供先進的晶閘管整流器系統，氫氣設備開發商三菱重工正在該園區開發能源脫碳技術研發基地中心。

ABB 閘流管整流器可確保滿載運轉時約 99% 的功率轉換效率，從而最大限度地減少能源浪費並降低穩定氫氣生產的整體成本。為 SOEC 電解槽提供 200 千瓦 (kW) 整流器系統凸顯了 ABB 對支援能源轉型新技術開發的承諾。






## 作者

**ABB Ltd.**

ABB 是技術領先的電力及自動化跨國工程公司，致力於推進永續社會及資源效率的未來。透過專業工程知識與軟體結合的解決方案，致力優化製造、移動、供電及運行方式。承襲超過 140 年的卓越成就， ABB 全球 105,000 位優秀員工，承諾持續推動加速工業轉型的創新科技。 按照所服務的客戶和行業組織，ABB 分為四個事業群。ABB 全球有 7 個研究中心，是我們開展研究和技術的重鎮，我們承諾繼續投資研發技術，以不斷地創新為我們企業的核心價值。ABB 所擁有的領先技術，帶動了現代社會的基礎，從革命性的高壓直流輸電技術、輪船渦輪增壓推進器。如今，ABB 更為工業馬達和變頻器、工業機器人的領導者之一。 ABB 1988 年於台灣正式設立分公司。經過多年拓展，ABB 台灣的員工分佈於台北、高雄及台中。在地化的團隊促進與台灣各產業的互動及多元發展，確立堅實的夥伴關係。ABB 在台灣特設立展示、訓練中心及運籌管理中心，都是專為有效的服務客戶所設立的，提供高效率專案工程管理、客戶培訓及準時交付產品及系統，使其客戶在提升工業生產效能的同時，更能降低對環境的影響。



# 攜手台灣加速低碳氫產業鏈發展

**高鴻鈞** 台灣德國萊因技術監護顧問股份有限公司 能源環保處總經理

人類正進入第四次能源轉型，重點在於用再生能源取代化石燃料，將高排碳的骯髒能源轉型為清潔能源。同樣，做為清淨能源的氫能， 積極目標是將高排碳的灰氫轉型為清潔氫或低碳氫。

台灣已於 2022 年 3 月正式公布「台灣 2050 淨零排放路徑及策略總說明」，其中「能源轉型」及「十二項關鍵戰略」包含零碳技術的「氫能」及負碳技術的「碳補捉、利用及儲存 (CCUS)」兩項戰略。因此基於國際經驗及近年台灣的氫能專案推動現況，德國萊因於 2023 年 11 月完成「台灣工業低碳氫產業經營挑戰研究」，提出以下七項加速推動的關鍵策略：

## 1. 加速低碳氫的生產：轉型藍氫與綠氫

氫能產業鏈發展必須能減碳，才有意義。其中，綠氫是利用剩餘再生能源電力 ( 如太陽光電、風力發電 )，透過水電解槽系統將水分解而獲得氫氣。而藍氫則是利用傳統化石燃料製氫 ( 灰氫 )，並結合碳捕捉、利用與封存（CCUS）的碳中和技術，以減少碳排放。其中由於碳利用技術發展及產能有限，所以藍氫仍以產能規模較大的地質碳封存方式為主。目前台灣每年生產 30 至 40 萬噸的高排碳灰氫，亟待早日轉型為低碳氫，而且還要因應未來氫需求量增大時的挑戰，因此建議台灣必須加速轉型藍氫和綠氫的發展，才能減碳。

此外，低碳氫產業鏈從一次能源、製氫、儲氫、輸氫、加氫、用氫等六大階段，都必須兼顧三大關鍵因素 - 氫安全、氫脫碳、氫經濟效益 ( 圖 1)，缺一不可。台灣必須同步掌握此三大關鍵因素，才能正確與國際的氫能永續發展接軌。

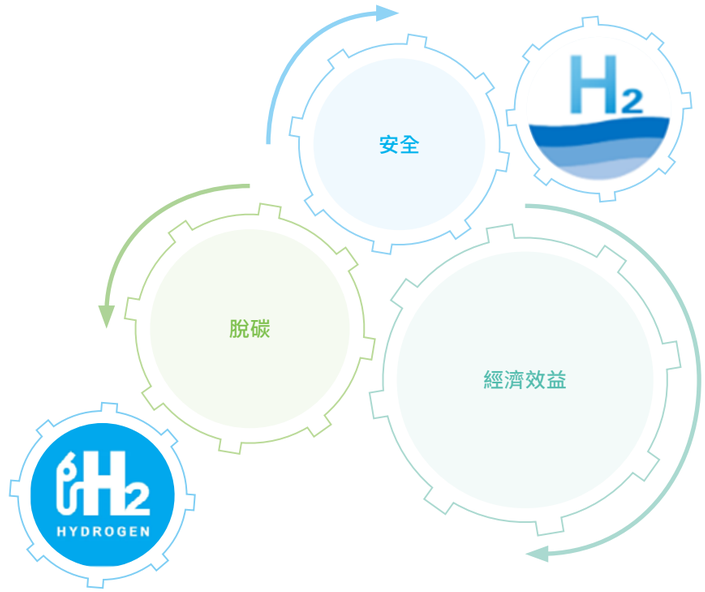



Figure 1 Three Key Factors for the Successful Development of the Hydrogen Industry Chain

## 2. 借鑑國際氫能發展經驗：政府主導落實國家氫能戰略

根據國際能源署（IEA）於 2023 年發布的《全球氫能評論》報告，全球已有 41 個國家制定了氫能發展策略，其中包括歐盟、德國、美國、日本及澳洲等。以德國國家氫能戰略 2023 年更新版為例 ( 圖 2)，德國加速 2023 至 2030 年推動計畫且增大低碳氫生產目標至 10 GW，並布局四大行動綱要：

1. 確保充足的低碳氫氣供應 ( 包括自主生產及進口 )
2. 發展高效率的低碳氫基礎設施 ( 包括德國氫能基礎設施、歐洲輸氫管網 、第三國進口低碳氫的基礎設施 )
3. 實施氫氣應用 ( 包括工業、交通、發電、建築供熱 )
4. 創造有效的框架條件 ( 規劃和審核程序、永續標準和認證、加強研究、創新和專業人員訓練 )

### 德國國家氫能戰略 2023 年更新版行動綱要

- 確保充足的低碳氫氣供應
- 發展高效率的低碳氫基礎設施
- 實施氫氣應用
- 創造有效的框架條件

2023 — 2024 — 2026 — 2030 →

近程 | 中程 | 遠程

圖 2 德國國家氫能戰略 2023 年更新版

所以氫脫碳及氫經濟效益就是國家氫能戰略的重點，然而因為涉及地緣政治、資源分配、獎助機制、工程技術、社會公民接受度等因素，所以低碳氫產業鏈必須由政府跨部門整合主導才能成功。因此建議台灣的「氫能國家隊」能仿效德國作法滾動修正台灣的氫能戰略，並深入主導推動氫能戰略，落實創造有利條件，並排除目標障礙。

## 3. 把握藍氫優勢的發展契機

藍氫與綠氫的優缺點見仁見智，在併行發展之際，必須根據各國的地域特色條件進行評估，規劃出各自最適化的發展路徑及策略。而氫氣成本取決於使用能源的技術、供需量變化、不同市場的能源價格波動等因素。IEA 於 2023 年《全球氫能評論》估算 2021 年藍氫生產成本約為每公斤 1.5 至 3.6 美元，綠氫價格則為每公斤 3.4 至 12 美元，綠氫是藍氫生產成本的 2.3 至 3.3 倍。雖然綠氫是最終實現淨零排放的理想技術，但由於生產成本、土地空間、技術要求都很高，因此綠氫的全面大規模生產尚需時日。相較之下，藍氫的技術成熟、可大規模商業化且成本相對較低，因此 CCS 發展較快的美國、加拿大、英國、挪威等國家皆積極推動藍氫產業，並認為藍氫是推動綠氫的催化劑，也是邁向綠氫目標的橋樑。

台灣目前在碳封存技術上具有成熟的地下儲氣能力，特別是台灣中油公司在使用耗竭的天然油氣田和封閉地質構造作為儲氣窖方面擁有豐富經驗。台灣陸地上的封閉構造以及沿海區域和台灣海峽的開放鹽水層擁有高達 600 億噸的二氧化碳封存潛力，遠遠超過 2050 年台灣封存目標 4000 萬噸之所需。因此台灣具備藍氫產業鏈的雄厚條件，建議優先把握台灣藍氫產業鏈的發展契機，提升藍氫的自主產氫能力、能源安全及基礎設施韌性，不僅能確保氫能產業鏈短期內的減碳效果，還能為長期的綠氫發展奠定基礎。

## 4. 以獎助機制促進健全的氫能產業鏈

氫能產業鏈的供需兩端必須同步地平衡發展，尤其企業投資必須能夠獲利，產業才能穩定健全。韓國制定的「氫經濟促進及氫安全管理法」氫能專法即為一例，一步到位完善氫能產業鏈相關配套措施，值得台灣借鏡。因此建議台灣主管機關更積極增修氫安全、氫脫碳及氫經濟的相關法規，例如低碳氫工場、碳捕捉工場及碳封存場之變更地目的法規、產業鏈獎助機制 ( 如租稅抵減、定額補貼、價差合約、雙拍賣機制、永續多元評分等 ) 等，業者才能獲得開發許可，並有效降低經營成本及風險，提振經濟效益。促使企業信心大步投資，必須兼顧 ESG 發展，才能建構台灣健全的氫能產業鏈。

## 5. 建立低碳氫認證機制

為降低能效耗損、排碳機會及營運成本，低碳氫生產過程的能源轉換次數必須越少越好，而低碳氫的成本及價格又是氫經濟的核心，因此建議台灣主管機關與國際認證機構合作建立低碳氫認證機制 ( 圖 3 案例 )，促進合理的低碳氫價格，結合獎助機制，保證低碳氫的脫碳品質，創造低碳氫的充分誘因，促使台灣早日生產出價格合理的第一公噸低碳氫。

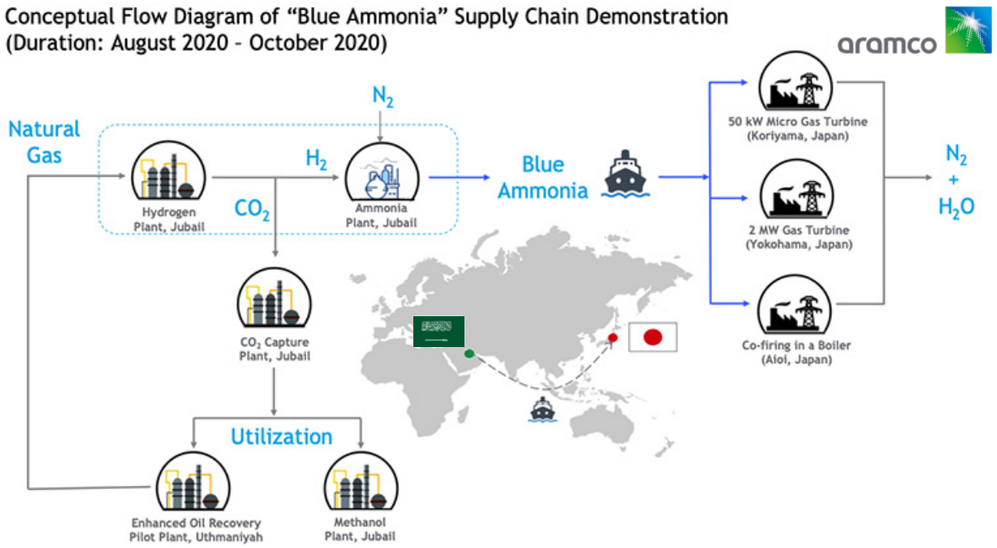



圖 3 Saudi Aramco 公司通過德國萊因的藍氫及藍氨認證的供應鏈示意圖

## 6. 落實安全風險管理而取得公民信任

為把握台灣藍氫產業鏈發展契機，必須兼顧突破關鍵技術及安全風險管理。例如在藍氫的地質碳封存場方面，除了目前「碳捕捉封存管理辦法 ( 草案 )」外，建議台灣依照國際標準 ISO 27914 強化碳封存場生命週期的風險評估、洩漏監測與地質封存驗證 ( 圖 4 案例 )，以確保技術安全性、減碳有效性及經營永續性，強化社會溝通，提振民眾對藍氫產業鏈的接受度與信任。

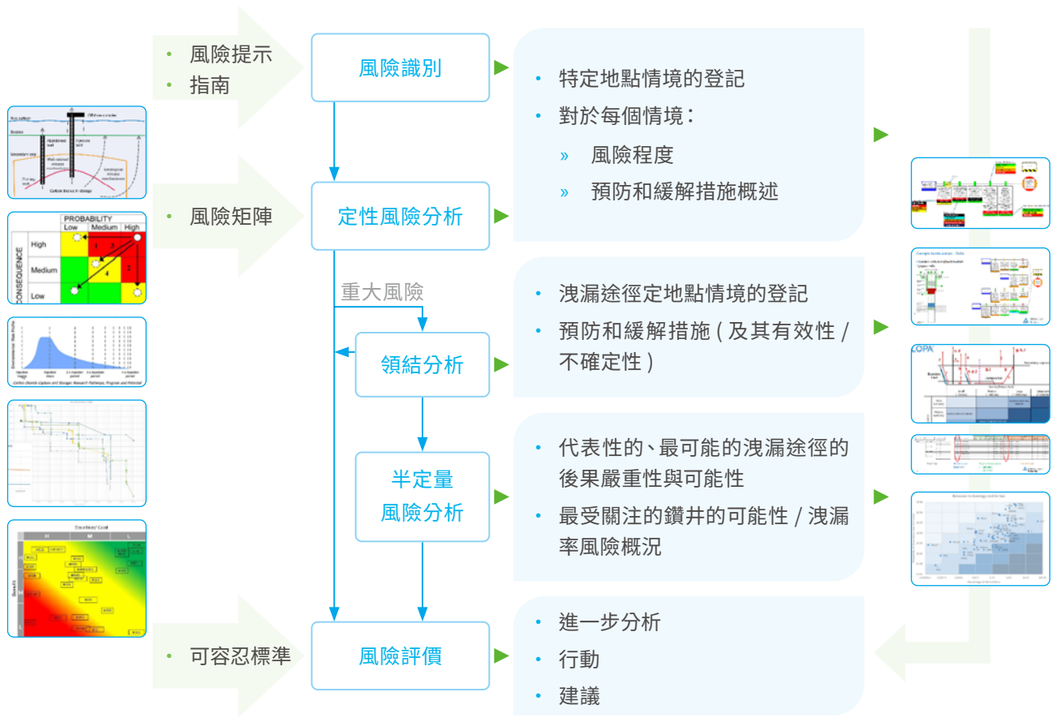



圖 4 德國萊因依據歐盟「2009/31/EC 地質碳封存指令」的碳封存場風險評估實例

## 7. 與國際合作氫谷驗證計畫

為減降低碳氫產業鏈發展的風險，歐盟的氫谷計畫建立不同特色條件的氫谷示範區進行驗證，例如德國有 14 個氫谷，計畫中包括評估氫氣優先使用者、低碳氫生產方法與資源分配，驗證最佳化輸氫方案，合理的投資公共資金，並確保民眾參與及接受度，最後整合氫谷資料庫提供串接氫谷網路。因此建議台灣與國際合作導入氫谷驗證計畫，持續精進低碳氫產業鏈的可行性、安全性及有效性。

德國萊因集團於 2021 年成立「氫能技術能力中心」，提供氫能價值鏈解決方案技術服務，圖 5 所示。



| 一次能源 | 製氫 | 儲氫 | 輸氫 | 供氫 | 終端用氫 |
|---|---|---|---|---|---|
| • 再生氫 (Power-To-X)<br>» 風電 / 太陽光電 ➡ 水電解系統製氫<br>• 低碳氫<br>» 天然氣重組製氫 ➡ 碳捕捉 / 儲存 / 利用<br>» 焦炭氣化製氫 ➡碳捕捉 / 儲存 / 利用<br>» 甲烷裂解製氫<br>» 其他製程低碳製氫 | | • 地面 / 地下儲槽<br>» LH2 ( 液態氫 )<br>» GH2 ( 氣態氫 )<br>» LOHC ( 液態有機 )<br>» 氨<br>» 合成氣 | • 長途管線<br>• 槽車<br>» LH2 ( 液態氫 )<br>» GH2 ( 氣態氫 )<br>» LOHC ( 液態有機 )<br>• 海上輪船 | • 天然氣混氫分輸管網<br>• 氫氣分輸管網<br>• 加氫站 | • X 原料<br>» 煉油<br>» 煉鋼廠 ( 鐵礦還原 )<br>» 合成氨 ( 化肥 )<br>» 半導體廠 (EUV 製程 )<br>» 工業原料 ( 氨、甲醇 )<br>• X 燃料<br>» 熱能 ( 供暖 )<br>» 發電 ( 燃氫氣輪機 / 鍋爐 )<br>» 交通 ( 燃料電池 / 汽車 / 巴士 / 火車 / 輪船 / 飛機 )<br>» 合成燃料 |

圖 5 德國萊因的氫能價值鏈解決方案





德國萊因在氫能領域，提供全面的氫能價值鏈解決方案，可協助在製氫、儲氫、輸氫、加氫、工業用氫、交通用氫、發電用氫、民生用氫等階段，實地驗證氫能產業鏈的氫安全、氫脫碳及氫經濟的成效，攜手加速台灣低碳氫產業與國際接軌及永續發展，並實現台灣 2050 年淨零排碳目標。



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專研石化、能源及環保產業領域有超過數十年經驗，負責大中華區能源及環保處及氫能技術能力中心，目前與德國總部等國際團隊致力於推動工業永續發展、淨零碳排技術、新能源應用、製程安全管理的輔導及認證工作。

BASELOAD POWER



# 地熱能源的優勢

**林義凱** 倍速羅得股份有限公司 資深地質師

在全球面對氣候變遷、能源短缺及環境污染等挑戰的背景下，發展可持續穩定供電且清潔的能源變得越來越重要。地熱能源為目前極具潛力的再生能源之一，其可做為基載電力獨特的優勢使其成為解決當前能源問題的重要選擇。作為地熱開發商，我們深切體認到地熱能源在台灣的潛力與挑戰。根據經濟部地質調查及礦業管理中心研究指出，目前台灣地熱蘊藏量約高達 40GW，且經濟部能源署亦於 113 年公布「地熱能探勘與開發許可及管理辦法」，針對地熱開發訂立場址規劃之邊界距離，避免各案場之間相互影響。然目前對於案場地熱井之間距與地下儲集層管理之議題習習相關，相信未來仍有討論的空間。政府現階段應該加大對地熱開發的投資，以促進再生能源的建設，實現淨零碳排的目標。

## 1. 穩定性與可靠性

相較於其他再生能源，地熱能源具有更高的穩定性，發電容量因素可達 95%，可作為良好的基載能源。由於地核的溫度高達攝氏 6,000° C，地下深度越深則溫度越高，甚至臺灣有些地區地溫梯度高達 80° C/ 公里，具有非常好的地熱資源 ( 圖一，以大屯山地區為例 )。這些熱量無論天氣如何變化，都能穩定地提供能源。這種穩定性使地熱能源成為可靠的基載電力來源，能夠有效彌補其他再生能源在穩定性方面的不足。



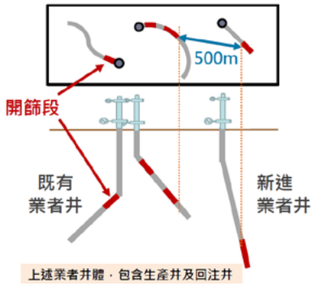
圖一 大屯山地區地熱資源

## 2. 低環境影響

地熱發電的過程中，二氧化碳的排放量非常低。地熱電廠的運行過程中，與化石燃料發電相比，碳足跡顯著降低 ( 圖二，倍速羅得冰島電廠 )。即使在最初的開發階段，地熱能源對環境的影響也比傳統能源要小。此外，地熱能源的開發還能減少對水資源的消耗，相較於水力發電，地熱發電對水資源的依賴性更低。目前，環境部亦針對地熱電廠的環評規定有所修改，將原本 10MW 以上電廠須經環評之規定提高至 50MW 以上電廠才須經環評審查。



圖二 倍速羅得公司於冰島的 Flúðir 電廠




圖三 規劃各案場之間井體距離 ( 摘自能源署，2023)

## 地熱開發與儲集層管理的關聯性

在地熱開發階段前期，最主要工作為地質調查與地熱模型建置等項目。在有初步概念模型後，遂進行鑽井驗證地熱資源。經確認地熱資源後，後續規畫電廠建置與開發。然地熱電廠的持續營運與否，將與地熱儲集層的管理與開發方式息息相關。此時，地熱儲集層的管理與模擬就非常重要。通常由於主管單位對其地下熱源的特性了解不足，以及在缺乏管理機制的情況下，進而開放多個開發商進駐。由於大家使用相同儲集層生產熱能而導致日後產能下降及該地地熱資源提早衰竭。另外，地熱流體的回注方式對地熱系統的永續利用亦至關重要，因為地熱系統大多是以裂隙為地下流體之通路。因此，若回注井位置設計不當，受限於土地限制，往往導致回注水太快流經地熱儲集層，造成生產井溫度冷卻，減少產能。目前國內原則上以生產井的地表投影距離約 500 公尺作為管理方式 ( 圖三，能源署公告資料 )，且地熱開發往往需要鑽定向井，目前針對用地補償機制也未有明確規範，若要加速地熱開發，須針對法規面進行檢討。

地熱儲集層管理面臨多項挑戰，建議可由以下幾個方面進行規劃：

### 1. 環境影響

地熱開發過程中，可能會導致地表以下的溫室氣體逸出、地下水位變化或噪音等問題。這些環境影響需要在開發前進行充分評估，並及早建立監測機制，以及在電廠開發與運行過程中加以監控。

### 2. 資源管理

隨著地熱資源的開發，必須進行有效的資源管理，以防止儲集層的過度開採導致資源枯竭。這需要對地熱流體的流量、溫度和壓力進行持續監測和調控，以確保資源的可持續性。

### 3. 經濟因素

地熱開發的初期成本高，並且需要長期的回報期，這對於投資者和開發商來說是一個挑戰。尤其是在資源評估和開發階段，需投入大量資金進行探勘和鑽井，這可能會影響項目的經濟可行性。因此，針對開發商財務狀況的評估，來給予探勘或開發權實屬必要。

### 4. 法規和政策

地熱資源的開發因為目前沒有地熱專法，所以在開發階段受到各種法律法規的約束，這些法規可能會影響開發的速度。且政策的不確定性會增加開發風險，並影響投資者的信心。綜合來看，地熱儲集層管理的挑戰涉及環境、技術、資源管理、經濟和法規等多方面，需要多方協作和綜合考量，以實現可持續的地熱能源開發。

## 結論

總結來說，地熱能源擁有穩定性發電、低環境影響以及促進地方經濟發展等諸多優勢，是未來能源發展的重要選擇。政府應該加大投資、政策支持和國際合作，推動地熱能源的快速發展，實現能源結構的優化和氣候目標的達成。只有通過產官學界的共同努力，才能在能源轉型的道路上取得成功，達成淨零碳排的目標。




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## 透過企業實現能源轉型

**Luuk van Heerde** Green Flash 執行長

## 光電和風能萬歲？

太陽和風：台灣擁有大量的太陽能與風能，產業正在逐漸大規模地採集這些資源。「大規模」意指光電和風電都需要龐大的基礎建設和投資，包括採集能源（風力發電場、太陽能發電場）和分配能源（電網容量和存取、儲存）。以這方面而言，並沒有節省時間和金錢的捷徑，這些都是世代相傳的事業。

上述再生能源唯一的問題是會讓受眾產生一種依賴性，且並非所有使用者都能適應這種新現況。這種依賴稱為「電力」。

## 勝者與敗者

在不久的將來，政府對於風力和太陽能等替代能源的重視很可能在台灣的業界形成一個兩級體系，贏家和輸家都很明顯。

贏家將會是較富裕的大型企業，以及大部分製造過程都依賴電力的中小企業。對他們來說，轉用綠色能源將是輕而易舉的事。對於那些品牌價值受到威脅的富裕公司而言，他們十分樂意支付環境成本，以確保自己的聲譽。使用有限能源，或只使用少量化石燃料驅動設備的中小企業，可以輕鬆管理新電力設備的有限成本、員工培訓和轉換新設備的停機時間。

輸家將會是嚴重依賴柴油和汽油驅動機器的中小企業，這些機器通常沒有實際的電力替代方案。有些設備是客製化和高度專業化的，因此更換成本昂貴。大規模的電力更換，例如更換整個機隊，可能會超出預算。

有些營運商在轉型為電動設備時，也會面臨一連串的營運挑戰，例如處理充電週期和停機時間，或是採用成本高昂的替代方案 ，即投資大量資金在複雜的電池交換設備上。

柴油發電機能在諸多領域中發揮作用，而電動設備卻無法提供替代方案。全台灣有數以萬計的柴油發電機被運用於現場發電或大型建築（如醫院和機場）的緊急備用電力需求，在經濟和技術上都沒有可行的替代品。我們也很難想像台灣武裝部隊在衝突期間乞求停火，以便為他們的電動戰鬥坦克充電，或是漁船拖著長長的延長線出海。

## 為中小企業續命

中小企業 （SME） 是台灣的經濟命脈。中小企業佔台灣 GDP 的一大部分，僱傭數百萬人。由於台灣的產品和零組件是全球供應鏈中不可或缺的一環，因此中小企業在維持台灣與全球接軌方面也扮演著重要的角色。許多這些企業都是傳統的小型公司，儘管表面新穎亮麗，根本上卻很可能是傳統的家族企業，以傳統價值觀及既定方法經營。

對於這些小型企業而言，轉型為更永續、低碳足跡的經營方式將是一個痛苦的過程。許多企業對此問題的認知有限，更重要的是，經營者看不到適用於自身的簡單補救措施。受大眾看好的離岸風力專案，與掙扎著尋找立即解決方案以滿足未來 ESG 需求的中小企業之間，兩者存在著巨大的落差。

有兩種因素將大大加劇此種分級化經濟落差的隱憂：優質胡蘿蔔的缺失，更強力的大棒的出現。

## 更強力的大棒：法規和罰款

我們都知曉胡蘿蔔和大棒的經典比喻：要打動某人，你需要一個激勵誘因—胡蘿蔔，以及對不服從者的懲罰—用大棒脅迫。

綠色措施過去只依賴大棒。強制實施的規則和法條需要花費金錢，會造成破壞，而且在很多情況下很難實施。多年來，我們依靠政府立法（法律、罰款、稅收）來說服用戶改用更永續的做法，方法是使污染替代方案變得難以接受且昂貴。

隨著 2050 年的臨近，社會很可能會出現某種恐慌。未來的政府很可能被迫收回前任政府雄心勃勃的主張和承諾，以及因選民失望而產生的所有負面政治後果。最有可能的結果是憑空出現一根更大的大棒，讓政府至少實現部分目標。

一系列針對傳統非再生能源使用者的新法規和懲罰性措施可能會隨之而來——這是一種對長期停留於理想化的綠色願景卻缺乏及時行動的本能反應。長期以承諾為主卻缺乏實質誘因的政策，其結果將導致以懲罰手段實現綠色轉型。

## 更強力的大棒：國際供應鏈施加的壓力

對於主要品牌而言，無意義的 ESG 策略已經變得太昂貴。越來越多消費者運用他們的購買力表態支持更永續的未來。在被揭發於印尼的血汗工廠雇傭童工後，運動用品製造商 Nike 花了十年才從影響中恢復。自此之後，全球企業瞭解到，他們再也不能將責任推卸給供應鏈，佯裝無知。

當全球企業採取行動，以確保分包商的作業方式符合品牌的核心價值與 ESG 承諾時，並不總是出於慈善或為了維護品牌形象：大多數歐洲企業也受到來自政府與股東日益增加的法律壓力，要求他們對供應鏈加以控管。

## 優質胡蘿蔔的缺失

好消息是，綠色措施越來越具有商業意義。它們變得更經濟、更靈活、且更容易實施。有了這麼多好的綠化選擇，企業更無法合理化自身的毫無作為。胡蘿蔔變得更大更容易消化。

然而，若要吸引企業邁向完善的永續實踐，可行的解決方案不僅要經濟實惠，還要實實在在。如果一個國家因為過時的法規而不允許銷售再生燃料，人民就很難在油箱中加滿這些環保燃料。

## 解決方案

對於許多企業來說，有一個既能增加胡蘿蔔又能減少大棒的解決方案：過渡性燃料。下一代過渡性燃料被設計成傳統礦物燃料的完美替代品，提供與現有設備無縫配合的便利性，並且不需要任何調整。例如， SAF（航空燃料的替代品）和 HVO（柴油的替代品）這類燃料以其易用性而聞名，它們可以以任何比例投入到任何現有的燃料儲存槽中，而不會造成任何干擾或導致性能下降。這些燃料的另一大優點是排放更潔淨：不僅一氧化碳、二氧化碳和氮氧化物更少，且不含硫，微粒物排放也大幅降低。

## 爭取時間

過渡性燃料的最大優勢是可以為使用者爭取時間。企業家可以利用這段時間來規劃長期過渡到電力系統的計劃，並為此建立必要的資本。這段額外的時間也可讓企業繼續以非常低的碳排放操作現有設備，直到機器的生命週期自然結束。

此優勢在很多方面都是合理的：柴油驅動的設備既耐用又昂貴。被電動機器取代的石化燃料機器通常不會被淘汰，而是轉售到二手市場。在大多數情況下，這些汙染嚴重的機器還會在地球的某個角落繼續運行數年。

當政府允許過渡性燃料進入市場時，它就買到了時間，而時間是最珍貴的商品。在一個瞬息萬變的時代，所有政府都必須平衡現代人和下一代人的福祉。過渡性燃料可讓政府有更多時間讓經濟適應新的現況，並完成所需的龐大基礎建設，以適應實際轉換為生產熱能和電力的再生能源。

## SAF

SAF，即永續航空燃料 ，是一項偉大的技術性中期解決方案。這種飛機燃料的有機替代品安全、易於實施（使用現有的設備和基礎設施），而且還能產生更清潔的排放。

不過，就近期而言，SAF 對於短期內的大規模應用來說應是不可行的。目前 SAF 的產量無法滿足全球大規模實施的需求，這就是目前只以少數比例混入傳統燃料的原因。它的價格高得令人望而卻步，而 SAF 的主要客戶 ，也就是航空公司， 是極少數著重燃料成本的企業範例之一。燃油價格的輕微上漲可在數週內導致整個航空公司倒閉。對航空公司來說，支付三倍的燃油費並不是一個選擇。

## HVO

HVO 是一種有機柴油燃料，其化學成分與一般柴油相同。HVO 是將脂肪和油在高溫下加氫處理（添加氫）而產生的，製作原理類似於加氫人造奶油。




目前，HVO 大多使用廢食用油 （UCO）以及食品和化妝品工業的廢棄產品，如棕櫚仁殘渣（PKR）和棕櫚油廠廢水 （POME），一種棕櫚油研磨過程產生的廢水生產。新類型的原料已經完成開發，並將大規模實施。未來的 HVO 很可能會從海藻、藻類、農業廢棄物和家庭廢棄物中生產。



HVO 可與普通柴油以任何比例混合，無需混合或攪拌（100% 混溶），這意味著 HVO 既可作為混合燃料，也可作為替代燃料。它的混合特性意味著使用者可以自由選擇加入 HVO 的比例，從而達到減少碳足跡的目的。使用 100% HVO 的柴油發動機可減少高達 94% 的碳足跡 — 接近碳中和。

HVO 的主要優勢之一是在全球範圍內生產，而且生產地點的數量正在大幅增加。這使得 HVO 的區域性採購成為可能，這意味著更短的供應線、更多的採購選擇、更低的價格和更低的運輸成本。

對台灣而言，HVO 再生柴油有許多額外的優點。與幾乎完全依賴中東生產的石油相比，從多個鄰近國家進行區域採購在戰略上更為安全，因為中東距離遙遠，航程途經多個潛在衝突地區，將引起許多安全考量。此外，持續進行的新原料研究也意味著台灣甚至有可能在國內生產 HVO。

HVO 已經存在了幾個世紀。它是一種久經考驗的柴油燃料，獲得所有主要柴油引擎製造商的認可和推廣，並獲得大多數歐盟政府的推廣。HVO 被各大品牌和全球企業廣泛使用。歐洲越來越多的加油站 （例如 Shell） 販售 HVO （100% 或混合） 供消費者使用。

## 生質柴油

生質柴油是另一種過渡性燃料，但在化學成分和應用方面與 SAF 和 HVO 差異顯著。生質柴油主要是一種混合燃料，可以少量添加到普通柴油中，以抵消部分碳足跡。有些發電機可以改裝為使用 100% 生物柴油，但這需要進行大規模的機械翻修，翻修後的發電機不能再使用普通柴油。

由於化學成分不同，生物柴油在炎熱潮濕的環境中會產生更多問題，例如保存期限有限、細菌污染和吸水等等。HVO 和 SAF 則沒有這些問題。

## 路障而非路線圖

我們公司 Green Flash 為了取得台灣 HVO 進口、儲存和銷售的許可，已經努力了超過十八個月，有時感覺就像是一場艱苦的戰鬥。主要的障礙源自 過時的標準和法律定義。根據石油管理法 （PAA），再生燃料在技術上不屬於 「石油 」產品，該法將石油定義為 「由原油所生產」，這種循環式的推理無濟於事。台灣的官僚體系向來對採取大膽舉措持保留態度。填寫現有表格上的選項是輕而易舉的事，但在現有的表格上增加新的選項，卻是一件困難的工作。

儘管政府審查和檢討現有法規總是個好主意，但現在不是為了一場理論辯論而擱置決策程序的時候。 台灣需要的是政府思維的轉變：一個新的關鍵績效指標，偏重於結果與行動。少一些不必要的會議 ，少一些表演性質的官僚作風，多一些具務實態度的政府官員，為解決跨部會問題而全力以赴。

## 透過企業精神實現能源轉型

SAF 將於明年在台灣推出。國營石油巨擘中油與政府自身部會 （交通部 / 民航局）花了一年多的努力才達成這個目標。主要原因在於行政流程上存在著一些挑戰。涉及的利益方眾多、層級複雜，回應時間長，且執行人員有時缺乏足夠的主動性和責任感，導致進度延誤。這意味著目前的再生燃料合規路線圖只適用於擁有無限資源和時間的大型企業，必要時可以等待數年。因此，預算有限的小型企業若想在台灣引進再生燃料，幾乎無法對台灣的淨零政策做出有意義的貢獻。

台灣持久不衰的經濟力量，來自其不屈不撓的企業家精神，以及對科技創新的渴求。如果我們無法在再生燃料領域賦予台灣當地企業家和小型企業能力，並協助他們實現過渡性燃料解決方案，將錯失當前重要的發展機會。

## 向歐洲看齊

台灣不需要追尋至天涯海角，許多成功實施再生燃料的典範近在眼前：在大多數歐洲國家，再生燃料都發展良好。歐盟國家提供了許多兼具胡蘿蔔與大棒的成功案例，值得我們借鑑。2023 年 6 月，歐盟委員會通過規則，規定混合燃料中生物燃料和沼氣的比例，可計入歐盟再生能源指令（Renewable Energy Directive）的交通再生能源目標。與此同時，歐盟生質燃料聯盟資料庫（2024 年）開放液態再生和可回收碳燃料交易的相關經濟經營者進行線上登記，以提高生質燃料的可追溯性，避免重複計算，並同時解決對欺詐的擔憂。不僅要有獎勵與懲戒，還要有使用兩者的明確規則。

平心而論，歐洲引進再生燃料的路程並非毫無顛簸。歐洲審計院（European Court of Auditors）發現，歐盟生物燃料政策缺乏穩定性，主要原因是永續性方面的挑戰，且大多數成員國尚未達到 2020 年的目標。然而，這也提供一個重要的啟示：**這些磨合期的問題並未妨礙歐洲國家允許私人企業開拓再生燃料市場**。HVO 和 SAF 在歐洲各地的生產、交易、銷售和使用都非常成功。這不僅為企業創造了綠色選擇，還產生了大量的重要數據，以及對需求、使用和挑戰的寶貴見解，同時也預防了數百萬噸的二氧化碳新排放量。

## 給予政府的建議

我們需要仔細草擬規則和法規，這點是無庸置疑的，然而，我們現在也需要採取行動。我們需要邊說邊做，在草擬更好的立法的同時，也設置一個沙盒計畫，讓新的舉措可以在此試驗和評估。

我們向台灣政府提出的建議不只是針對行政院和產業發展署，我們也希望看到相關部會根本上的改善，組織架構中從上至下對行動與對話的承諾。

1. **承認再生燃料對經濟的重要性**
   對目前妨礙台灣引進再生燃料的法規做出改善，以保障台灣經濟的利益。
2. **確認再生燃料對環境的重要性**
   將更潔淨的再生燃料列為環境部優先關注的事項，以保護台灣的環境和空氣品質。
3. **任命一位「再生燃料首長」（Renewable Fuel Tzar）**
   由一個人或一個部門擔任單點聯絡人，負責處理有關再生燃料的立法和許可問題。他們 / 它將有權要求政府組織及其部門負責履行其使命和官方職責。
4. **削減繁文縟節**
   授權所有相關政府部門在合理的時限內作出回應，並提供明確的答案和可行的建議。
5. **建立沙盒計畫**
   為台灣所有再生燃料設立為期兩年的即時豁免，以便在相關立法進行調整和面向未來的同時，開始引入必要的 ESG 措施，例如 HVO。

台灣擁有驚人的自我革新能力。且觀一些大規模實施的綠色運輸方案 （Youbike、捷運、高鐵、Gogoro），就知道台灣已經準備好，願意且有能力接受改變範式的解決方案，讓綠色燃料成為下一個成功範例。



### 作者

**Luuk van Heerde**
**Green Flash**
**執行長**

Green Flash 是在台引進 HVO 再生柴油的先驅，一家具有前瞻性的台灣企業。HVO 是傳統柴油的替代品，與現有的柴油引擎 100% 相容，且使用上不需要更換任何設備。HVO 燃燒更乾淨，煙塵微粒更少，廢氣排放量也更低。

企業能夠透過採用 HVO 再生柴油持續使用現有的柴油驅動設備，直到其自然生命週期結束，同時還能為一個更環保的地球做出重大貢獻。使用 HVO 的傳統柴油引擎可減少高達 90% 的碳足跡。

Green Flash 懷抱一個單純的使命：透過企業實現能源轉型。該公司的願景是推廣更環保的企業思維，並提供台灣企業實用、環保的解決方案。 為了達成這些長期目標，Green Flash 與教育工作者、企業家和政府組織合作，在台灣推動綠色燃料的意識，並為其架構一個更完善的系統。

Luuk van Heerde（阿姆斯特丹，1962 年）是國際品牌行銷公司 Look Right 的創辦人，也是 Green Flash 的執行長。他曾在歐洲和美國從事廣泛的媒體與傳播工作，目前在他的新家園台灣致力推廣永續燃料。

CRÉDIT AGRICOLE
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## 銀行業必須扮演台灣推動淨零目標的重要推手

### 羅弘伯 法商東方匯理銀行台北分行 執行長

“Working every day in the interest of our customers and society” 是法國農業信貸集團 Crédit Agricole Group，( 以總資產論，為世界第九大銀行 ) 所堅持的信念。東方匯理銀行 (Crédit Agricole CIB) 作為該集團旗下的企業與投資銀行分支，除協助國際資本市場協會 (International Capital Markets Association, ICMA) 訂定綠色債券原則 (Green Bond Principle)，用於供永續債券發行人遵守的自願性指引外，並共同發起赤道原則 (Equator Principles)，針對專案融資的環境和社會議題提供一套行業基準。

東方匯理銀行在台營運歷史可追溯至 1981 年。深耕台灣的東方匯理銀行，不僅致力於向本地企業和金融機構提供優質服務，並積極引進國際經驗，協助台灣發展。

遵循法國農業信貸集團全球的永續銀行與金融策略，東方匯理銀行台北分行也將支持台灣的永續發展納為企業責任。

這篇報告將分享我們在協助客戶與社會達成淨零目標的經驗與學習成果，並提供對於台灣達成其淨零目標的多項建議。

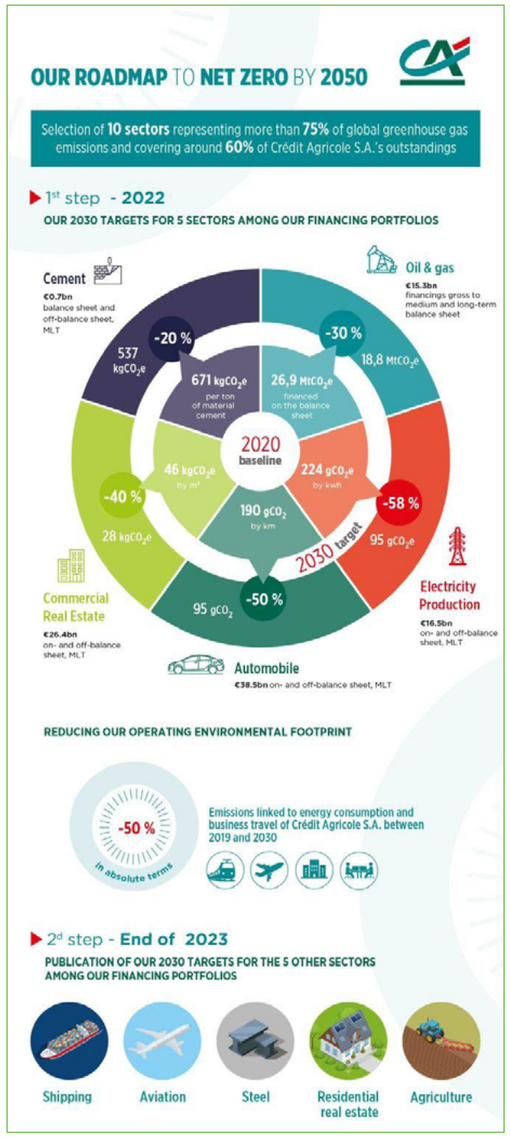
## 法國農業信貸集團氣候策略 - 可執行的淨零計畫

東方匯理銀行承諾在 2050 年實現淨零碳排放目標。有鑑於永續發展重要性日漸提高，本行並在 2000 年代成立永續部門。

東方匯理銀行的氣候策略奠基於以下三項主軸：

1. 大量融資與投資再生能源、低碳設施、乾淨技術和節能專案；
2. 協助所有客戶完成其社會責任和營運轉型；
3. 停止放款予新的化石燃料開採項目，並策略性地支持現有能源業客戶轉型，使該行業溫室氣體排放減少速率較國際能源總署 (International Energy Agency) 所定義的 2050 年淨零情境加快兩倍。

東方匯理銀行定期更新公司氣候策略，並在 2023 年 12 月完成最近一次更新。該策略針對本行資產組合中的前十大碳排產業訂定 2030 年中期目標和 2050 年長期目標。




Caption: Crédit Agricole CIB has targets for 10 of the most carbon-intensive sectors in its portfolio, with intermediate targets for 2030 and long-term targets for 2050

本行以清楚的計畫內容、控制制度，以及完善的揭露來執行這些氣候策略。例如，法國農業信貸集團在 2022 年針對構成其超過 75% 放款支持之溫室氣體排放量的十大產業頒布淨零進程，設定具體之減少排放目標。隨後本集團執行該目標並密切追蹤其進度，並在 2023 年年底揭露其中五個重點產業的執行進度：

### 1. 石油及天然氣

已於 2022 年年底提前完成 2030 脫碳目標 - 較原定時程提早八年。

- 減少 40% 放款排放量，領先達成原 2030 年目標 ( 減少 30%)
- 針對石油開採產業的曝險總額，2022 年較 2020 年減少 17%

### 2. 能源

以 2020 年為基準，2022 年碳強度已按照計畫減少 16%。本行對於低碳能源的曝險總額 ( 包含透過客戶者 ) 也大幅增加。

### 3. 汽車

2022 年的放款排放量之碳強度已減少 8%，與 2030 碳排目標相符。

### 4. 商業房地產

2022 年的放款排放量之碳強度與 2020 年相當。

### 5. 水泥

2022 年的放款排放量之碳強度較 2020 年小幅增加 3%。

**我們也在該氣候策略中，針對其他五大產業公布新承諾：**

### 6. 鋼鐵

- 二氧化碳排放量於 2030 年前減少 26%
- 優先考慮融資低碳鋼鐵之生產相關技術
- 針對使用綠電的新鋼鐵製造設施提出積極的融資政策

### 7. 航運

- 二氧化碳排放量於 2030 年前減少 36%
- 優先考慮融資低碳航運相關技術
- 針對使用綠色燃料的新造船舶提出積極的融資政策

### 8. 航空

- 二氧化碳排放量於 2030 年前減少 25%
- 優先考慮融資第四代飛機
- 針對使用綠色燃料的新製飛機專案提出積極的融資政策

### 9. 住宅房地產

- 支持房屋所有人進行節能設備的更換
- 發展客戶的創新解決方案
- 利用信用審查和定價來推動舊屋翻新

### 10. 農業

- 協助農業轉型計畫
- 推廣永續農業
- 發展農業倫理平台

為了落實該氣候策略，東方匯理銀行訂定監理架構來管理上述減碳目標，安排顧問與支持人力，並招攬多位相關專業人才 ( 例如：東方匯理銀行共有約 250 位永續金融專家、在集團的地區銀行內則有約 50 名能源轉型顧問 )。東方匯理銀行並設立氣候與永續發展委員會，用來監督策略的執行進度，並由集團最高管理層每季審查一次。

## 台灣的能源轉型帶來挑戰與機會

東方匯理銀行是台灣唯一一家為所有台灣離岸風電專案提供融資的銀行，截至 2023 年年底，我們已提供離岸風電專案超過新台幣 160 億元的融資。風場完工後，預計每年將產生 9,374 GWh 的潔淨能源，相當於 4.63 百萬噸碳排放減少量 ( 根據經濟部的計算方法 )。我們將持續投入資源，並堅信能源轉型是台灣達成更廣義的永續發展與淨零目標的關鍵。

經過多年的努力，台灣現在已是再生能源領域的領導者，並在相關建設方面獲得國際的廣泛認可。儘管過程中面對多樣挑戰，台灣距今為止已有四個離岸風電項目已經或即將進入商業營運階段。

隨著能源轉型建設持續推進，新的挑戰也陸續出現。以第三輪離岸風場項目為例，開發商必須簽署企業購售電合約 (CPPA)，以提供有意使用綠電的企業一個直接購電的管道。企業購售電合約是目前以國營的台電為購電及配售電中心架構的進一步發展，理論上可以帶來更具彈性的商業電力市場安排，但它卻也為開發商及有意購電的企業帶來挑戰。主要的原因在於購電者長期信用能力的不確定性 - 由於購售電合約長達約 20 年，在這麼長的期間內原先承諾購電的企業可能因任何原因而無法繼續履行其義務，使專案無法達成原想定的未來現金流。在這種情形下，由於銀行無法在一定信心下估算還款現金流，可能一開始即不願意提供融資，導致專案在還沒開始時就已無法進行。

上述擔憂並非僅發生在台灣的專案。實際上諸如購電者風險分析、外部支持安排，以及一個可迅速轉賣電力的完備市場等皆已在其他地區被探索或採用過，用來解決疑慮。但在台灣，由於多數有意購電者並未持有國際認可的信用評等，或無法取得集團支持，導致尋找解決方案的過程更加複雜。

東方匯理銀行在過去幾年與其他相關機構和政府積極合作，希望為面對此一挑戰的專案找尋緩解風險的方法。我們一同討論各種計畫，例如當原承諾購電者退出時的替代性財務資源和替代購電者。我們也參與與兩層式購電架構有關的討論與研究 ( 基於對綠電使用的共同目標，由較具規模與高信用能力的購電者出面承諾購電，再轉售予其他有需求者 )，以及促進綠電供需平衡的電力交易市場，使再生能源成為可供及時購買的商品。

上述所有方法都是知易行難。東方匯理銀行具備多年的全球永續金融經驗，願意和相關機構合作，將想法落實為行動。

## 台灣的能源轉型已打下堅實基礎，應以更積極態度面對挑戰

以下是針對台灣持續進行能源轉型的幾項建議：

- **持續溝通：**我們建議政府應持續推動現有的能源轉型策略，並與相關團體持續溝通與合作。
- **有效利用綠能：**綠色能源可被視為輔助，而非完全取代傳統能源來源 ( 例如核能發電 ) 的選項，其主要貢獻在於停止化石燃料的使用 - 截至目前，化石燃料時仍佔台灣發電結構的 70% 以上。第三輪離岸風電場計畫等實際案例的成功執行也可以增強市場對綠色能源市場的信心。
- **能源儲存和節能：**我們認為，太陽能、離岸風能以及綠色能源儲存和節能 (例如氫) 是支持台灣能源轉型目標的重要關鍵。
- **未來可實施計畫：**其中包括鼓勵本地銀行支持綠色金融、更有效地執行與各國的雙邊稅務協議以減少信用保險保費的預扣稅負擔、為聘用國外人才提供更大的靈活性等。
- **外部顧問：**法國東方匯理銀行鼓勵台灣接軌國際，並利用外部顧問及其經驗順利執行。
- **台灣的本土價值：**在上述努力後，台灣在上述這些關鍵領域的成就可以整合成一個新的商業模式，新的產業也可以建立。作為首批擁有永續金融團隊的銀行之一，東方匯理銀行是設計適合當地市場的永續金融建設的專家，非常樂意支持台灣的未來規劃。

最重要的體認是台灣的能源轉型需要所有團體的積極合作。銀行的支持就是其中一個關鍵項目。

雖然外國銀行僅佔台灣銀行業總資產的 3%，這些銀行卻提供超過 70% 的台灣離岸風電專案融資。由於每家銀行的資本有限，如果目前的銀行參與模式沒有改變，我們預期現有參貸銀行可用於台灣離岸風電專案的資源將很快用罄，無法支持未來的離岸風電專案項目。

若國內金融機構，尤其是公股銀行，也能積極參與台灣能源轉型，離岸風電項目將會有更豐沛的資金支持。東方匯理銀行願意與國內銀行分享永續項目金融的相關知識，協助解決其中牽涉的專業知識議題，讓同業可在專案融資領域扮演更積極的角色。

## 提供更具彈性與創新的金融工具，協助企業克服傳統永續金融限制

財團法人中華民國證券櫃檯買賣中心早在 2017 年 4 月即發布綠色債券作業要點，該作業要點反映國際通行的 ICMA 原則，並在綠色投資項目、獨立驗證和發行後揭露要求等方面進行一些本土化調整。櫃檯買賣中心隨後整合更多其他市場實際經驗，以及發展綠色債券更久的市場的監理架構，其中包括更嚴格的資訊揭露流程、債券發行人公司層級的綠色投資計畫書、適格的第二 / 獨立方意見，以及技術標準參考等。

經過多年的努力，台灣已從此綠色債券作業要點發展到全面性的永續金融架構，涵蓋綠色和社會債券 / 貸款 / 存款、永續發展融資以及與永續目標連結的產品。

東方匯理銀行在永續金融領域扮演全球領導者角色，在台灣綠色債券市場發展初期便積極參與。在 2017 年 7 月，東方匯理銀行成為第一家在台灣發行綠色債券的外國發行人，並在三年後 (2020 年 )，成功發行兩檔新台幣計價的綠色債券，用來支持本行在台灣離岸風電專案的放款。

愈來愈多的本地機構投資者 / 放款者對責任投資 / 授信展現興趣，對永續金融的需求迅速提升。在此發展趨勢下，我們卻也發現傳統的綠色金融工具（例如綠色債券等規範發行所得款項必須用於特定綠色項目的籌資工具）事實上無法滿足許多有心於淨零目標的籌資需求。這種限制對於台灣企業來說尤其常見 - 大多數借款人由於其業務性質而沒有資格發行綠色債券或取得這類綠色融資，儘管他們有意提升其永續發展的努力。

東方匯理銀行是第一批協助台灣企業客戶透過新型金融工具 ( 與永續發展目標連結的貸款 / 商業票據 / 擔保 / 債券、綠色存款等 ) 訂定並達成其永續目標的銀行之一。早在 2022 年，我們就為台灣的一家企業集團客戶安排了與其永續發展目標連結的融資。該融資計畫中預先設立數項永續發展目標，用來鼓勵公司減少碳排放。隨後我們也以此原則進行了其他交易，目前該產品結構已被台灣金融機構廣泛採用在如貸款、擔保、債券等金融服務。

自 ICMA 在 2020 年六月公布永續目標連結債券 (SLB) 原則後，市場針對該類債券的定義和要求變得更加明確，根據 ICMA 原則發行的相關債券在市場上也愈來愈受到歡迎。此外，隨著貸款市場協會永續目標連結貸款（SLL）相關指引的發展，這類貸款也迅速攀升。

SLB 和 SLL 最突出的特色是募集資金的用途沒有特定限制。借款人無需將融資取得的資金全部用於合格的綠色資產 - 實際上，借款人可以選擇將融資取得的資金用於一般企業用途，並支持企業的永續轉型。這些特色使 SLB 和 SLL 特別吸引碳排密集型行業，以及僅持有有限綠色資產的發行人 / 借款人。

更不用提的是，SLB 和 SLL 的利息支付機制將連結至借款人的永續發展目標。因為這些融資可以向市場表達借款人達成永續發展目標及朝向淨零目標的決心，其更能強調借款人之核心永續策略及溫室氣體管理的企圖心。如果任何借款人能夠達成其 SLB/SLL 中設定的目標，將顯著提高企業聲譽，並加強借款人向外界傳達該公司已將其永續發展計畫付諸實施之訊息。

## 轉型是關鍵

台灣確實有可能轉型。

為了讓台灣達成淨零目標，除了發展再生能源之外，企業和製造業的轉型十分重要。在此過程中，銀行必須扮演積極的角色，與客戶緊密合作。

除了藉由提供永續目標連結融資來使企業達成永續發展目標外，轉型金融以相似的方式協助企業 - 借款人可取得融資來處理與其營運相關的環境議題，並將其營運轉換成對環境以及其未來業務發展都更具可持續性的模式。

這個概念不會自動運作 - 企業對因應氣候變遷和業務轉型的投資，關鍵的成功因素包括企業理解進行相關轉變的必要性，以及銀行與客戶之間在幾乎每一進程中的密切合作。東方匯理銀行的經驗是，當我們第一次向客戶介紹永續實踐時，客戶往往會持保留態度，原因包括懷疑氣候行動的緊迫性、對實現目標缺乏信心，或將轉型視為昂貴的支出。在展示同行的成功案例，並證明永續發展是有價值的投資而不是無謂開支之後，客戶開始被說服並同意共同採取行動。隨著時間的推移，此類成功案例為各行業的其他參與者提供了效仿的動力。

我們和政府機關和高碳排產業的持續互動也取得成果。多年來，我們觀察到台灣的許多客戶認定淨零目標具有挑戰性，主要因為其行業別的營運特性，且可取得的解決方案有限或所需要的資源尚未到位。

我們與合作夥伴持續努力排除這些困難，自 2022 年開始，各種重要的基礎假設與建設（如政府層級的綠色分類標準、碳權市場）和解決方案（如永續目標連結貸款和債券、氣候變遷金融等）陸續推出，使永續目的的資金更容易獲得。另一方面，科技發展開始讓不可能的減碳方法成為可能，或至少使某些方案變得更便宜。

東方匯理銀行在氣候轉型方面有豐富的經驗。我們與客戶合作實現氣候變遷因應目標，例如：再生能源使用、減碳排新製程 / 產品的推出、能源儲存，以及協助客戶的全球營運擴張計畫以實現綠色經濟潛力等。我們也安排總金額達十億歐元以上的融資，協助低碳水泥和電動汽車零件製造產業的技術發展和全球擴張，以支持他們的轉型。

## 淨零的範疇不僅限於相關企業 - 我們需要透過更緊密的合作實現社會共同目標

最後但同樣重要的一點是，整體社會對於因應氣候變遷威脅的重要性以及為何淨零目標如此關鍵的認識，將決定我們在此提及的各種努力的成敗。溝通和參與是不可取代的，銀行需要採取行動。

東方匯理銀行透過積極倡導因應氣候變遷和淨零排放來實現上述目標。從 2022 年到 2024 年，我們在 30 多場活動中擔任活動設計、贊助商、主題演講人、客座業師、小組討論，和專案 / 文章撰稿人等不同角色。在這些活動中，我們強調及時的轉型計畫如何降低企業或社會所面對的風險、提供實現永續發展目標的案例參考，並提出可實施的建議。我們以針對特定議題的深入研討的形式與各單位合作，以及與政府機關或監理機構的直接溝通，使相關議題的討論更具攸關性。

我們也為員工和社區（例如台北法語學校的學生）提供氣候教育拼圖 (Climate Fresk) 和生物多樣性培訓。這是促進永續發展的持續努力的一部分，使每個人都朝著共同目標努力，並向年輕一代傳播相關知識。

另一個策略是結合相關團體的努力。東方匯理銀行所發行之創新互惠共榮綠色債券就是一個例子。這些債券發行結合了兩個分開但相關的概念，以應對重大的永續發展挑戰 - 第一是使用債券發行所得款項來支持對台灣再生能源專案的融資；二則提供另一筆公益性質的捐款予 Plastic Odyssey 組織，支持其減少海洋塑膠垃圾污染的全球專案。 這些債券發行中特有的互惠共榮機制，展現在債券投資人、發行財務顧問和發行人東方匯理銀行台北分行的共同努力和夥伴關係 -- 東方匯理銀行台北分行將（1）因投資人減少對利率水平的要求而節省的債券利息成本，（2）因發行財務顧問減少債券發行成本而節省的資金，以及（3）東方匯理銀行台北分行額外提供的額外一筆資金之總和，捐贈予 Plastic Odyssey-- 我們相信這一共同挹注最終將惠及包括參與此一計畫者在內的整個社會（此所謂互惠共榮）。

我們持續進行上述計畫。自 2021 到 2024 年，我們與超過十家台灣金融機構合作，總投入的公益性質捐款超過新台幣五百萬，用於協助該組織推廣生物多樣性和支持循環經濟的活動。



### 作者

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**執行長**

羅弘伯先生 (Mr. Laurent Potin) 是法商東方匯理銀行台北分行的執行長，負責管理及監督該行在台灣的所有業務和營運。

羅弘伯先生具審計和顧問的專業經歷，在 1999 年加入法國 Crédit Agricole Group 負責資本市場活動稽核。其於 2004 年獲指派為東方匯理銀行環球金融市場部歐元 MTN 部門的主管，並於 2007 年至東京擔任該行亞洲區利率衍生性金融商品部門的營運長。在接任台北分行執行長前，羅弘伯先生為東方匯理銀行日本分行的環球金融市場部業務發展主管暨該部門的營運長。



## 從氣候相關揭露框架看金融機構的角色和臺灣政府、企業的治理轉型挑戰

臺大風險中心

隨著氣候變遷日趨嚴峻，為減緩全球氣溫上升造成不可逆的影響，淨零排放成為全球共識。在此趨勢下國內外各項氣候相關政策法規應運而生，迫使臺灣高碳排企業面臨轉型挑戰。此外，根據 AON 怡安 2024 氣候與巨災洞察報告，2023 年各地多項氣候災害與經濟損失金額不斷創新高，其中僅三成損失由保險公司承擔，仍有近七成的保障缺口（AON, 2024）。因此，在氣候實體與轉型風險的衝擊下，期待金融部門能挑起轉型責任，幫助位於氣候脆弱地區的企業能提升氣候調適能力，並促進資金投入支持能源密集產業、高碳排產業進行低碳創新強化氣候韌性。

## 臺灣接軌國際氣候相關揭露政策

同時，為因應氣候變遷對產業、金融界所造成的營運與財務上的衝擊，讓投資人、銀行、保險公司有一致的標準可以檢視各企業面臨的氣候風險，金融穩定委員會於 2015 年設立氣候相關財務揭露（Task Force on Climate-related Financial Disclosures, TCFD）工作小組，並於 2017 年發布 TCFD 建議書。我國相關主管機關回應國際趨勢自 2021 年起陸續要求本國銀行、保險業與上市櫃公司自 2023 年起揭露氣候相關資訊。2023 年 6 月國際永續準則理事會（ISSB）發布永續揭露準則 IFRS S1（永續相關財務資訊揭露之一般規定）及 IFRS S2（氣候相關揭露）。我國金管會也隨即在 2023 年 8 月公布我國接軌 IFRS 永續揭露準則藍圖，規劃資本額 100 億元以上的上市櫃企業自 2026 年起適用 IFRS 永續揭露準則。

從國內外發展趨勢顯見，氣候相關揭露已逐漸由自願轉向強制性規範，這對氣候治理遲滯落後的我國而言，將帶來重大挑戰。因此，臺大風險中心自 2022 年開始針對營收一億以上臺灣企業進行「企業氣候相關財務揭露調查」，連續三年持續深化議題，調查我國企業在氣候風險評估與揭露的進展，剖析政府與企業面對淨零轉型遲滯的挑戰（臺大風險中心，2024）。

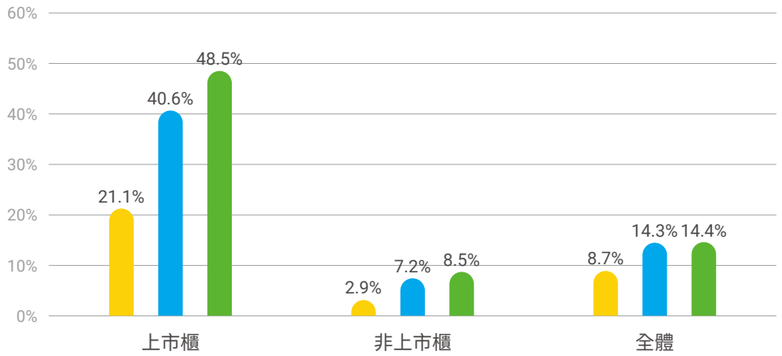


RSPRC, NTU

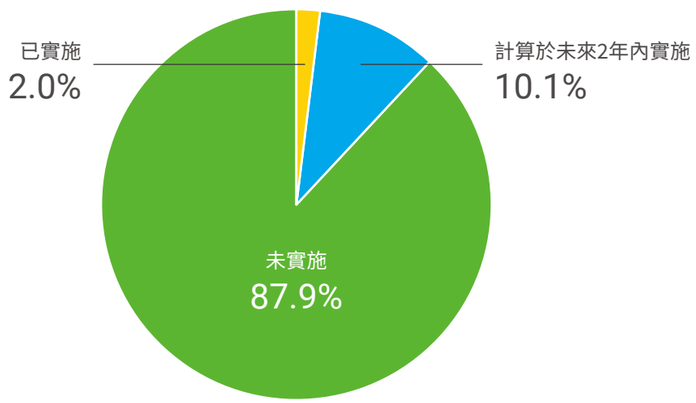
## 碳定價、能源轉型遲滯導致企業持續觀望

綜整三年調查結果顯示，政策法規是推動國內企業氣候作為的重要因素，我國金管會自 2020 年推動綠色金融 2.0、公司治理 3.0，至 2022 年上市櫃公司永續發展路徑圖，促使上市櫃企業在溫室氣體盤查、查證有清楚的依循路徑，氣候相關揭露的比例依序提升。然而碳定價制度實施一再延宕，再生能源發展條例用電大戶條款檢討進度落後，導致企業持續觀望。僅少數企業導入內部碳定價，未能有效將碳成本納入企業治理與決策考量，因而在低碳與能源轉型方面緩步不前。又由於臺灣關鍵產業多屬於國際供應鏈的一環，若國內無法建置低碳能源使用環境以符合國際品牌要求，將使臺灣整體產業錯失競爭優勢。

### 氣候相關財務揭露 (TCFD)



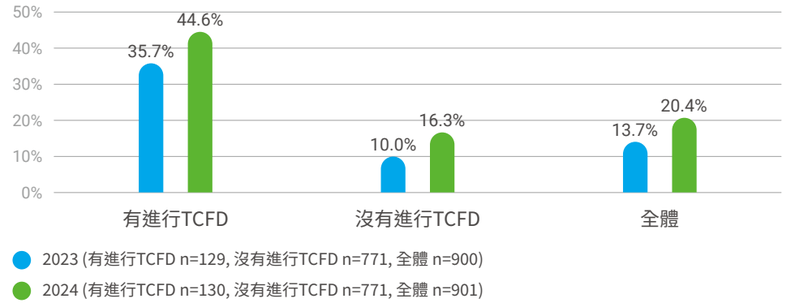

### 內部碳定價 (2024, n=901)




## 企業整體缺乏低碳創新氛圍

再者，企業進行中長期氣候相關風險評估、財務影響評估、情境分析使用等，都未能大幅進步，難以發展具備韌性和前瞻思維的系統性策略。同時，企業面臨人才培育挑戰，也未見積極推動薪酬與氣候相關績效之連結，難以將氣候思維深入企業組織文化，致使大多數企業仍未能掌握氣候機會，建構低碳轉型策略。然而，經交叉分析結果顯示，有進行 TCFD 的企業有較高的比例進行低碳創新，這反映出遵循 TCFD 框架讓企業能更有效地透過氣候相關風險與機會的識別與評估結果，即早採取低碳策略行動，以避免被排除在全球低碳供應鏈之外。

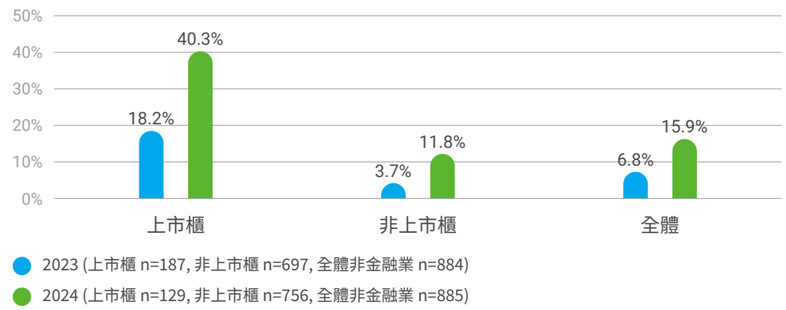
### 低碳創新




## 金融機構扮演關鍵角色

最後，臺灣金融業呼應主管機關的政策方向，正履行推動企業因應氣候變遷之重要支柱角色，上市櫃企業有更高的比例曾受金融機構要求提供永續報告書、用電量、溫室氣體排放量等氣候相關資訊，且與去年相比呈倍數成長。金融機構也願以多軌策略提供氣候金融商品、要求揭露氣候相關資訊、建構鼓勵低碳產品與製程創新的優惠融資條件，在促進企業邁向低碳轉型上扮演關鍵角色。

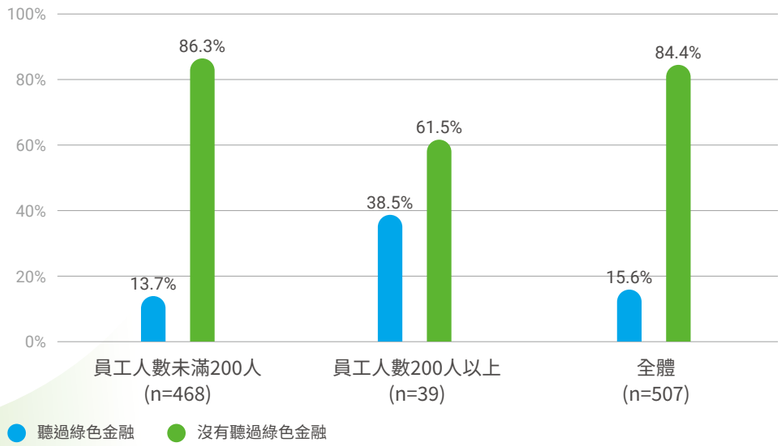
### 曾被要求提供氣候相關資訊



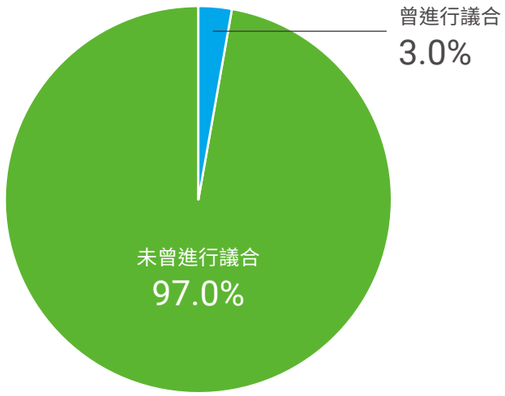
## 綠色金融影響力未觸及中小企業

然而，2024 年臺大風險中心首度針對實收資本額 500 萬元以上臺灣企業，依產業比例分層抽樣進行「綠色金融對高碳排產業影響調查」。調查結果卻指出，多數中小企業甚至未聽過綠色金融，顯示在綠色金融相關政策穩步推行之下，始終未能觸及規模較小的企業，可能導致大型企業在推動整體供應鏈減碳佈局受阻。除了政策對中小企業未能有效產生影響力外，金融機構也尚未積極與企業進行氣候相關議合。僅少數受訪企業表示已有金融機構開始關注其碳盤查、淨零路徑規劃、低碳生產技術等議題。然而經研究分析發現，氣候相關議合對企業氣候揭露與減碳行動有正面影響，建議金融機構應將氣候相關議合納入日常業務流程與關鍵績效指標，以驅動企業實行減碳策略。

### 綠色金融




### 氣候相關議合 (n=507)

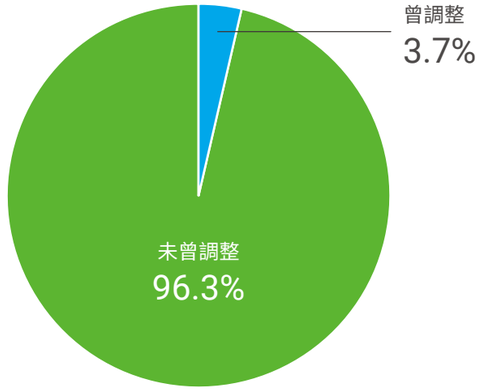



## 金融機構尚未落實將氣候風險納入業務流程

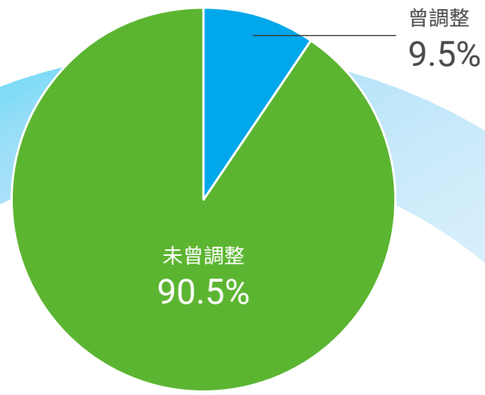
除此之外，調查結果也顯示，已有少數企業在對土地、建築物、機器設備等進行融資或保險時，金融機構曾因考量其過去的氣候災害與未來風險，而調整融資方案或保險費。因此企業應即早識別氣候相關風險與評估衝擊程度，並提出具體的調適策略與實踐，以在與金融機構進行議合時爭取更好的條件。但總體來看，現階段金融機構對企業的要求不高且尚未落實將氣候風險納入其核心業務與內部決策流程。而根據分析結果，銀行融資支持對企業投資永續經濟活動具正面影響力。呼籲金融業應擴大將資金分配給積極投入低碳活動的企業，以推動實體經濟轉向低碳永續。

### 曾遇金融機構因考量實體風險而 ...

#### 調整融資方案 (n=507)




#### 調整保險費 (n=507)



## 小結

臺大風險中心從氣候相關揭露框架出發，綜合分析企業在氣候治理、風險評估與低碳實踐上的差異與挑戰，呈現出政府治理與企業治理轉型落差。儘管在金管會明確的路徑指引下，已緩步驅動企業進行氣候相關揭露，但在碳定價制度和低碳能源上卻缺乏前瞻治理規劃，金融機構也尚未能將氣候風險評估納入整體業務策略中，難以帶動產業轉型。而面對氣候變遷的挑戰，金融機構應透過積極提升與企業議合，提供資金支持與保險保障，以推動企業加速淨零轉型與氣候調適。然資金的驅動仍需整合且連貫的政府低碳轉型治理相互支援，以建構氣候與培育淨零創新生態系，擴大金融影響力。

## 參考資料

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臺大風險中心 產業氣候風險研究團隊

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## 作者

臺大風險中心
產業氣候風險研究團隊

臺大風險中心長期致力於低碳社會轉型治理分析研究，除持續累積紮實的專業研究成果，也透過多元途徑推廣傳播，促進社會各層面對話。在氣候緊急時代，我們急需推動能源與永續發展轉型，本中心的研究提供社會科學視角，讓政府、企業與民間組織等相關利害方發展創新治理框架與政策倡議。近年本中心亦結合永續金融研究，接軌國際 SDGs 與 ESG 等指標，廣納多元領域、串連國際社群，期許在實現 2050 淨零排放目標的同時，以兼容並蓄的發展途徑落實公正轉型，不遺落任何人與社群。

台灣電力公司
TAIWAN POWER COMPANY



# 碳捕捉與封存技術應用於電力業之發展與挑戰

**鍾年勉** 台電綜合研究所 所長

碳捕捉與封存技術 (Carbon Capture and Storage, CCS)，顧名思義是一種將工廠排放源中二氧化碳分離捕捉後，將其輸送至適合的地點灌注至地底封存的一種技術。其能夠有效減少大型點排放源，例如火力發電廠、化學工廠、天然氣開採產業等所排放的二氧化碳。近年來由於碳捕捉與封存技術所延伸的技術，包含由大氣中捕捉二氧化碳，簡稱直接空氣捕捉 (Direct Air Capture, DAC)，以及結合生質能源的生質能碳捕捉與封存 (Bioenergy with Carbon Capture and Storage, BECCS) 技術，甚至可達到負碳排放 (Negative Emission) 的效益。

根據國際能源總署 (International Energy Agency, IEA) 所提出的全球淨零碳排情景 (Net Zero Emission, NZE) 下，碳捕捉與封存技術占全球總減碳量兩成，顯示了該技術在減碳路徑的重要性[1]。臺灣國家發展委員會於 2022 年公布的「臺灣 2050 淨零排放路徑及策略總說明」中提到，臺灣 2050 年須達到年捕捉與封存約四千萬噸的二氧化碳，且在對電力業的建議發電配比中，加裝碳捕捉與封存技術的火力機組發電量須達 20-27%，兩者皆顯示了碳捕捉與封存技術在國內外對減碳的實質效益與重要性[2]。



綜觀碳捕捉與封存技術對於電力業的發展，可概分為三個角色，其一、針對單一電廠設計碳捕捉工廠；其二、搭配化石燃料產氫技術生產藍氫；其三、搭配直接空氣捕捉與生質能技術，達到負碳排效益。本文以下針對三個角色進行說明：

其一為針對電廠設置碳捕捉工廠，藉此分離並捕捉火力電廠煙道尾氣中所排放的二氧化碳，此種方式可應用在不同燃料發電的電廠，也普遍應用於作為基載發電角色的機組，藉由提高機組與碳捕捉工廠的操作容量因子 (Capacity Factor)，可有效並同時降低兩者高額的設備建置攤提成本 (CAPEX)，以避免發生過高均化發電成本 (Levelized Cost of Electricity, LCOE) 以及單位碳移除價格 (Cost of Avoided Carbon)。但也因碳捕捉屬耗能程序，在同時考量其經濟與能耗效益下，一般設計捕捉電廠排放源中 85-95% 的碳排放量，是較為經濟可行的比例。

其二為搭配化石燃料轉製氫氣，即將製程中產生的二氧化碳透過碳捕捉與封存技術移除，此種方式產生的氫氣稱之為藍氫 (Blue Hydrogen)。藍氫可取代部分天然氣作為燃料至既有的氣渦輪發電機組來降低碳排放量。國際上較為新式的天然氣氣渦輪機組 ( 如 Siemens SGT-6000G)，普遍可容許 30 vol.% 以下的氫氣與天然氣進行混燒 (Co-firing) [3]。此法普遍適用於尖載或調頻發電角色的機組，透過投入藍氫混合的比例增加，減碳量也可以隨之下降。假設於氣渦輪機組中以 30 vol.% 的藍氫取代天然氣，約可以下降 25% 的碳排放量。

其三為搭配直接空氣捕捉或生質能發電廠加裝碳捕捉與封存技術所帶來的負碳排放效益，藉此彌補上述兩者仍不易避免的碳排放量。直接空氣捕捉技術在國際上最為知名的案例為冰島的 Orca 計畫；而生質能搭配碳捕捉技術則為美國伊利諾 ADM 公司的乙醇生產廠計畫。

雖碳捕捉與封存技術並非新技術，最早在 1970 年代即有天然氣開採行業導入，但綜觀國際電力業，目前僅有位在加拿大 SaskPower 的 Boundary Dam 計畫，以及美國 NRG 能源公司的 PetraNova 計畫共兩座燃煤電廠，在 2013 年前後導入商業化規模 ( 捕碳量能大於一百萬噸 ) 的碳捕捉技術，主要挑戰之一在於碳捕捉設施的建置與捕碳成本昂貴，兩項計畫總經費分別約為 15 億與 10 億美金，換算單位捕碳成本約為每噸二氧化碳 105 與 70 美元 [4 5]。為降低高成本的障礙，使 CCS 技術可順利於電力業推廣，兩項計畫皆有受到當地政府的補助。除成本因素外，CCS 技術無法大量運用於電力業的另一原因是捕捉後的二氧化碳量體過大導致去化困難，因此需要更先進的儲集層開發技術以解決這項問題。近年來隨著各國政府對淨零碳排的路徑與目標越趨明確，各項如碳費、碳足跡與跨國碳運輸等政策也逐漸列入法規，越來越多火力電廠也陸續開始宣布將導入碳捕捉技術，如美國的 Gerald Gentleman 電廠內的燃煤發電機組，與英國 Net Zero Teesside 的天然氣發電機組，皆已開始進行導入碳捕捉與封存技術的可行性研究。



Taipower

對於台電公司而言，未來火力發電機組導入碳捕捉與封存技術會遇到的其中一項挑戰在於捕碳對電價的影響。根據本公司所開發的碳捕捉與封存經濟計算模型 (Technical Economic Analysis, TEA) 初步計算，在既有的技術情景下，於燃煤機組與燃氣機組捕捉其所排放的 90% 二氧化碳，核算均化發電成本可能會分別增加約 80% 與 43%。因為我們相信隨著技術的發展成本仍有下降空間，所以台電公司目前朝向建置小規模碳捕捉測試廠如先行了解該技術導入電廠可能帶來的挑戰 ( 台中火力發電廠內建置減碳園區，如圖 1)。該減碳園區由 2019 年起已有 2 套由本公司自行開發的碳捕捉設施 ( 各別年捕捉量 6 噸二氧化碳，如圖 2) 開始運行至今，其分別採用化學吸收法與物理吸附法來捕捉燃煤機組排放煙氣中的二氧化碳。園區內另有年捕捉量 2,000 噸二氧化碳的小型碳捕捉測試廠、再利用捕捉二氧化碳的智慧溫室、展示台電減碳歷程的教展中心、以及搭配水電解產氫與捕捉下的二氧化碳再利用產製化學品的技術，也將於 2025 年起逐步完工啟用。台電公司並將規劃投入小型碳封存示範計畫 ( 年灌注量 2,000 噸 )，藉此搭配上述小型碳捕捉測試廠所捕捉的二氧化碳，來完成一系列碳捕捉與封存技術的供應鏈示範計畫。

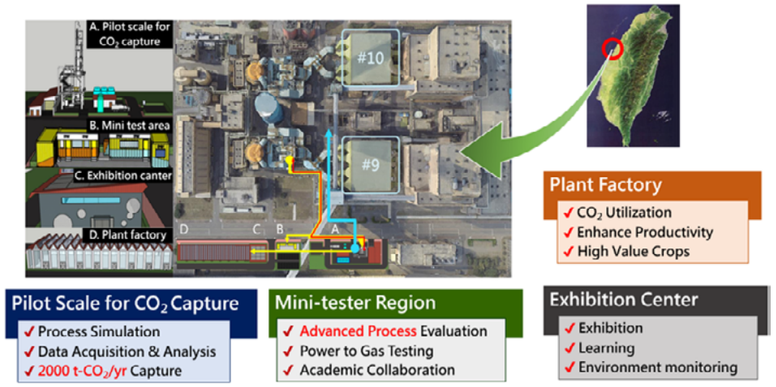



圖 1 台電公司於台中電廠建置之減碳技術園區




圖 2 台電公司自行開發之碳捕捉實廠技術，圖左為化學吸收法，圖右為物理吸附法

為加速推動碳捕捉與封存技術，台電公司也積極與國外學研機構及廠商合作交流，期望透過國外成熟技術與經驗，來協助既有電廠導入該技術。合作內容包括與挪威商立恩威公司 (DNV) 共同推動規劃台中減碳技術園區、與美商 Kellogg Brown & Root 公司 (KBR) 合作於大林發電廠燃煤機組的先期可行性評估、與美國電力研究院 (EPRI) 於台中電廠燃氣機組進行先期可行性評估、與日本中央電力研究所 (CRIEPI) 合作進行地球物理探勘並分析於彰濱工業區鑽取的地質岩心樣本等。今年並以林口電廠為標的，展開整廠燃煤機組的碳捕捉與封存技術的先期可行性評估 ( 圖 3)。

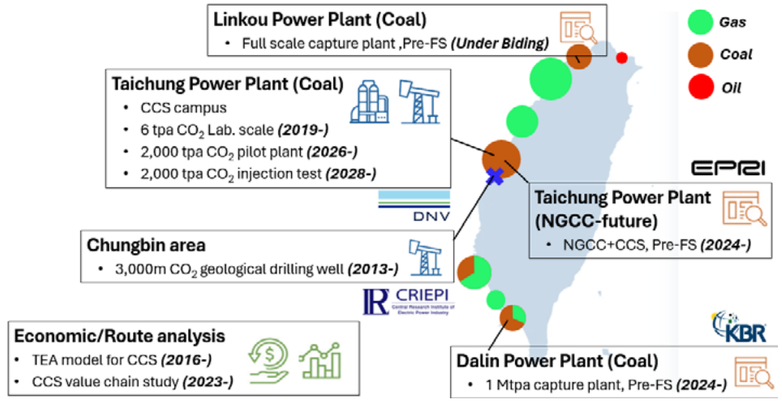



圖 3 台電公司於 CCS 技術之國際合作現況

對於既有的火力電廠而言，碳捕捉與封存技術是既有最為成熟的減碳技術，台電公司正透過建置小型測試與示範的碳捕捉與封存技術鏈，以及吸收國際的經驗與合作交流、並透過先期經濟技術分析，藉此加速該技術的導入並同時降低建置碳捕捉廠的風險，協助政府達到 2050 年淨零排放目標。

[1] IEA, Net Zero by 2050 - Roadmap for the Global Energy Sector. IEA, 2021.
[2] 國家發展委員會，臺灣 2050 淨零排放路徑及策略總說明，民國 111 年 3 月 30 日。
[3] EPRI, Record-Breaking Hydrogen Blending for an Advanced-Class Gas Turbine. Constellation Hillabee Power Plant Blend Test. 2024.
[4] IEAGHG, Integrated carbon capture and storage project at Saskpower's Boundary Dam power station, 2015.
[5] DOE/NETL,W.A. Parish Post-Combustion CO2 Capture and Sequestration, 2020.

# 台灣電力公司綜合研究所

台灣電力綜合研究所（Taiwan Power Research Institute，簡稱 TPRI）是台電公司的研究及試驗機構，扮演研試技術領導、企業經營智庫及營運技術樑柱等專業角色，其策略包括建構公司短中長期的研究規劃，推動技術創新與應用，並通過跨系統合作促進重點項目的落實，同時加強顧客服務，以應對未來挑戰。

面對能源轉型與電業改革，TPRI 提供台電公司所需研發與試驗服務，投入前瞻電力技術研究與應用，並推動研發與業務的合作，促使公司穩健成長，此外也推動電力技術多元化，結合創新策略與新創加速器，引領電力市場及產業升級發展。在營運上，TPRI 配合政府的能源轉型與淨零排放政策，確保穩定供電，加速再生能源與智慧電網的應用，推動數位轉型與科技創新，實現零碳永續的目標。





## 作者

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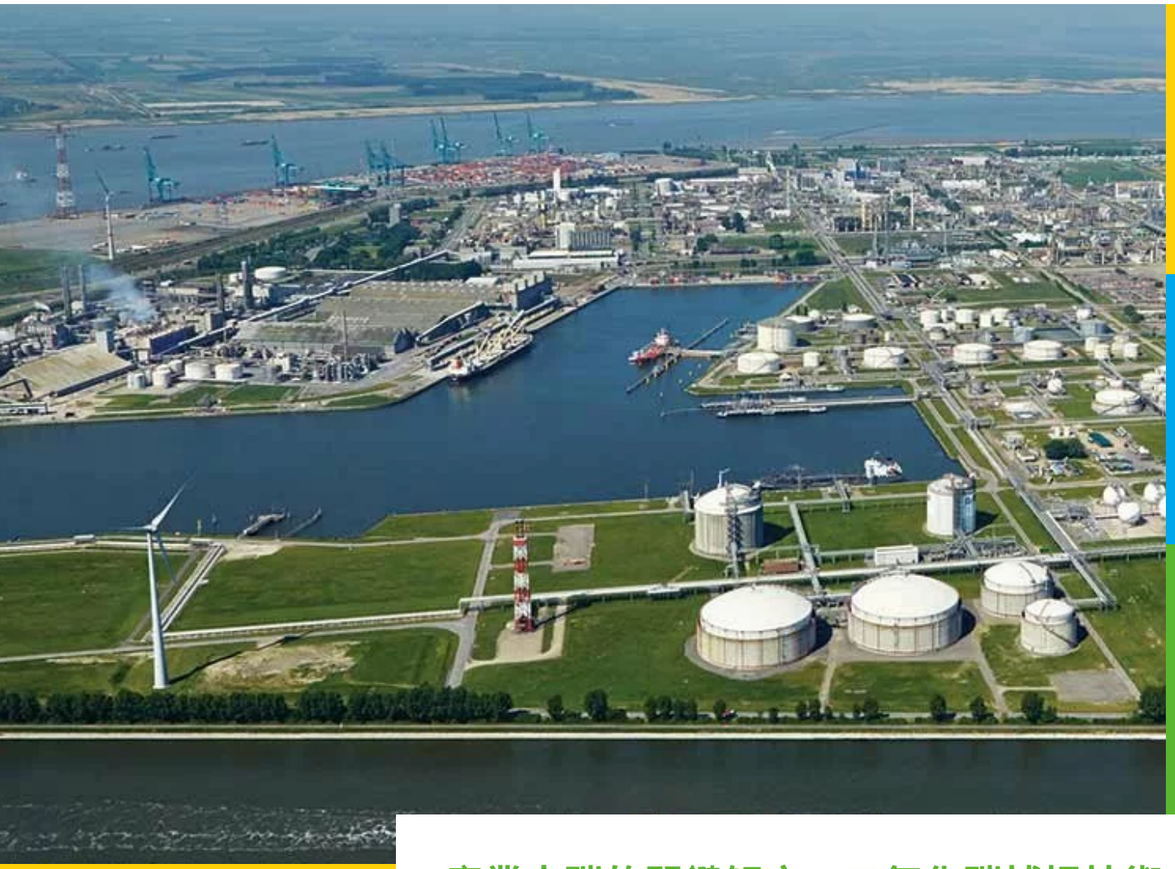
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### 學歷

博士：國立清華大學核子工程學系
學士：國立清華大學動力機械工程學系

### 經歷

- 綜合研究所所長（自 2019 年 6 月起）
- 綜合研究所副所長（2017 年 7 月起至 2019 年 6 月）
- 綜合研究所能源研究室主任（2011 年 11 月至 2017 年 7 月）
- 綜合研究所能源研究室研究員（1999 年 3 月至 2011 年 11 月）
- 電力綜合研究所核能工程師（1993 年 11 月至 1999 年 3 月）



## 產業去碳的關鍵解方：二氧化碳捕捉技術

## 願景

全球 20% 以上的二氧化碳排放量來自工業活動。如今，我們面臨的挑戰是如何快速部署具體的解決方案，以大幅減少這些排放。在現有的技術中，碳捕捉與封存 (CCS) 是水泥、冶金、石化和化學等碳排放量最高、最難去碳行業的關鍵解決方案。這些行業也是該技術影響最大的行業，因為其所產生的二氧化碳濃度最高。

碳捕捉與封存 (CCS) 的原理是在源頭捕捉二氧化碳排放，對其進行處理和淨化，然後將其回收或永久封存於地質構造中。世界各地正在進行大規模的碳捕捉與封存專案，尤其是在歐洲和美國，這兩個國家的專案總計佔全球的 70% 以上。液空集團是這一領域的領導者之一，其專有的 Cryocap™ 技術可在將二氧化碳運送至封存場地之前進行捕捉、淨化和液化。



## 行動

液空集團參與了許多大型的 CCS 專案，尤其是在歐洲。在荷蘭，當地政府制定了 2050 年前將溫室氣體排放量減少 95% 的遠大目標，液空集團參與了 Porthos 專案，荷蘭最大的二氧化碳減排計畫。對液空而言，該專案包括在鹿特丹附近的 Rozenburg 氫氣生產廠安裝 Cryocap™ 設備，從而實現自身設施的去碳化。該專案還包括建設一條管道，從 2026 年起，將當地幾家工廠排放的二氧化碳經由鹿特丹港輸送至北海，並將其封存在距離海岸 20 公里遠，深達 3,000 公尺的枯竭天然氣田中。

總結而言，Porthos 專案將有助於每年減少 250 萬噸的二氧化碳排放，約佔鹿特丹工業活動所排放二氧化碳的 10%。液空還參與了與水泥製造商 EQIOM 合作的 K6 專案，該專案的目標是透過 Cryocap™ 技術，在前 10 年的運營中捕捉約 800 萬噸的二氧化碳，使位於法國北部的 Lumbres 水泥廠成為歐洲第一家碳中和水泥廠。秉持同樣的精神，液空也將為位於法國北部 Réty 的 Lhoist 石灰生產廠的去碳化做出貢獻。

最後，作為 D'Artagnan 專案的一部分，這兩家工廠所捕捉的二氧化碳將被運送到敦刻爾克港的臨時儲存平台，然後再從那裡運到北海地下 1,000 至 2,000 公尺處進行封存。到 2027-2028 年，D'Artagnan 專案有助於每年減少 150 萬噸二氧化碳排放。

液空集團也參與了歐洲許多其他同類型的計畫，例如 Kairos@C、Antwerp@C、ECO2 Normandie 和 Callisto 等計畫，這些大型專案都展現了液空為自身與客戶資產去碳的專業能力與承諾。





Air Liquide

## 作者

### 液空集團 - 亞東工業氣體

液空集團是全球工業和醫療保健領域之氣體、技術和服務的領導者，在 60 個國家擁有約 66,300 名員工，為超過 400 萬的客戶及患者提供服務。氧氣、氮氣和氫氣是生命、物質及能源不可或缺的小分子。它們是液空的專業科學領域，自 1902 年集團成立以來，一直是公司的核心業務。

立足當下，放眼未來是液空集團的策略核心。在其 2025 年的策略計畫 ADVANCE 中，液空集團堅定地追求結合財務與非財務的全面績效。著眼於新興市場，液空集團受惠於其強韌的商業模式、創新能力與技術專長等重要資產。藉此，集團開發了有助於氣候和能源轉型的解決方案（特別是氫能源），推動醫療保健、數位和高科技等領域發展。

2023 年，液空集團的營業額超過 275 億歐元。液空集團在巴黎泛歐證券交易市場上市（A 類），同時是法國 CAC 40 指數、歐盟 STOXX 50 指數，以及 FTSE4Good 社會投資指數與 DJSI Europe 指數成員。

亞東工業氣體（Air Liquide Far Eastern；ALFE）係由全球工業氣體製造及服務的領導者，營運超過百年的法國液空集團（Air Liquide）與遠東新世紀集團（Far Eastern）於 1987 年合資設立於台灣，為在台投資規模最大的法籍製造商，在台灣員工超過 780 人，服務據點遍及台北、新竹、台中、台南、高雄，以及各大科學園區。



# 淨零碳排與循環經濟之結合－廢棄物進行二氧化碳捕集與再利用之潛力

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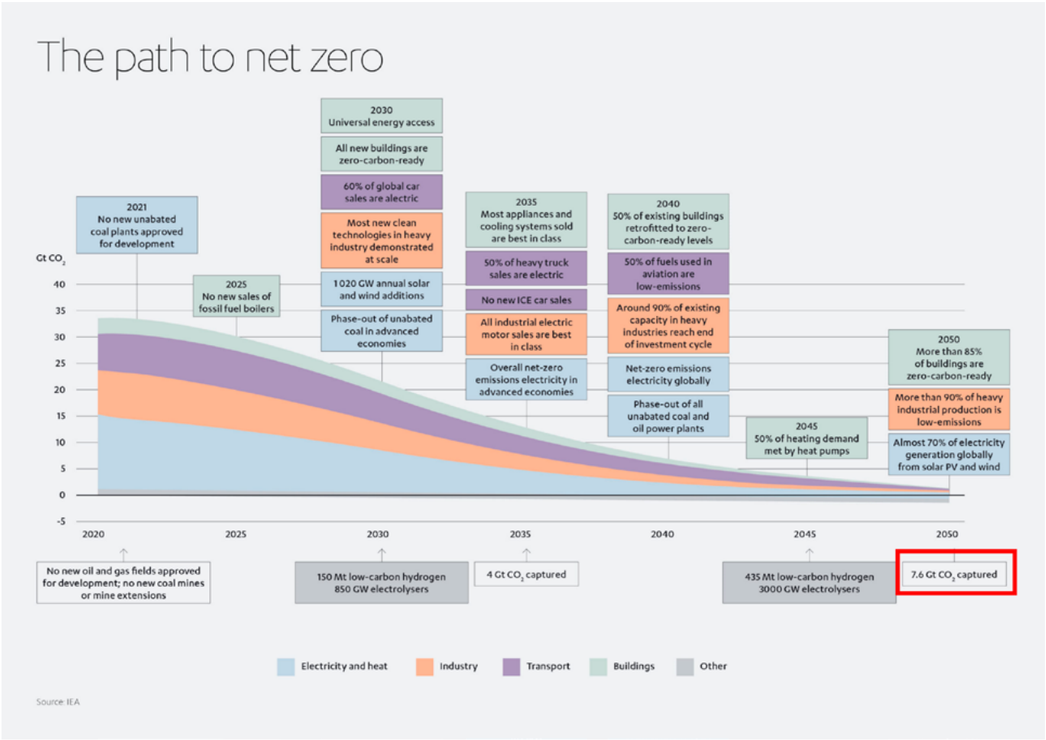
## 淨零碳排介紹

溫室氣體 (Greenhouse gases, GHGs) 為能夠吸收和釋放紅外輻射的氣體，這些氣體原本在大氣中的作用為維持適宜生命存在的溫度。當太陽輻射 ( 主要是短波輻射 ) 穿過地球大氣層，並以長波輻射 ( 紅外線 ) 的形式將能量釋放回大氣層時，大氣中的溫室氣體 ( 如二氧化碳、甲烷和水蒸氣等 ) 能夠吸收這些長波輻射，並將一部分能量釋放回地表[1]。透過溫室氣體吸收能量，能使地球表面的平均溫度大約保持在 15° C 左右，但如果沒有溫室氣體，地球表面的溫度則會降至約 -18° C。

然而，當人類活動導致大氣中溫室氣體濃度過度增加時，就會引發增強的溫室效應，人類大量排放的常見溫室氣體為二氧化碳 ($CO_2$)、甲烷 ($CH_4$)、一氧化二氮 ($N_2O$) 與氟化氣體 (F-gases) 等，這些氣體大多由燃燒化石燃料、森林砍伐、畜牧業養殖與工業活動等過程中產生。雖然這些溫室氣體的含量相對大氣中其他成分的濃度較低，但卻導致地球的能量平衡發生變化，從而引起全球氣溫上升、海平面上升與極端天氣事件增加等一系列氣候變化現象[2]。



目前人類排放最大宗的溫室氣體為二氧化碳，其在大氣中的濃度已由工業革命前的 280 ppm 上升至 420 ppm，並造成地球溫度上升約 1.4° C[3]。由於大氣中二氧化碳濃度對氣候變遷的影響，聯合國政府間氣候變遷專門委員會 (IPCC) 呼籲，全球若要將平均升溫控制在攝氏 1.5°C內，必須在 2030 年減少碳排放至少 43%，並在 2050 年實現淨零碳排[4,5]。為了達到淨零碳排的目標，國際能源署 (IEA) 公佈了淨零碳排路徑圖 ( 圖一 )，由圖可知，2035 年前，主要以發展能源轉型與產業結構重組為主；2035 年後則需要大力進行二氧化碳捕集、再利用與封存技術 (CCUS)，且捕集量需高達約 7.6Gt[6]。

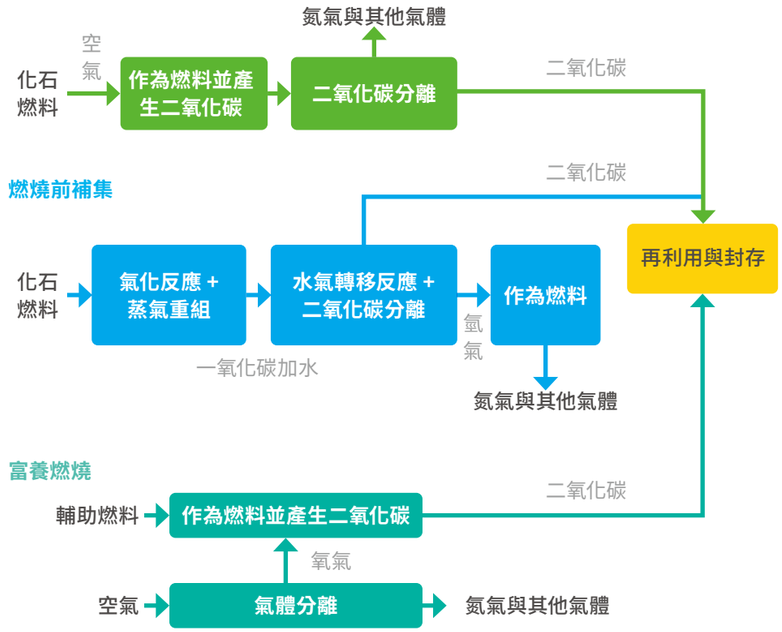



圖一 國際能源署公佈之淨零碳排路徑圖

## 二氧化碳捕集與再利用技術

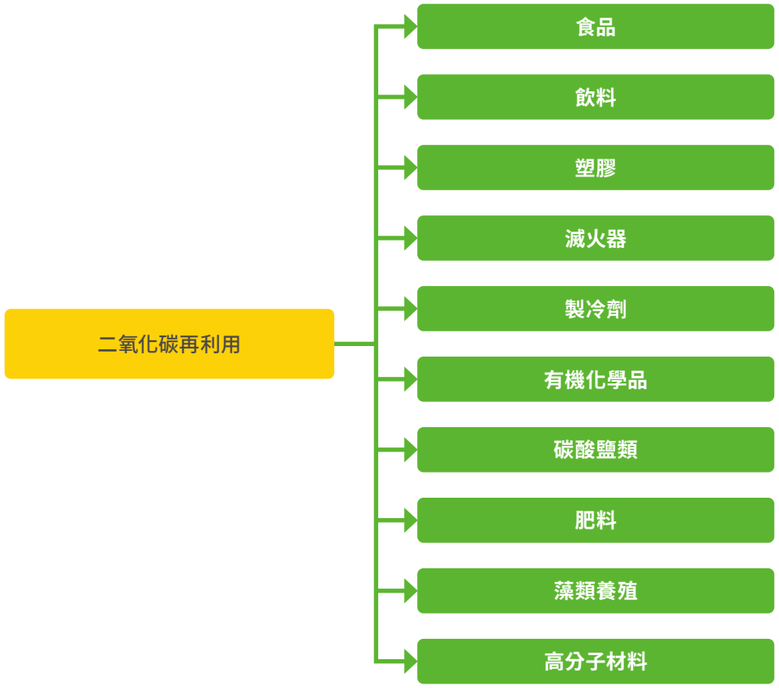
CCUS 是將工廠排放或大氣中的二氧化碳進行捕集和灌入地底封存或再利用的技術，捕集、再利用與封存的內含介紹如下：

- **碳捕集**[7]：將二氧化碳從工業過程或燃燒化石燃料的排放源中分離出來。主要可分為燃燒後捕集、燃燒前捕集及富氧燃燒 ( 圖二 )。燃燒後捕集是指在燃燒過程結束後，從排放的煙氣中捕集二氧化碳的技術。這種方法通常涉及使用吸收劑從煙氣中分離出二氧化碳；燃燒前捕集是在燃料燃燒之前，先將燃料轉化為合成氣 ( 氫氣與一氧化碳 )，一氧化碳可當作燃料使用，後續再以二氧化碳形式分離或作為其他化學品的原料；氫氣則可作為乾淨能源使用，降低二氧化碳排放量，這種方法通常用於煤氣化或天然氣重組的過程中；富氧燃燒是先將空氣中的氧氣分離後，利用高濃度氧氣進行燃燒，以產生純度較高的二氧化碳，使二氧化碳利於使用與封存。三種流程常見搭配的分離技術為吸收 ( 物理與化學 )、吸附 ( 物理與化學 )、薄膜分離、化學迴路燃燒與低溫蒸餾等[8]。




圖二 燃燒後捕集、燃燒前捕集及富氧燃燒流程圖

- **再利用：**捕集後的二氧化碳可以轉化為其他有價值的產品，例如用於增強油氣回收(EOR)、製造化學品或無機材料等 ( 圖三 )[9]。若以製造化學品為例，二氧化碳通常可透過熱化學、電化學和光催化等多種技術轉變為化學品。在這些技術中，光催化二氧化碳還原為具有高度潛力的方法，因為它利用可再生資源—太陽能，將二氧化碳轉換為甲酸、甲醇、乙醇、乙酸和碳氫化合物等。這個過程模仿了自然光合作用，透過陽光將二氧化碳和水轉化為有價值的化學品。在轉換過程中，半導體材料如金屬氧化物、金屬硫化物，以及最新的碳基光催化劑是促使反應發生的關鍵 ( 催化劑的選擇、反應條件和助催化劑對於提高二氧化碳還原的效率和選擇性至關重要 )。此外，將葡萄糖或纖維素等生物質與二氧化碳還原結合，還可使這一過程更加環保和高效，同時實現生物質的降解和二氧化碳的轉化。




圖三 二氧化碳捕集與再利用之用途

- **封存：**如果二氧化碳無法被有效利用，則可將其長期封存在地質結構中，如地下鹽水層或枯竭的油氣田，防止其重新進入大氣[10]。目前二氧化碳封存的方法主要分成地表礦化封存、海洋封存及地質封存。礦化封存是將二氧化碳與某些天然存在的礦物進行化學反應，使其轉變為穩定的碳酸鹽礦物，永久封存；海洋封存是將二氧化碳注入深海，使二氧化碳以固態或液態儲存在海洋的巨大容量中，來封存二氧化碳；地質封存為將二氧化碳注入地下深處的岩層或枯竭的油氣田中，以地質構造來永久封存二氧化碳[11]。

## 廢棄物進行二氧化碳捕集與再利用之技術開發

由於並非所有地區都有適合的地質條件來封存二氧化碳且部分地區的民眾對於地下封存二氧化碳存在擔憂，特別是潛在的環境風險和對當地社區的影響，故不少國家與企業將重心發展於二氧化碳捕集與再利用技術[12 13]。

二氧化碳在捕集過後可透過再利用程序應用於：製備碳酸鹽類 ( 礦物碳酸化 )、有機化學品生產、燃料合成、碳纖維和高分子材料與食品工業等。除了上述提到利用光催化進行二氧化碳還原外，將二氧化碳與鈣、鎂、鈉與鉀等鹼土金屬或鹼金屬反應以形成碳酸鹽類的礦物碳酸化法也具備多種優點，例如：礦物碳酸化的原料 ( 如鈣鎂矽酸鹽礦物 ) 在地球上廣泛存在，故這種技術具有較高的應用潛力、不受地域限制；礦物碳酸化不會產生有害副產品且反應過程為自發反應，故過程較為環保，且最終產物可以應用於建築材料及土壤改良等多個領域，進一步減少資源開發[14 15]。此外，由於許多廢棄物中富含鈣、鎂、鈉、鉀等元素 ( 鹼性廢棄物 )，故可利用多種工業廢棄物實施，不僅能夠處理工業廢料，還可以實現二氧化碳的捕集和再利用，達到淨零碳排與循環經濟結合的目標[16]。

目前常用來進行二氧化碳捕集與再利用之鹼性廢棄物主要為：飛灰、鋼渣、水泥窯粉塵與混凝土廢棄物及海淡鹵水等[14 17 18]。飛灰、鋼渣、水泥窯粉塵與混凝土廢棄物等鹼性固體廢棄物進行礦物碳酸化的方式可分為直接礦物碳酸化與間接礦物碳酸化兩種[14]。直接礦物碳酸化又可分成氣 - 固直接碳酸化與氣 - 液 - 固直接碳酸化，氣 - 固直接碳酸化是最基本簡單的碳酸化方法，該反應在一步過程中發生，其中純化的二氧化碳氣體與鹼性廢棄物直接反應形成碳酸鹽類 ( 式一、式二 )，由於此反應為放熱反應且較為緩慢，故反應速率低是氣 - 固直接碳酸化法的主要缺點。氣 - 液 - 固直接碳酸化則是在水或水蒸氣存在的狀況下使鹼性廢棄物與二氧化碳反應，反應過程中，二氧化碳會先與水氣形成碳酸，碳酸會再與鹼性廢棄物進行反應，使鈣、鎂以離子態形式與溶於水的二氧化碳形成碳酸鹽類 ( 式三至式六 )。雖然氣 - 液 - 固直接碳酸化可增加反應速率與形成之碳酸鹽類的純度，但在氣 - 液 - 固直接碳酸化中，碳酸通常無法充分酸化溶解鹼性固體，故所形成之碳酸鹽類仍有產量較低與純度不高的缺點[14]。

- 式一：
  $(Ca, Mg, Fe)O_{(s)} + CO_{2(g)} \rightarrow (Ca, Mg, Fe)CO_{3(s)}$
- 式二：
  $(Ca, Mg)SiO_{3(s)} + CO_{2(g)} \rightarrow (Ca, Mg)CO_{3(s)} + SiO_{2(s)}$
- 式三：
  $CO_{2(g)} + H_2O_{(aq)} \rightarrow H_2CO_{3(aq)}$
- 式四：
  $H_2CO_{3(aq)} \rightarrow H^+_{(aq)} + HCO_3^{2-}{}_{(aq)}$
- 式五：
  $(Ca, Mg)^{2+}_{(aq)} + HCO_3^{2-}{}_{(aq)} \rightarrow (Ca, Mg)CO_{3(s)} + H^+_{(aq)}$
- 式六：
  $(Ca, Mg)^{2+}_{(aq)} + CO32^-_{(aq)} \rightarrow (Ca, Mg)CO_{3(s)}$

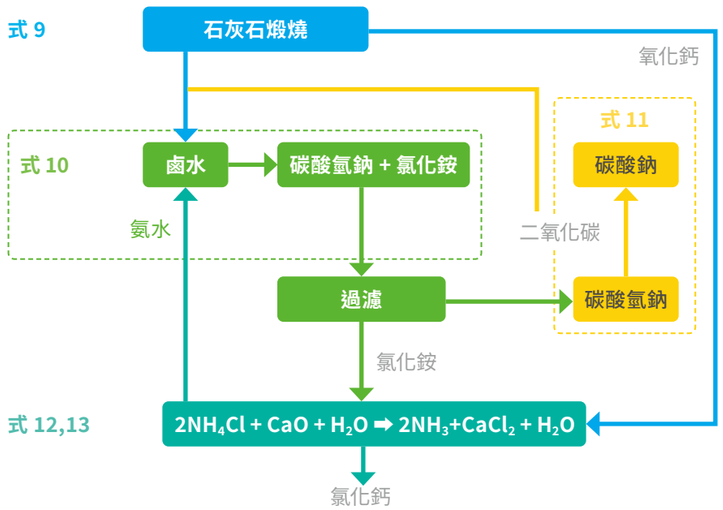
為了改善此狀況，間接碳酸化的構想便被提出，間接碳酸化由兩個獨立的階段組成。第一階段為利用酸性物質如醋酸、硫酸銨、氯化銨、鹽酸、硫酸或乙二胺四乙酸等將鹼性廢棄物中的鈣、鎂溶解，並於第二階段進行碳酸化過程（式七與式八）。間接碳酸化可以提高反應速率、允許反應在一般壓力下進行，且反應過程中消耗的能量也較直接碳酸化過程低。此外，間接碳酸化可在第一階段溶解過程中控制酸液濃度、溶解時間與溫度等，使鹼金屬或鹼土金屬與其他雜質分離，故分離後便可將高純度鈣、鎂溶液進行第二階段碳酸化，達到高純度與高產率的目標[14]。

- 式七：
  $CaO_{(s)} + 2CH3COO^-_{(aq)} \rightarrow Ca^{2+}_{(aq)} + 2CH_3COO^-_{(aq)} + H_2O_{(aq)}$
- 式八：
  $Ca^{2+}_{(aq)} + 2CH_3COO^-_{(aq)} + CO_{2(g)} + H_2O_{(aq)} \rightarrow CaCO_{3(s)} + 2CH_3COOH_{(aq)}$

除了鹼性固體廢棄物外，海淡鹵水也可進行二氧化碳捕集與再利用，且由於海淡鹵水與一般鹼性固體廢棄物性質不同，故進行的碳酸化方式有所差異。海淡鹵水為海水淡化過程的副產物，其鹽分為一般海水的 2-10 倍，故隨意排放將會造成周遭海域鹽分上升與溶氧量下降等缺點[19]。海淡鹵水中含有高濃度的鹼金屬與鹼土金屬，因此被視為適合進行礦物碳酸化的潛力廢棄物，其進行礦物碳酸化的方法為 Solvay Process 與胺類載體法[20 21 22 23]。Solvay Process 是工業生產碳酸鈉的主要方法，此法由於原料便宜且易得：鹽鹵（來自井鹽或海鹽）和石灰石（式九至式十三與圖四），故全世界碳酸鈉產量的 75% 源於基於 Solvay Process 的化工廠[24]。Solvay Process 之所以與海淡鹵水及二氧化碳捕集有關的原因是透過式十，由於鹵水內含有高濃度的氯化鈉，故只需要額外添加氨水即可進行此步驟並產生碳酸氫鈉，碳酸氫鈉便可用於食品業或藻類養殖等用途。此外，式十之氨水的作用是提供鹼性環境以吸收二氧化碳，故可針對需求替換成不同胺類，甚至也可利用氧化鈣、氧化鉀等鹼性固體來進行，這些利用不同胺類或鹼性物質進行的 Solvay Process 則被稱之為 Modified Solvay Process[25]。



- 式九：
  $CaCO_3 \rightarrow CaO + CO_2$
- 式十：
  $NaCl + NH_3 + CO_2 + H_2O \rightarrow NaHCO_3 + NH_4Cl$
- 式十一：
  $2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$
- 式十二：
  $CaO + H_2O \rightarrow Ca(OH)_2$
- 式十三：
  $Ca(OH)_2 + 2NH_4Cl \rightarrow CaCl_2 + 2NH_3 + 2H_2O$



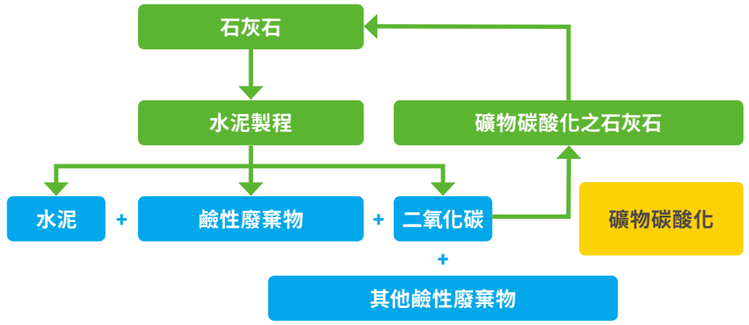

圖四 Solvay Process 流程圖

胺類載體法則是先利用 pH Swing Method 將鹵水 pH 值調整至 10 與 12，以沉澱出氫氧化鎂與氫氧化鈣，接著再利用胺類液體作為載體吸附二氧化碳，並將氫氧化鎂與氫氧化鈣置入其中進行反應 ( 式十四 )。由於二氧化碳易被胺類液體吸收，故溶液內的氫氧化鎂及氫氧化鈣即可透過反應轉變為碳酸氫鎂與碳酸氫鈣，後續再加熱便可獲得碳酸鎂與碳酸鈣。

- 式十四：
  $(Ca,Mg)(OH)_{2(s)} + CO_2(\text{In amine carrier}) \rightarrow (Ca,Mg)HCO_{3(s)}$

## 廢棄物進行二氧化碳捕集與再利用之效益與結語

從上述可知利用廢棄物進行二氧化碳捕集與再利用可以達到捕集二氧化碳與產生有價材料的目標，而主要產生之物質為碳酸鈣、碳酸鎂與碳酸氫鈉等。這三種物質皆為應用範圍廣泛的化學品，可用於建築材料、肥料、醫藥產品、食品添加劑與清潔劑等。除了提供的經濟價值外，礦物碳酸化的最大價值為可協助不少產業達到碳循環的目標，以水泥業為例：水泥生產過程中需要將將石灰石、黏土、矽砂、鐵渣等原料以適當比例配料，並經旋窯以 1450-1500°C高溫煅燒，以形成熟料。此過程中石灰石會分解成石灰和二氧化碳，故若能利用水泥窯粉塵、混凝土污泥和拆除廢棄物等鹼性廢棄物將二氧化碳捕集並產生碳酸鈣等物質，便可將這些材料回用至水泥業製程中 ( 圖五 )，不僅減少二氧化碳排放量，同時還可減少原料開採使用量，再進一步降低碳排放量。




圖五 礦物碳酸化之碳酸鈣回用至水泥業製程示意圖

雖然利用廢棄物進行二氧化碳捕集與再利用的技術尚在萌芽階段，但根據文獻統計：臺灣常見的鹼性固體廢棄物，如鋼渣、水泥和混凝土廢棄物、焚化飛灰、燃煤飛灰與紙類廢棄物等，每年約可分別捕集 2.11、1.55、0.29、0.14 與 0.07Mt 的二氧化碳[26]。而若是以產業別來看，這些鹼性廢棄物分別可協助各產業減少 14.5%、28.1%、136%、0.18% 與 2.95% 的二氧化碳，顯示利用鹼性固體廢棄物進行二氧化碳捕集具有一定潛力[26]。海淡鹵水的部分，臺灣每日則是約排放 4 萬多噸的鹵水，若能將其全部用於礦物碳酸化，可望能負擔海水淡化廠的碳排放量，並提供碳權給其他產業，代表利用海淡鹵水進行二氧化碳捕集與再利用也具有可行性[26 27]。

目前，國際上雖有許多關於淨零碳排之研究，但利用廢棄物進行礦物碳酸化的研究具有其特殊性，不僅可以將二氧化碳捕捉與再利用，更可以加強其與廢棄物處理之間的關聯，希冀將錯置的資源重新引入正軌，並將兩者轉變為有價值之產物，以結合循環經濟與淨零碳排的理念。

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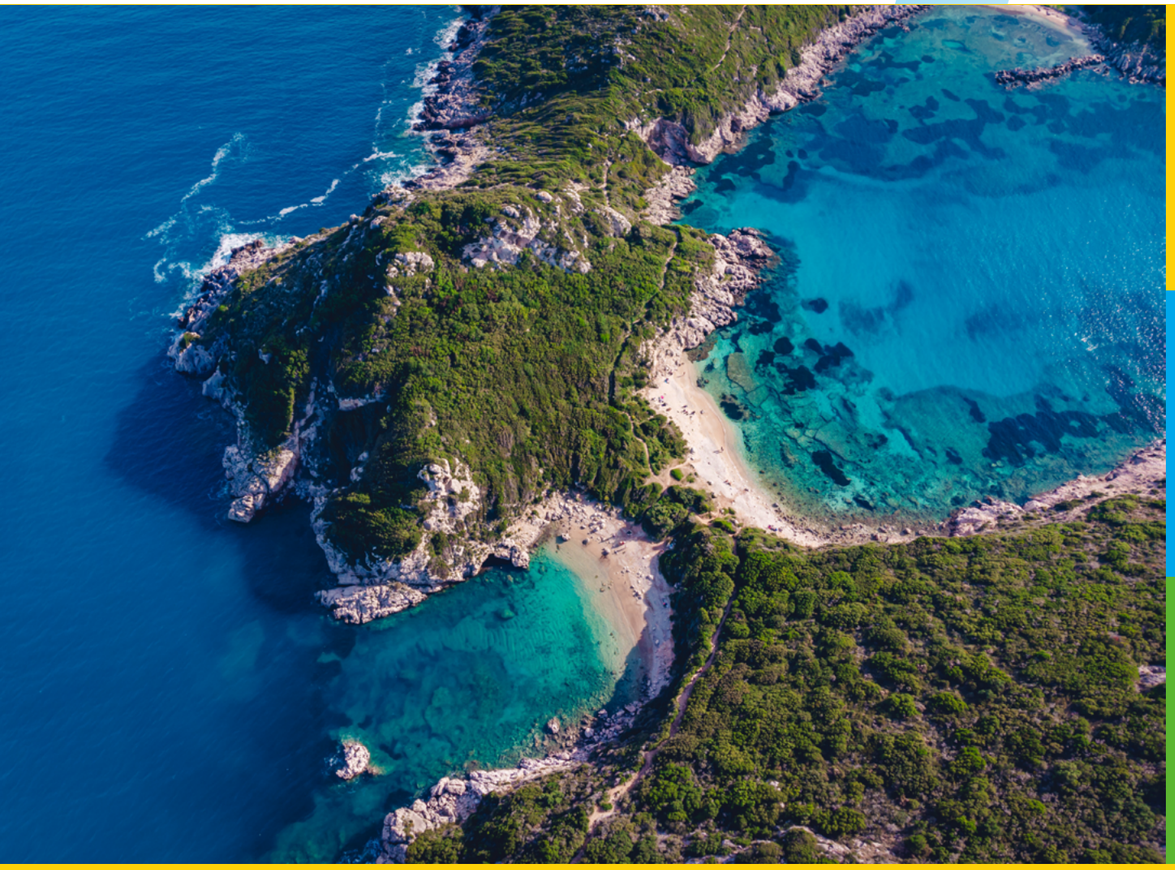
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李政翰 助理教授現為國立成功大學資源工程學系之專任教授 ( 同時為 Hi-GEM 協同研究員 )，研究領域主要利用廢棄物發展資源再生、循環經濟、提煉冶金、綠色創新及淨零碳排技術。目前除了從廢棄物進行元素循環外，也透過高值化技術將廢棄物直接轉變為可使用之材料，達到資源再利用的目標。而從廢棄物所循環分離的各元素，也能透過高值化技術應用至各產業，提升資源循環的經濟性。二氧化碳捕集與再利用 ( 淨零碳排技術 ) 則是從廢棄物直接實施，或是利用從廢棄物循環後的元素 / 材料進行，提升各元素 / 材料的應用價值，同時直接為淨零碳排貢獻力量。

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# 實現淨零排放的最速路徑

## Kenny Liu 施耐德電機台灣 永續發展事業部經理

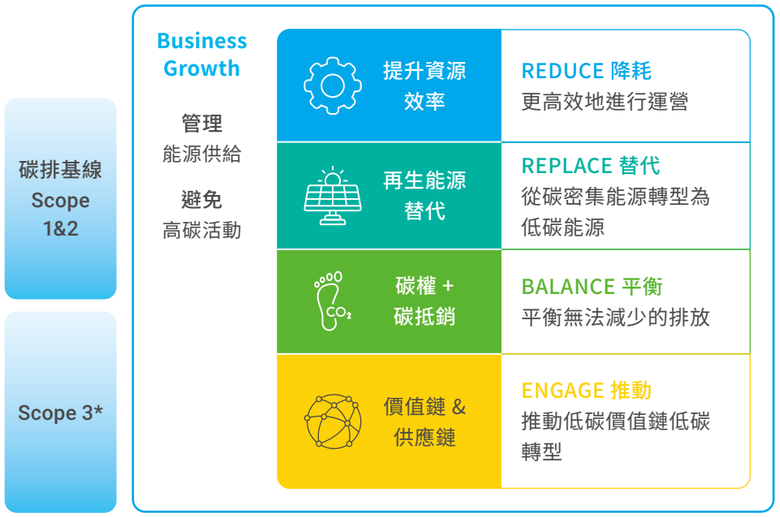
隨著工業社會的發展，人類對進步的需求無法避免，透過創新與行為轉變所帶動的消費模式轉型，將使經濟逐漸脫碳。 以當前的現況來看，不同類型的企業在面臨碳減排方面可能存在不同的挑戰和困境，例如國際綠色貿易壁壘、國內碳有價政策、供應鏈壓力、資本市場反饋等，本文將以企業的角度出發，說明能效管理優化如何助力企業快速實現永續淨零轉型。

我們認為企業邁向淨零排放有三大步驟，分別為：戰略規劃、路徑實施、績效管理。企業想實現淨零排放，制定碳中和戰略，首先要對其碳排放量進行盤查，瞭解自身當前的碳排放情況。更進一步，進行碳盤查的同時，建立企業自身的碳排放資料庫，為進一步分析如：碳排放變化趨勢、再生能源、憑證需求預測等提供資料來源；同時需要加强碳資產管理專業人才的培養及團隊的建立，以應對未來不斷擴大的碳資產管理需求。

在瞭解自身碳排放的基礎上，企業進行淨零規劃戰略的第一步是“想清楚”，包含企業進行節能減碳的路徑、短中長期計劃的投資與回報、標杆企業的作為等等。基於這些思考我們建議企業從“識別外部壓力”、“明確自身定位”和“創建淨零路徑”三個維度來規劃自身的戰略。



企業在宏觀層面思考未來可能的碳中和解決方案，而在具體的執行過程中則要對每一種路徑進行詳細分析，及執行落地。整體而言，企業一定要基於目前的碳排放現狀 ( 包括範圍一、二、三 ) 以及未來的業務增長情境，制定清晰、合理、可落地，成本可控的碳減排路徑，能夠兼顧企業低碳轉型與業務增長，實現永續發展。我們認為可以將減碳的路徑分為以下四種形式：**降耗** - 提升資源效率、**替代** - 即再生能源替代、**平衡** - 權益 + 抵消、以及**推動** - 價值鏈脫碳。




就實現碳中和目標來說，降低能耗往往是第一步。通過能效優化，企業可以在不影響生產效率和產品、服務品質的前提下，提高能源效率，減少能源消耗和碳排放，在降低用能成本的同時，加速實現淨零排放。結合施耐德電機衆多的服務案例和研究經驗，我們認為能效優化主要包括以下四個方面：

- **節能技術和產品：**選擇符合企業實際的節能技術和高效產品，根據企業所在地的自然稟賦，以及企業自身實際的用能結構和習慣，選取最合適的節能技術和產品，從而達到系統效率的最大化。
- **運行優化控制:**通過導入電氣化、數位化自動控制系統，根據實際需求設置控制參數，使設備能够根據企業實際生產製造、運營需求，動態調節運行狀態，以實現設備或系統的最佳化運作。
- **能源回收利用：**在企業生產營運的過程中，通過對未被利用的餘熱、餘能進行合理的回收及再利用，將有效減少能源使用過程中的損耗與浪費，提升企業整體用能效率。
- **科學化管理：**科學化能源管理，是企業節能減碳的重要手段。導入數位化技術，依據企業能源管理需求，構建能源管理的數位化平臺， 實現企業用能資料的實時監控和分析，為企業節能減碳提供持續的洞見與績效管理。

能效優化適用於任何產業。不僅適用於化工、金屬製造、水泥建材等大型流程製造業，及資料中心、工業園區等能源密集型產業和領域，越來越多的其他產業，如電子製造、半導體、再生能源、食品飲料、製藥等非能源密集性企業，逐步意識到節能減碳的價值與重要性，並開始與外部的顧問夥伴合作，規劃實施能效優化計劃。在新建專案階段，可以通過詳細的綠色低碳規劃，如圍護結構、機電系統、再生能源建置設計等，在專案的設計階段規劃出合適的路徑，並在後續的採購、施工、營運等階段確保營運與設計的一致性；在既有專案階段，伴隨業態或功能布局的變化，用能設備及系統性能的衰減，所導致的整體營運效率下降，極需通過能效優化的方法，挖掘節能潛力，規劃節能減碳具體措施和實施路徑。

由於在企業的永續轉型中，能效提升是一項系統的專業工程，有其專業的方法學和工具，用於識別、評估和實施、及追蹤能够提升能源效率的改進措施，而企業當中往往缺乏相關的經驗以及專業人才，所以我們建議企業結合永續轉型的目標及各階段的計劃，尋求專業的外部夥伴進行：

- **能源審計和研究：**對企業的能源使用情況進行全面的審計和評估。這包括收集和分析能源資料，識別能源使用的瓶頸和低效環節，以及評估潛在的能效改進機會。
- **節能優化方案設計：**制定詳細的能效優化計劃，包括選擇適配的節能技術、確定商業模式和具體優化步驟等，確保計劃具有可操作性及可實施性。
- **節能優化實施：**依照優化計劃，逐步實施能效改進措施。這可能涉及到技術升級、設備替換、工藝調整等多個方面。確保實施過程中有足够的資源和支持，以克服潛在挑戰和障礙。
- **節能績效追蹤：**在實施優化措施後，定期監測和評估效果。包括收集和分析優化後的能源資料，與優化改進前的性能進行對比，以確保實現預期的能效提升。

企業採取行動主動脫碳的必要性毋庸置疑，而現實中很多企業仍處于觀望態勢。其背後的原因不管是對當前或未來的政策趨勢、行業發展缺乏深刻認識，還是對投資回報存有疑慮，較大一部分原因源于全局和長期思維的欠缺。因為每一項具體減碳措施的背後都意味著系統性的變革支撐，而絕非單個場景或部分的改善：

- 戰略制定上，需要從業務發展出發，結合企業內部碳排放現狀和外部市場分析， 建立可持續願景和目標，並確定行動的優先級；
- 路徑選擇上，結合外部資源及企業自身管理改善，擁抱節能減碳技術及數字化技術，從技術可行性和投資回報率等方面綜合分析各種減碳路徑和方案，結合企業的承受能力，執行減碳計劃

企業行動緩慢的另一原因是企業對淨零排放的認知趨於狹隘，如容易錯誤地將低碳轉型置于成本節約的對立面。事實上，在我們服務客戶以及調查研究過程中，我們發現很多企業已經基于合理的戰略規劃，實施能效優化、精益管理、循環經濟等達到了節約成本與減碳的雙重效果。因此，我們建議企業應當將低碳運營，作為永續發展的長期目標和降本增效的嶄新機遇，科學化的培養低碳運營的能力。






## 作者

**Kenny Liu**

**施耐德電機台灣**

**永續發展事業部經理**


### 組織簡介

施耐德電機的宗旨是創造更大的影響力，賦能所有人最大化利用能源和資源，推動人類進步和永續的共同發展。在施耐德電機，我們稱之為 Life Is On。施耐德電機的使命是成為您實現高效和永續發展、且值得信賴的數位化夥伴。作為全球工業技術領導者，我們為智慧工業、基礎設施、面向未來的資料中心、智慧建築與家居帶來領先世界的電氣化、自動化、數位化專業知識。憑藉厚實的領域專業知識，我們提供整合端到端生命週期與 AI 的工業物聯網解決方案，包含互聯產品、自動化方案、軟體與服務，並透過數位孿生幫助客戶實現獲利成長。施耐德電機是一家以人為本的企業。我們擁有由 15 萬名同事與超過 100 萬名合作夥伴組成的生態系統，並在 100 多個國家發展業務，以確保我們了解客戶與利益關係人。我們在每件事、每個行動中積極實踐多元共融，並期待為所有人創造永續的未來。

### 作者簡介

Kenny Liu 現任施耐德電機台灣永續發展事業部經理。專注於企業永續發展領域，職責涵蓋企業合作、生態圈拓展、永續轉型策略建議及專案實施。Kenny 在中國大陸擁有超過 10 年的豐富經驗，並持有 ISO 14068-1 碳中和主任稽核師、ISO 14064-1 組織級溫室氣體盤查主任稽核師、ISO 14064-2 專案層級溫室氣體減量暨抵換專案主任稽核師、ISO 14067 產品碳足跡主任稽核師、PAS 2060 碳中和建置、UNPRI 高級責任投資分析等多項專業執照。



## 引導客戶邁向綠色未來

作為一家全球化公司，我們有責任在整個價值鏈中減少溫室氣體排放。您可以在我們的官網上查看我們基於科學目標的氣候承諾，以及我們如何為向低碳社會轉型作出貢獻。最重要的是，我們推出了一項新策略，旨在引導客戶了解永續解決方案，幫助顧客實現其氣候目標。

◀ 了解更多關於我們的氣候承諾

你知道嗎？一台能耗 500 kW 、每年運行 8,000 小時的壓縮機所排放的 $CO_2$ 量幾乎等於 2,400 趟倫敦至紐約的來回航班。因此，確保設備以最高效的方式運行絕對是重中之重。我們只要在製程上做些微的改變就可以在碳排放和成本方面節省大量資源。

值得慶幸的是，有 94% 的壓縮機能源是可以被回收的，這些回收後的能源讓用戶在冬天暖房、夏天降溫，甚至轉換成電能。不是所有選項都需要複雜的系統—例如說，製程中所產生的熱能可以直接用一些管路系統來傳送。

## 邁向綠色未來的十步指南

這類實用資訊正是我們壓縮機技術 (Compressor Technique) 部門新的策略核心。其目的旨在協助客戶永續解決方案，您可以在阿特拉斯・科普柯（Atlas Copco）官方網站上看到減碳計算工具和邁向綠色環保的十步指南。

我們希望用客戶的語言來談論更多，我們不是談論我們有多棒，而是更專注於為何公司應該選擇我們，以及我們擁有哪些解決方案。第一步就是邁向綠色環保。

永續發展是未來每間公司將面臨的最大挑戰和機會之一。許多公司正在努力達成雄心勃勃的減碳目標，同時尋求利用最新的綠色技術，從而在競爭中取得優勢。

## 節省

這十步指南可以幫助公司在製程上減少浪費並節省資金。有些公司因不當使用壓縮空氣或設計系統效率低下，浪費了多達一半的電力。例如，每增加 1 個大氣壓，所需的功率就會增加 8%，因此將工作壓力保持在最佳水平上可以產生很大的影響。當一項正確的行動需要一次性的大額投資時，它往往能帶來長期的成本節省。如果將舊設備與新的壓縮空氣解決方案相比，回本的速度非常快，而與可以實現的能源節省和 $CO_2$ 減排相比，投資成本顯得微不足道。」

◀ 了解更多有關我們的碳減排計算工具的資訊

**製程效率分析**

### 1. 應用與安裝

壓縮空氣在不同生產製程中扮演非常重要的腳色。 然而， 空氣需求隨著時間變化，原有設備可能無法滿足該空氣需求， 導致能源成本增加和碳足跡提升。

### 2. 儲存與分配

壓縮空氣系統中的管路分配和儲氣筒罐往往會被忽視， 但它們在效率中扮演著至關重要的角色。 透過完整設計的空氣系統是可避免壓力下降， 同時節省能源和成本。

### 3. 空氣品質

製程中有適當的空氣品質可以有效防止水分、油污、灰塵甚至微生物等污染物，這些都可能影響生產穩定性以及產品品質。

### 4. 空氣量與流動模式

要注意生產中的不同流量模式。 需求的變化也需要考慮。 Atlas Copco 的 AIRchitect 服務可以視覺化您的流量模式並展示潛在的系統改進方案。

**壓縮系統優化**

### 5. 核心技術

無油、微油、齒輪式、螺旋式、活塞式或離心式壓縮技術， 廣泛應用於各種工業用途。Atlas Copco 可依據您的生產需求， 協助您選擇最適合的技術方案。

### 6. 設備控制

我們的先進控制器搭載智慧運算，能夠協助管理壓力並優化電力耗能， 有效降低電力消耗與碳足跡。

### 7. 系統控制

即使是最節能的產品（如壓縮機、乾燥機等），也只有在相互配合下才能發揮最大效益。中央控制器可以將系統效率最大化， 同時降低碳排放量。

### 8. 可回收能源

壓縮空氣運轉過程中會產生熱能， 別讓這些熱能白白浪費了！ 透過消耗後的能源再利用，這也是為什麼我們的能源回收系統可以降低製程中能源消耗。

**遠端監控系統**

### 9. 系統維護

壓縮空氣系統的良好維護，節省的能源費用將遠超過維護成本。 延遲 維護不會幫您省錢，反而得不償失。

### 10. 系統監控

遠端監控系統讓您隨時隨地監控並優化壓縮機機房， 並符合 ISO 50001 能源管理標準的要求。





## 作者

**阿特拉斯科普柯股份有限公司**

我們是阿特拉斯・科普柯集團，在台灣市場已深耕許久，集團至今超過 152 年了，我們提供四大業務領域：**壓縮技術**、**真空技術**、**工業技術**以及**動力技術**，為客戶提供高品質和高效能的壓縮機以及售後服務。

壓縮空氣無所不在，可用於許多行業，在您的工廠中您都會看到空氣壓縮機的身影。讓我們一起不斷成長並推動社會前進。



# VEOLIA 微電子半導體及光電工業用水管理與回收效能提升策略

**袁宇正** 台灣威立雅環境資源 ( 股 ) 公司 提案應用 / 專案開發經理

## 前言

全球高溫、強降雨等極端氣候，造成各地乾燥、森林大火及洪水等天然災害頻傳，氣候變遷影響更為劇烈，面對降雨時間及空間的異常變化，致使汛期與旱期的應變更無法預期，也使得水資源管理更加嚴峻。台灣地區降雨量雖豐沛 ( 一年約有 936 億噸之降雨，在扣除蒸發與河川直接排入大海水量損失 ; 每年可利用水資源量約 143~177 億 M3 利用率僅 14~19 % 實在非常低。蓄水設施 ( 水庫 ) 可調節提供水量約總用水量的 23%，另 20%來自地下水外，其餘約 57%，全賴自河川直接引水。因河川陡峭，降雨流失極快，無法維持一定的流量，以提供地面水，在旱季就有缺水問題，尤其中南部乾旱期長達八個月，其水資源供應更不穩定。我國近年來工商業發展迅速，人口不斷增加，經濟持續穩定成長，國民生活品質逐年提高，使得民生、工業用水量及水資源需求急遽增加。為因應未來用水劇增之需求，政府除將積極全面推動節約用水措施及回收再利用為重要永續發展因應之道。( 經濟部水利署 楊偉甫署長 2010-10-15)

行政院核定產業穩定供水策略宣告提高工業用水循環利用率，在強調水資源得以永續發展利用及落實總量管制機制之原則下。隨即於 1995 年核定「現階段工業用水發展政策綱領」之政策，2000 年推動「節約用水行動方案」以及 2005 年進行「水資源永續發展政策規劃」等相關政策，以穩定供應工業用水，並持續提升工業用水效率，擴大推動節約用水工作，期於 2021 年達成平均用水回收率 65% 之目標並加速規劃 2031 年工業區整體用水回收率達 75% 的目標，為改善與持續提升工業用水效率，然目前工業用水回收再利用面臨之水資源管理問題，在法規行政管理面、用水特性面及廠商態度面仍有待克服突破。產業用水效能提升計畫 (2023-09-22) VEOLIA 藉由已成熟與驗證之處理設備與流程管理技術分享與交流，並配合相關政策加強 ( 工業區 ) 用水計畫管理，積極營造產業多元水源應用評估及水資源整合等推動，希冀持續提升產業因應極端氣候的韌性，打造更具效率的用水環境。

# 國內工業用水及回收再利用現況

## 1. 工業用水回收再利用之推動需求

國內水資源依用水標的分別為**生活用水**、**農業用水**、**工業用水**及**保育用水**。根據經濟部水利署統計資料，近十年來台灣每一年的平均用水量約為 168 億噸，其中生活用水佔 18.9%，工業用水佔 9.6%，農業用水佔 71.4%。雖然工業用水的佔比是最低的，但產值卻上佔生產毛額達 30 %。因為台灣經濟不斷成長未來工業用水的需求每年快速增長。根據經濟部水利署預估，有鑑於台灣未來人口數將呈現微幅下降，生活用水量會小幅減少，農業用水持平，但**工業用水則會大幅度上升，並超過生活用水減少的數量**。我國目前工業用水回收率落後歐美日本等先進國家，且工業廢水種類及水質較為複雜，各別工業之水回收多再利用於清潔及次級用途等，為顧及不與民用爭水並穩定台灣經濟成長，故在**水回收再利用之技術面及廢水收集分流之管理面**，均有相對較大研發改進突破的空間。

經濟部水利署水資源永續發展政策規劃，以 2021 年為基礎年情況，我國工業用水量將以約 29 億噸為工業用水資源之**管制總量**（財團法人中興工程顧問社環境工程研究中心）。加上近年來台灣半導體微電子與光電產業已成為國際重要之供應源；將其他產業外移因素考量在內，依經濟部近幾年促進產業投資優惠方案，針對半導體微電子與光電產業最需要之土地成本等租稅優惠吸引根留台灣，此類企業工業用水資源之合理使用，提升合理用水效率及創造水資源運用效益，輔導產業落實水回收再利用技術及管理機制，將是未來工業用水策略重要議題。

## 2. 工業用水與回收再利用現況

依廢水產生量範圍分類統計如表 1 所示，目前事業廢水回收再利用者大部分仍集中於中小規模事業。依回收使用用途而言，現行事業廢水回收後用途整體比較以**「製程」為主**，其次為「冷卻」等次級用水。

| Range of WW flows at listed management (CMD) | Plants in listed management | Plants WW flow in average (CMD) | Reclaim water to go for use (%) | | | | |
|---|---|---|---|---|---|---|---|
| | | | % in WW flow | Manufacting Process | Cooling system | Treatment units | others |
| | | | | each use with in total reclaim water (%) | | | |
| 100,000-1,000'000 | 1 | 410,705 | 98.83 | 13.45 | 86.5 | 0 | 0.05 |
| 50,000-100,000 | 4 | 70,839 | 80.32 | 73.53 | 26.36 | 0 | 0.11 |
| 10,000-50,000 | 15 | 22,299 | 55.06 | 99.28 | 0 | 0 | 0 |
| 5,000-10,000 | 16 | 7,067 | 62.25 | 90.4 | 8.97 | 0 | 0.62 |
| 1,000-5,000 | 124 | 2,149 | 67.6 | 91.3 | 5.75 | 0.65 | 3.34 |
| 500-1,000 | 74 | 745 | 64.11 | 87.84 | 11.63 | 0.41 | 2.96 |
| 100-500 | 163 | 246 | 63.04 | 89.65 | 4.51 | 2.16 | 9.09 |
| 50-100 | 115 | 76 | 61.97 | 86.21 | 8.24 | 0.33 | 7.02 |
| 0-50 | 1,010 | 60.9 | 65.04 | 90.83 | 4.21 | 1.18 | 5.96 |

表 1 水污染管制列管申請事業廢水回收再利用統計
資料數據原始來源：呂鴻光，「水回收再利用」，2006

## 3. 工業發展面臨之水資源管理問題

根據前經濟部水資源局 86 年資源政策白皮書上所載，台灣地區工業用水量至 2021 年預估將增為 11.61%。尤其是台灣朝工業區發展，工業用水具有區域集中性，以北部地區為例，因工業區較多，其工業用水比率便達 16.51%，明顯高於中部地區的 6.94%。而半導體工廠所集中之新竹地區，其區域用水集中情況，應更高於北部地區之一般平均比率。工業用水及生活用水均依賴送水設備及送水管線輸送，快速且集中的用水成長，使得區域用水因供應設備、供應量無法迅速跟上需求而失衡，因而時有限水、缺水的危機。過去幾年來，新竹科學園區便因為用水的快速成長而一直遭遇到限水與缺水問題的威脅。**在開源不及之下，節流措施便成為此區域廠商—特別是半導體業者**—目前所積極去研究與進行之對策。(UMC 江岱叡半導體工廠用水節約之研究 )



### 台積公司三大科學園區用水占比

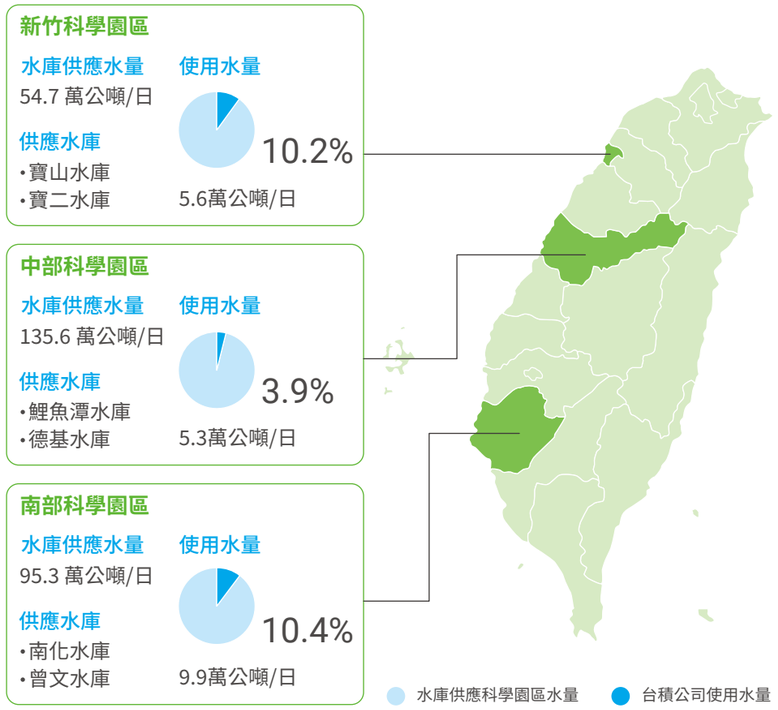



圖 1 園區用水占比分析
資料來源 : 經濟部水利署網站公開訊息

鼓勵廠商導入再生水使用，降低自來水使用量依賴度，提高園區抗旱韌性，是目前工業發展面臨之水資源管理問題之首重：永康、園區（台積電）及安平等再生水，自 2022 年起陸續供水到南科，2023 年底前供水約達每日 3.8 萬噸，加上興建中之仁德及水滴等再生水廠（含換水），預計 2030 年再生水使用量達 31.91 萬噸／日以上（包含竹科 9.7 萬噸／日、中科 9.86 萬噸／日、南科 12.35 萬噸／日）。期待未來將再提高用水回收成效，半導體及光電業製程回收率達到 85%以上，科學園區用水回收率預計 2032 年提高至 80%以上，以降低整體用水量。( 工商時報 03/28/2023 國科會：半導體、光電業 用水回收率拚 85%以上 )

資料來源：工業用水量係根據經濟部水利署歷年工業用水統計 ; 回收率係根據 ( 連錦漳，2006)

## VEOLIA 於工業水回收再利用提升回收率的建議

台積電對傳統水庫的用水和計劃使用從其污水中回收水有很強的自我實踐園區領頭羊角色及使命必達意識。配合目前水處理技術皆可供應穩定之水量與水質，然在面臨用水成長壓力等嚴峻條件下，又環境變遷等資源有效及永續議題趨勢下，還要思考精進加強水回收再利用效能與合理程序與節能減碳以致在提升回收水量 (70% up to 80%) 是日顯艱困與急迫。

VEOLIA 非常願意與各單位合作，實現淨零目標。以下是我們提供的解決方案：

經過驗證的技術處理裝置和傳統廢水的處理工藝流程，可實現凈零污染 / 微汙染精煉去除，並減少程序之碳足跡，且確保降低對排放水水質污染負荷的理想，提供節能、低耗電，及提升水回收系統運轉效率的優勢；同時還節省了大量的建設成本，並在進一步的回收水廠中為運營支出做出貢獻，並減少了回收水廠系統組操作管理介面間的複雜與風險。

### VEOLIA 用水特性瞭解與尋求合作客戶的支持與提供

VEOLIA 衷心期待針對事業客戶單位用水標的，建立用水基線資料建立，在水量部分包含原始取水量、重覆利用水量、產製水量、消耗水量及排放水量等；水質部分處理器要求水質、處理器要求水質及製程水質變化機制。利用給水系統圖、製程流程圖，探討生產線上各製程使用水量及水質要求關聯性。根據水資源盤查結果，針對廠內各單元之用水流程、供排水量及各水質變化等彙整至水系統圖，再針對各系統組成作滲漏分析及水量平衡試算。

用水最適化評估包含循環水再利用 (Recycling) 及回收再利用 (Reuse) 兩類。就循環水再利用而言，如冷卻用水或加熱用水，程序中除溫度改變外，水質並未受相當程度之影響，均可再循環使用。而回收再利用水，則應先行清查全廠具回收潛力之排放水點，以及再利用點所需的製程單元的水質數據，再進一步依達到水質要求之水回收技術及設備規劃，進而使製程用水回收再利用。

## VEOLIA 在台灣工業用水回收再利用之策略與推薦技術

台灣工業用水回收再利用推動之策略面與管理面實乃相輔相成。又因製程系統複雜，且需求及製程排放之水質往往因製程特性而異。如 1. 有機和無機化合物 2. 溶解物和顆粒物 3. 易揮發性和非易揮性 4. 反應性強、惰性強 5. 親水疏水特性物質 6. 溶解氣體 .. 等。汙染物質因製程分流管理疏失之不完全，或其他異常操作，乃至清洗汙染，均有可能廢水排放異常與造成回收水水質穩定管理的干擾與風險。

VEOLIA 針對上述汙染物干擾特性與其汙染物移除當量效能所需的成本 ( 含土木、電耗、碳排、耗材 ..... 等 ) 進行程序優化評估 ( 如圖 2) 使之達到廢水處理效能提升與最大化產水量，再配合智慧控制與簡化產水流程管理介面為最終目標。

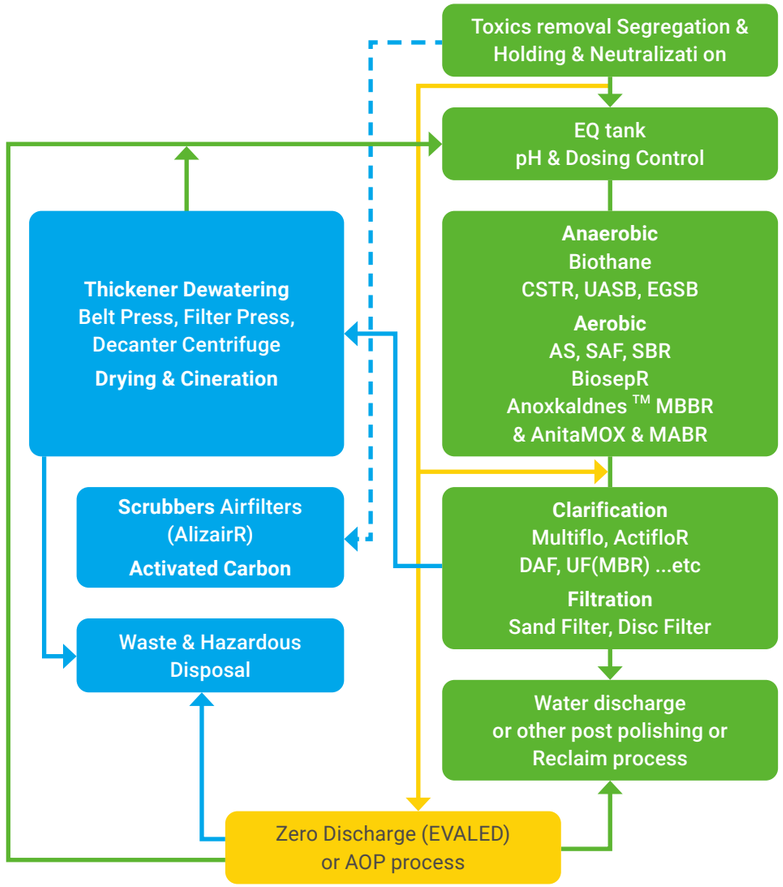



圖 2 VEOLIA 廢水處理回收再利用程序之相關配套設備

VEOLIA 將基於工業客戶用水與廠務管理系統性思維，針對廠內處理器與節水廢水處理設備整合方式加以評估分析。同時，考量落實水回收再利用技術整合優化後之價格合理性，以維繫與客戶關係共利發展之重要關鍵。減碳規劃與特殊汙染物清除處理的設計及回收經濟效益，將被視為達成 VEOLIA 生物轉型全球政策 (biotransformation global policy) 並推動水回收再利用之首要任務。

## 結論

「再生水資源發展條例」公布後，明定「水源供應短缺之虞地區者，開發單位應使用一定比率之系統再生水」，相關子法如「水源供應短缺之虞地區使用再生水辦法」等正積極研擬中，也突顯水資源整合的重要性。面臨缺水問題除開發新水源外，回收各地區廢污水處理廠之廢污水，供給當地工業用戶使用，已成為新興水源開發之重點。國內工業區內聯合污水處理廠因水質多樣性且不穩定之因素，造成廢水回收之困難，極少部分工廠將納管水回收作為冷卻塔與次級清洗用水，其餘則直接納管排放。倘若能整合該區域內廠商之水資源，依供水端廠商放流水水質水量媒合適宜之使用端廠商，除可節省供水端廠商廢水處理費及納管費外，亦可降低用水端廠商原水取水量及費用，達成區域水資源整合再利用，並提升企業綠色形象。

針對用水密集、高耗水產業與用水大戶進行節水輔導作業，配合工業用水多元化、廢水回收再利用、水資源整合、用水管理系統推動以及節水創新技術宣導工作，提高工業用水回收率。回收率已由 2002 年的 46.0% 大幅提升至今約 70%，並預期應可朝未來更艱難用水回收更高之目標提升邁進。除了克服用水回收技術面的高成本問題外， VEOLIA 將推動全球視野角度與政策，配合減碳去污（去除微污染物）和再生創新解決方案，並配合符合當地規範與行政機制的策略，以實現本地化的雙贏合作。為響應政府政策預期，我們應朝未來之用水回收目標邁進，以往 2031 年政府推動工業用水回收再利用率 80% 之目標推進。

欲查相關參考資料，請造訪 Veolia 官方網站：http://veolia.tw/en。




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**提案應用 / 專案開發經理**


### 專業年資

27 年

### 學歷

英國國立布萊福德大學 (UK, University of Bradford) 環境科學博士

### 專案經歷 (2015~2023)

- AnitaMOX (類厭氧氨氧化) 生物測試 / 中試測試性能結果得到驗證，功能設計得到威立雅總部核准
- 在香港沙田污水處理廠進行 A/O…..MBBR （1000 CMD） 試點測試
- 新建的 UASB 用於去除 TMAH 調試，接續現有的 A/O...MBR 在 Giant-Plus 污水處理廠 （2000 CMD） 提升 BNR 工藝性能的調整試車至最終全廠放流達標
- Firmenich (印尼) 餐飲工業污水處理廠現場審核，用於績效評估，以增加改造的生產效能
- 雀巢 (泰國) 餐飲工業污水處理廠新安裝的 MBBR 啟動與全廠放流達標
- Friesland （印尼） F&B 工業污水處理廠現場審核，用於對廢棄 ZLD 改造的性能審查

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## 交通運輸的減碳趨勢與技術應用

減少交通運輸領域的碳排放是實現全球永續發展目標的關鍵。自 2000 年以來，重型車輛的二氧化碳排放迅速增加，迫使各國轉向更具可持續性的運輸解決方案。目前，歐洲道路運輸約佔總溫室氣體排放量的 25%，其中公車和重型卡車為主要排放來源。因此，盡早實現重型車輛零排放成為首要目標。

交通電氣化是移動減碳趨勢的核心，無論是在工業、建築，還是交通運輸領域，電氣化轉型對達成可持續發展目標至關重要。隨著道路運輸電氣化進程加快，電力和氫能有望成為主要能源。國際能源署（IEA）預測，最終能源使用中的電氣化比例將從當前的 23%提升至 55%，以達成淨零排放目標。

電動巴士和卡車的普及是目前的主要趨勢，公共運輸機構和車隊運營商紛紛採用高功率電動車解決方案，並且隨著公共充電設施的投資和電網升級，創新充電基礎設施也應運而生。此外，電動巴士被視為城市交通減碳的關鍵要素，不僅減少排放，還優化公共運輸系統。為了支持大型車隊的電氣化，電網到插座的充電基礎設施也在不斷演進，確保電力的穩定供應與高效分配。重型卡車和巴士的電氣化進程快速推進，市場上也推出了新型電動巴士。與此同時，電池技術的進步使得電動車的續航里程延長，充電時間縮短，進一步推動了減碳趨勢。





## 減碳過程中的挑戰

在實現交通運輸減碳的過程中，面臨著多方面的挑戰，包括技術、成本和運營層面的困難。電動車的高昂前期成本是主要障礙之一，電動巴士的價格通常是傳統巴士的兩倍，電池成本佔據很大比例。儘管在燃料和維護方面有長期節省，但這對於車隊運營商來說仍是財務上的難題。

另一個重大挑戰是電網基礎設施的升級需求。隨著越來越多的電動車上路，尤其是重型車輛，電力需求將大幅增加。現有電網可能無法應對這些新負載，導致峰值負荷和電網限制問題。因此，需要大規模投資來更新電網，並提供更強大、可靠的連接。

運營上的挑戰也不容忽視。電動巴士和卡車需要精心設計的服務系統，以確保運行可靠。電動車在不同的操作條件下（如不同的負載、溫度和距離）的性能可能不穩定，因此需要持續監控和智慧物流系統。路線也需要根據電動車的特定需求進行調整，如充電時間表和可用性，這可能降低運營的靈活性。

標準化充電基礎設施的互操作性問題同樣值得關注。不同的充電速度（慢充、快充和機會充電）缺乏統一標準，這使得城市和企業在規劃和投資基礎設施時面臨困難。

能源部門的參與至關重要。不同城市的能源分配模式意味著電力成本在地區之間可能差異巨大。確保穩定且具成本效益的電力供應，是電氣化努力成功的關鍵。維護方面，電動車的特殊需求需要新的診斷、維修和安全方法，這也增加了運營的複雜性。



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## 日立能源的解決方案與優勢

日立能源通過其 Grid-eMotion® 解決方案，正積極應對上述挑戰。Grid-eMotion® 提供兩種不同的解決方案：Grid-eMotion® Fleet 和 Grid-eMotion® Flash。這些系統提供了全面的充電基礎設施，從電網到插座，專為巴士和重型車輛設計，助力電動交通的無縫轉型。

Grid-eMotion® Fleet 非常適合需要大量直流電的車輛停車場，利用與中壓直接連接的整流變壓器，提供靈活的解決方案。該系統以集中化的電力模塊設計，能根據車隊規模擴展，減少複雜性、提升可靠性，並確保充電過程的順暢。通過集中整流過程，維護得以簡化，系統可靠性也得以提高，因為任何充電模塊都可以輕鬆更換，而不會造成重大干擾。

Grid-eMotion® Flash 則專注於公共巴士的高功率路徑充電。該解決方案允許巴士在短暫停靠（如乘客上下車時）期間快速充電，顯著減少停機時間，使巴士的運行效率與柴油車輛相當。閃充技術減少了大容量電池的需求，優化了車輛的能源消耗，降低成本。此外，該系統具備高度的靈活性，未來無需巴士與基礎設施之間的通信即可操作，從而確保系統的前瞻性。

這些解決方案帶來了諸多好處，如減少排放：通過電氣化巴士和卡車，Grid-eMotion® 直接促進了二氧化碳排放的減少，幫助城市和企業實現可持續發展目標。此外也能夠有效提升運營效率：借助智能充電解決方案和模塊化維護系統，停機時間最小化，車隊的運營更加可靠和具有成本效益，同時也能做到成本節省的需求。儘管前期成本較高，但隨著時間的推移，運營商可通過降低燃料成本、減少維護需求和優化能源使用實現顯著節省。而日立能源的解決方案專為隨著車隊規模的增長而設計，是小型和大型運營的理想選擇。系統的靈活性允許運營商輕鬆適應未來的技術進步。

## 日立能源成功案例

日立能源的 Grid-eMotion® 解決方案已在全球各地成功應用。於加拿大魁北克市，日立能源在 2023 年啟用了 6 台 100 kW 的充電器，為當地的電動巴士車隊提供支持，展現了其解決方案在城市環境中的實效性。



在德國柏林，2023 年於兩個巴士車庫安裝了 56 台 75 kW 的充電器，支持柏林的公共運輸系統實現減碳目標。瑞士日內瓦自 2018 年起部署了 Grid-eMotion® Flash 解決方案，利用三台 430 kW 的終端充電器和 12 台 600 kW 的快速充電器，使巴士系統達到與傳統柴油車隊相同的效率，並顯著減少排放。此外，於澳大利亞布里斯本，2023 年啟用了 16 台 600 kW 的閃充充電器。

日立能源的 Grid-eMotion® 解決方案在全球多地取得成功。於加拿大魁北克、德國柏林、瑞士日內瓦和澳大利亞布里斯本等地，該技術展示了其可靠性與適應不同環境的能力。這些成功案例凸顯了日立能源的解決方案在支持城市公共交通電氣化、減少碳排放以及提高運營效率方面的貢獻，並展現了其應用的潛力。台灣方面，目前台灣電力公司（TPC）已在新竹忠孝路劃出土地，用於開發最先進的智慧停車結構。該設施預計將設有 325 個停車位，其中一些停車位配備了 V2G 和 V1G 混合充電站，突顯了台灣對永續能源和智慧基礎設施發展可能。相信日立能源的創新解決方案在全球持續推進交通運輸領域的減碳進程，也為台灣未來發展智慧交通設施提供了寶貴的經驗與支持。

### Depot charging

**2 Bus Depots**
Britz and Cicero

**CCS2 double plug**
Single and dual plug charging stations

### Technology

**14 x 75kW (x2)**
**3x DC-DC modules**
Chargers simultaneous or sequential

**1.25 MVA**
Grid connection









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## 作者

台灣日立
永續能源

前身為 ABB Power Grids 電網事業群，ABB 於 1988 年在台灣成立，三十餘年不斷創新、精進。2020 年 7 月 1 日，日立集團和 ABB 共同成立新合資公司「日立 ABB 電網」，延續電網業務的營運成績，並做為台灣企業與日立 ABB 集團全球資源的連接橋樑，為客戶、員工和社會創造更多的價值，從 2021 年 12 月 1 日起正式更名為「台灣日立永續能源」。目前，全台約 132 位員工，營運據點分佈台北、台中、高雄。

憑藉在電力領域超過百年的經驗，日立永續能源擁有領先業界的技術，能滿足各產業的電力需求。我們為台灣產業，如半導體、電子、石化、電力、風力發電、再生能源、鋼鐵、造紙、營建等，提供穩健的軟、硬體技術對策。解決方案包含：電網系統自動化、電網整合、變壓器產品與高壓產品暨服務、離岸風電、太陽能、儲能解決方案。

日立永續能源是台灣企業的長期事業夥伴，以高效完善的營運系統，為客戶提供高品質服務並贏得信賴。專業、熱情、積極的工作態度，使我們成為客戶的最佳選擇與策略夥伴。日立永續能源陪伴客戶成長，協助客戶在競爭激烈的國際舞台上保有競爭優勢。在台灣，有專屬的日立永續能源專業工程師隨時待命，為客戶提供無微不至的技術服務，確保客戶端的產線運作不間斷。

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博世正致力於引領氣候中和交通

## 形塑電動交通新紀元

**楊建新** 台灣博世 原廠汽車零件業務部總經理

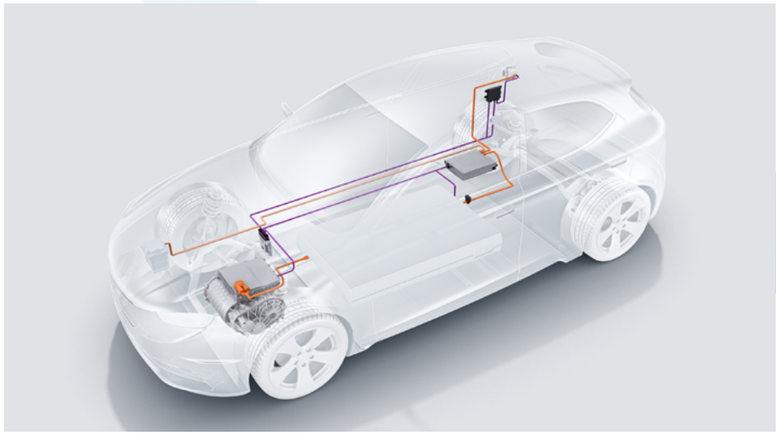
交通移動正在歷經變革，從而更有效率地守護環境。全球交通科技領導供應商博世正致力於引領氣候中和交通發展。為此，博世憑藉豐富的跨領域經驗及長才，確立電動交通最佳夥伴的地位。從晶片、電動軸 (e-axle)、軟體與服務，乃至電池回收科技，博世是整條電動交通價值鏈上的領導供應商。電動交通對博世來說是具成長潛力的市場，不僅是我們核心業務之一，更是全球電動交通減碳的關鍵科技。

## 鞏固動力系統市場領導地位

博世正在推動電動交通的轉型，並把握商機。身為動力系統解決方案的市場領導者，博世領航電動動力趨勢，並從電動自行車到商用車廣泛布局。2022 年，我們的電動驅動元件產量較前一年增加 50%，而在 2019 年至 2023 年間，我們的客戶數量亦成長一倍。

對於電動驅動系統而言，安全、性能、續航力、重量和安裝空間都是必須考慮的要素。博世的電動一體化動力系統解決方案 e-axle 電動軸，能為電動車解決這些挑戰。e-axle 結合馬達、電力電子及變速箱，由精巧的單一機組直接為車輛的車軸提供動力，有助於降低電動動力系統的複雜性。電力電子裝置可將電池中的直流電轉換為電動馬達所需的交流電。電動馬達則負責機械式的能量轉換，最終透過變速箱將行車動力傳送至車軸，從而驅動車輛。系統電壓高達 800 伏特，透過碳化矽 (silicon carbide, SiC) 半導體科技提供更高的功率密度，效率高達 96%，電動動力系統解決方案更上一層樓，可透過高扭力、快速充電和增加續航里程讓車輛快速加速。除了最佳化的性能、輕巧的設計以及單一裝置內高度的系統整合，e-axle 提供具成本效益的整體解決方案，集創新、經濟與效率於一身。

隨著動力系統多樣化，不同電動化程度的解決方案也相應而生。集中式動力系統控制器能為功能更多、軟體複雜度更高，以及需要更多動力的汽車車聯網提供解決方案。車輛控制元件能協調，甚至執行動力系統元件的功能，包含控制逆變器、電池管理系統、變速箱以及引擎管理系統。透過標準化介面傳輸數據控制電池充電，亦能被整合進車輛控制元件。此外，電氣 / 電子 (electrical/electronic, E/E) 架構中加入抽象層級，讓動力系統元件的變更處理更簡便，並節省附屬元件相關控制單元的資源。其模組化設計結合可調校的硬體與軟體，車輛控制元件可靈活配置，以滿足未來其他需求，提供中型及大型兩種版本的標準化車輛控制元件，亦可進一步擴充以滿足客戶需求，以最新一代的引擎管理為基礎，採用資源最佳化的微型控制科技。



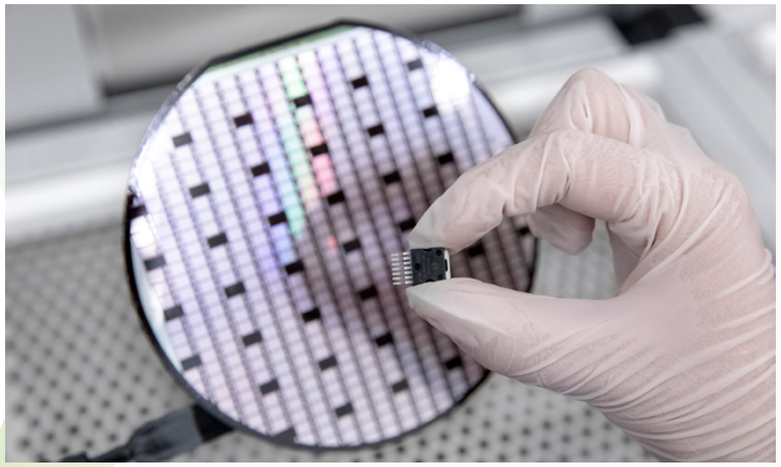
e-axle 結合馬達、電力電子及變速箱，由精巧的單一機組直接為車輛的車軸提供動力

隨著電動動力系統更加強大、高效，熱能管理的重要性也逐漸提升，以確保電動車的續航力及舒適度再升級。博世正運用智慧熱能管理系統，增加電動車及混和動力車輛的續航力。結合冷媒及冷卻迴路並進一步優化系統，能使冷熱調節更加精準，提升電池效率，同時確保所有零組件都在其最佳溫度範圍內作業。為此，博世正著手研發預先整合的彈性熱能解決方案，僅需幾個零組件、簡單的步驟及配線，即可輕鬆完成安裝，同時省去安裝空間及重量。此外，熱能管理系統能為乘客維持車內宜人的舒適溫度，其中，全球通用的車用無刷鼓風機在座艙內的角色至關重要。視室外溫度及車內駕駛及乘客的需求，鼓風機能將空氣送進車內，使其溫度下降或上升。此外，智慧馬達的拓樸結構能讓設計更加精巧，大幅降低重量的同時提升能量密度，並減少噪音。

## 小晶片，大助力

博世在汽車系統業務及半導體生產領域獨具專業，憑藉超過 60 年的經驗，博世正透過遍及全球的製造及合作夥伴網絡，以及對製造、研發的永續投資，形塑未來交通：博世的半導體及感測器讓行車更安全、舒適、碳排放更少。博世正針對研發領域持續投資，並拓展全球半導體製造網絡，產品組合包含車用積體電路、微機電 (microelectromechanical systems, MEMS) 感測器、功率半導體以及動力模組。針對自定義 E/E 架構的車廠，博世能針對其功能需求，以其半導體專業，提供不同規格的解決方案。

在電動交通領域，博世專注於創新半導體材料碳化矽 SiC，這項關鍵的零組件將可望降低里程焦慮，而全球電動交通的快速發展，正帶動這類特殊半導體的龐大需求。在電動車內，碳化矽晶片不僅能延長行駛續航力，更能減少高達 50% 的能源損耗，讓充電更具效率。此外，碳化矽晶片可讓車用電池在充電後行駛得更遠 – 與矽基晶片相比，續航力平均可增加 6%。博世持續深耕半導體事業，希望帶動相關業務成長，並重金投資以拓展版圖。2023 年，博世收購位於美國加州羅斯維爾（Roseville）的晶圓廠，擴充碳化矽晶片產能。博世的目標是於 2026 年在美國生產首批碳化矽晶片，並在未來數年將產能提升十倍。不同於平面結構，博世將採用垂直結構的碳化矽晶片製程，提升晶片的功率密度，並將是第一個讓碳化矽科技上路的製造商，2023 年所推出的第二代科技讓效能提升 30%。2026 年起，博世預計將在更具成本效益的八吋（200 毫米）晶圓上，生產首批垂直結構的碳化矽晶片。



博世專注於創新半導體材料碳化矽 SiC，可望降低里程焦慮，助力電動交通

## 軟體定義電動交通

未來，交通移動將可望突破傳統汽車功能限制，電動交通當然也不例外。使用者正尋求方便使用、令人振奮的交通服務，如同在智慧型手機上無縫使用的數位服務。軟體定義交通即將到來，形塑以使用者為中心的雲端生態系統，能大大助力電動交通。透過雲端電池以及聯網汽車能源管理系統等軟體及服務，博世正提升電動車的效率、延長其生命週期，並讓便利性再升級。

電池是電動車中最有價值的零件之一。電池越舊，性能和容量就越低，車輛的續航力也越短。對於電動車製造商、車隊營運廠商及使用者而言，電池通常仍是影響車輛可靠度和效能的未知因素。要從外觀評估電池狀態通常相當困難，因此可能導致實際續航力較預期更差、電池容易突然故障，或需要完全更換電池從而產生高昂的成本的狀況。因此，博世運用在電池與電動驅動器領域的廣泛專業，結合聯網與雲端服務的豐富知識，提供完整且具成本效益的單一解決方案。此雲端智慧型軟體功能可持續分析電池狀態，並採取適當措施防止或減緩電池老化。這些措施可以減少電動車最昂貴的組件 — 電池的損耗可達 20%。從車輛及其周圍環境收集的即時資料相當重要，雲端服務可利用這些資料優化每道充電程序，並透過儀表板為駕駛提供客製化的電池省電提示及訊息。博世的聯網電池服務支援以電動車電池為中心的經濟生態系統的發展，在新的價值鏈與商業模式中，完整涵蓋產品生命週期的所有層面。

透過聯網汽車能源管理系統，博世提供模組化的創新軟體解決方案，整合電動車的熱能管理、動力系統和電力系統，能最佳化車輛層級的能源分配，進而降低能源消耗並提高舒適度。它也為安全回家模式等新功能奠定基礎，可在必要時降低加熱與溫度控制等舒適性設備的耗電量，協助車輛以剩餘電池電量抵達目的地。根據目前的操作模式在車內進行智慧型能源分配，是電力驅動效率、車廂舒適性、車輛及其元件使用壽命的核心因素之一。這種方式可以降低系統和使用成本。此外，節能操作可增加電動車的續航力，這意味著需要更少的充電站。精確的續航力預測可簡化最有效路線規劃，以及沿途最佳充電站的導航功能。充電期間，智慧型負載與能源管理可以保護電池健康，使用者也可以使用不同的充電模式來個人化充電過程，例如選擇充電速度特別快或成本效益特別高的模式。



博世提供模組化的創新軟體解決方案，整合電動車的熱能管理、動力系統和電力系統

## 工業科技帶動循環經濟

電池是純電動車中成本和資源最密集的零組件之一。隨著電動車數量逐漸增加，資源卻是有限，電池回收相關的法律要求日益提高，相伴而來的挑戰顯然與日俱增。從環保的角度而言，電動交通快速發展固然正面，但未來也無疑將需要更大量的鋰離子電池。這類電池含有鋰與鎳等珍貴的稀缺原物料，原物料的回收因此別具經濟和生態意義。然而，只有完全放電的電池才能被安全地拆解，並隨之分解為化學成分。為此，博世已經開發電池深度放電的完整自動化解決方案，形塑工業回收的可能性，以及產能快速擴充的潛力。

據 Fraunhofer 系統與創新研究所 2021 年的研究指出，2040 年以前，僅在歐洲的電池回收所需技術性系統即需投資逾 60 億歐元。回收的價值在於，在最理想的狀態下可回收電池中高達 95% 的化學原料，並將回收後的原料再度用於電池生產製程。博世開發的自動化放電系統，不僅簡化回收過程，還能提高效率並加強安全性。該系統結合 TS 5 輸送系統與數位開放式平台 ctrlX AUTOMATION，形成完整的自動化解決方案，並突破機器控制間的傳統界限。TS 5 輸送系統可在診斷放電站和拆解站之間運送來自不同製造商的不同尺寸和類型的電池，接著 ctrlX AUTOMATION 的模組化解決方案會在放電站對電池芯進行放電。放電設備可自主進行初步檢測、去除化學活性的深度放電過程，乃至最終檢測。

憑藉此系統，過去需要 24 小時手動完成的流程，現在僅需不到 15 分鐘即可完成。這個解決方案亦能提高作業人員安全性，並大幅降低日後的火災風險。此流程將協助使電池回收更快速、更安全且更具成本效益。整合性的解決方案適用於製造商和系統整合商。其模組化設計可以較低成本，進一步擴充數量，因應未來電池回收的挑戰。博世力士樂採用開放式標準規劃通訊與程式，因此能輕鬆整合到不同應用的資訊系統架構中，以達成工業規模的電池回收，並提供彈性擴充的可能性。




博世力士樂結合 TS 5 輸送系統與數位開放式平台 ctrlX AUTOMATION，提供電池回收的自動化解決方案



### 作者

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**原廠汽車零件業務部**
**總經理**

楊建新自 2013 年起擔任台灣博世汽車原廠零件業務部總經理，負責博世在台灣四輪及二輪市場的原廠零件銷售相關業務。除了台灣博世的職務之外，楊建新長期參與歐洲在臺商務協會（ECCT）智能移動委員會，倡議公平合理的監管環境，推動創新交通移動解決方案。

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## 綠色低碳物流：電動化的減碳未來

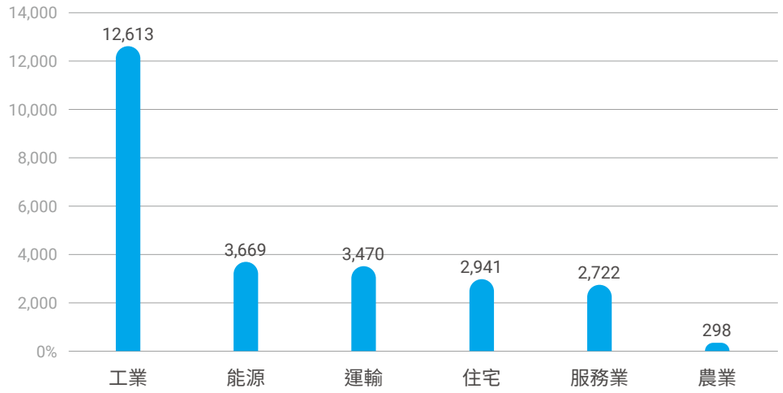
### 周志鴻 裕利醫藥 總裁

為呼應國際淨零排放的趨勢，台灣也立下 2050 年淨零排放路徑及目標，並在 12 項關鍵戰略中，納入由交通部主辦的「運具電動化與無碳化」及「淨零綠生活」中的「推廣綠色貨運」行動，讓物流車電動化成為物流業者實現綠色低碳運輸轉型的重要方式，但要實際投入運用，仍面臨諸多挑戰。唯有透過政府及企業公私協力，加速推進運具電動化及無碳化的步伐，並實踐運輸減碳的目標。

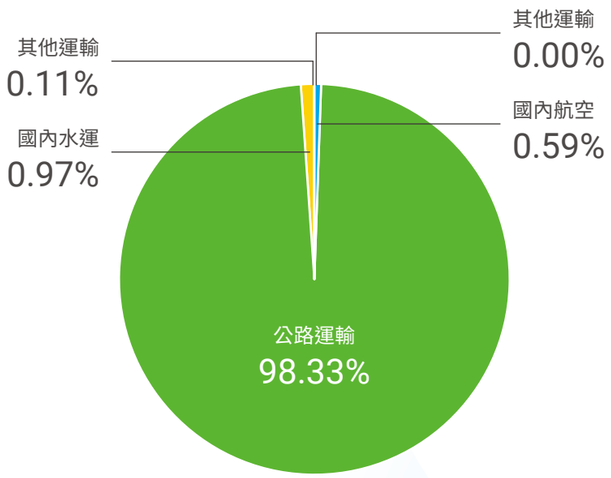
## 物流運輸佔全國碳排放量約 4% 永續轉型刻不容緩

根據最新公布的國家溫室氣體排放清冊報告（2024 年版），運輸部門在 2022 年二氧化碳排放為 3,470 萬公噸，占總排放 13.45%，僅次於工業部門 ( 佔 48.90%) 及能源部門 ( 佔 14.22%)，目前是第三大排放部門，過去 10 年間台灣交通運輸碳排放量卻未明顯降低，與前一年 2021 年的 3,390 萬公噸相比，二氧化碳排放量年增率為 2.33%，主要來自公路運輸增加 2.11%。

### 台灣各部門二氧化碳排放量 ( 單位：萬公噸 (10 $tCO_2e$))




細究運輸部門碳排放量結構發現，公路運輸佔比高達 98.33%。其中，雖然仍是以 50.54% 的小客車佔比最高，但大貨車與小貨車分別佔 18.31% 與 11.81%，等於在貨運就佔超過 30%，若將物流貨運碳排獨立看，等於佔全國碳排放量 4%，物流的永續發展轉型已經刻不容緩。



## 台灣電動物流車應用現況

目前，台灣的電動物流車發展仍處於起步階段。在小型車部分，近期國產車廠推出了全新 3.5 噸電動商用貨車，並計劃於 2025 年量產上市，市面上亦有日本製造的 5 噸及 8.5 噸的中小型電動商用車。在中型及大型電動商用車方面，仍以歐美品牌的進口電動商用車為主。但若要加速電動車實際應用在物流產業，在政策及配套措施仍有以下三點挑戰尚待克服：

### 挑戰一：電動物流車選擇有限，規格和價格尚不明確：

目前，台灣市場上的電動物流車選擇仍然有限。雖經濟部為加速國內商用電動車產業鏈發展，推動國內車廠投入國產電動貨車發展，但整體市場上的電動物流車型號和規格仍不多，且面臨綠色溢價（green premium）狀況，國產價格尚未明確公佈，而進口車款售價為柴油車款兩倍之高。

國外研究指出，在有選擇的情況下，大多數人不願意或是沒有能力支付綠色溢價，而具有高意願的人則會期待產品具備更好的效能。以物流業者實務上最關心的里程續航力來說，從我們經驗，每趟車次滿載情況下，行駛里程來回需 200 公里；若電動車規格無法解決「里程焦慮」問題，將使得有意願轉換的物流業者在無法充分評估成本效益，難以進行轉換使用。

### 挑戰二：現有產官合作以台灣本土商為主，外商需求未被看見：

經濟部產發署於 2023 年推出「電動商用車示範運行補助案」，支持國產車廠與物流業者合作實地測試，驗證電動商用車的品質與安全性。但在媒合補助案對象時，均以國營及本土物流業者為主。

然而，在台營運的外商公司，在符合歐美永續法規情況下，在減碳目標訂定上更加積極，並有強烈動機採用永續方案。以裕利醫藥為例，已在科學基礎減量目標倡議 (SBTi) 下，訂定 2030 年需要碳中和的目標：與 2021 基準年相比，需減少 42% 在範疇一及範疇二碳排放量；目前裕利透過多項減碳方案，已成功減碳 38%，並持續往碳中和之路邁進。

建議政府在考量帶動國內電動車發展及推動低碳運輸方案時，應廣納入在台發展的外商建議，更有機會透過外商公司全球營運網絡，帶動國產電動車及相關系統在國際市場能見度及國際業務機會。

### 挑戰三：政府配套措施和補助須加強

政府應加大對電動貨車的補助力度，並提供更多的配套措施，如業者購車補助，牌照稅燃料稅減免、充電設施補助、維修服務補助等。以日本為例，日本國土交通省 2021 年公告受理「補助引進商用電動車輛」（事業自におけるの集中的導入支援）計畫申請。日本政府將透過對購車與充電設備建置費用的補助，以達成 8 噸以下小型車在 2030 年新車販售占比 20% 至 30%，以及在 2040 年電動車與零碳燃料車輛新車之電動車販售占比達 100% 的目標。

反觀台灣，目前補助方案，多著重在電動小客車上，在電動商用車相關政策尚待建立。此外，應制定關於物流貨運相關的明確政策及時程，來支持物流業者加速低碳轉型的腳步。




## 醫藥物流的永續轉型經驗

在台灣，每兩個藥品及醫療器材，就有一個是透過裕利醫藥服務。作為台灣醫療產業的重要供應鏈，裕利醫藥台灣於 2024 年率先引進醫藥業中第一台電動冷鏈貨車，與 Volvo 合作導入 17.5 噸電動冷鏈貨車，肩負桃園物流中心到中部地區的藥品及醫材品運送任務。

與同等級柴油車相比，不僅大幅減少 60% 碳排放量，更能減少城市及醫療院所的噪音干擾。目前在運送到全台 20000 間醫療院所、診所及藥局的最後一哩路車隊，裕利醫藥已在過去幾年逐步汰換成符合歐盟六期排碳標準的柴油車輛。

在車隊及路徑管理部分，裕利更導入 AI 算力協助計算最佳運送路徑，優化車輛調度及燃油使用。希望未來能與醫院共享庫存資訊系統，當系統發現醫藥材缺貨，便可統一與周邊醫療院的配送進行整合規劃，達成最低碳排量和高效率運送。

除了電動車外，裕利醫藥更提供醫藥材運輸許多具體可行的減碳方案，如採用替代保麗龍的 eZ Cooler 包材，60 小時不間斷維持低溫，還可重複再利用；未來還計劃引入物流箱，以減少一般藥材運送中的耗材使用。




## 結論

台灣在電動物流車發展雖然取得了一定的進展，但仍面臨諸多挑戰。物流業者在選擇電動物流車時，面臨選擇有限、規格和價格不明確的問題；政府的配套措施和補助仍顯不足，無法全面支持物流業的低碳轉型。

為了實現 2050 年淨零排放的目標，政府和業者需要共同努力，加強對電動貨車的支持力度，推動物流業的綠色轉型。裕利醫藥將會持續關注台灣電動商用車的發展，也希冀優先導入醫藥物流營運使用，加速脫碳化、電動化，打造綠色醫藥物流車隊，讓台灣醫療院所在治療病患同時，減少對於環境的衝擊，協助政府一同達成淨零轉型目標。







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**總裁**

投身醫療保健產業已超過 20 年，2009 年加入亞洲最大醫藥服務公司 - 裕利醫藥，掌管台灣事業，推動全面數位化及永續轉型，成為醫療產業全方位服務商。近三年，台灣成為裕利集團營業額最大的分公司，事業群橫跨醫藥物流、醫藥行銷代理、臨床試驗物流及病患照護領域，實踐「讓醫藥服務更普及」的願景。

畢業於台灣大學森林環境暨資源學系、台大 EMBA。曾任 3M 台灣產品經理、寶麗來（Polaroid）遠東台灣總經理，2002 年加入美商惠氏台灣，從台灣市場，一路跨足中國及香港事業體等，擁有豐富跨市場管理經驗。

裕利醫藥為亞洲最大醫藥保健服務集團，成立於 1922 年已超過一世紀，服務橫跨 13 個市場，合作客戶包括全球前 20 大製藥公司。裕利台灣成立於 1988 年，擁有全台最大冷鏈醫藥物流中心，客戶群超過 90 家國際、本土藥廠與生技公司，醫療產品及醫療器材配送於全台 2 萬家醫療院所、診所及藥局，近年更協助運送超過 7 千萬劑新冠肺炎疫苗、篩檢試劑及抗病毒藥物供國人防疫使用。一顆藥從臨床試驗，到上市後的銷售、醫療院所下單、揀貨、出貨、運送，直到病患拿到藥品，都經過裕利的服務。



## 為您的員工和地球提供更好的空間

身為一家在現代世界中營運的企業，永續發展已成為企業的核心需求。您的投資者對此有所期望，客戶也有所要求，員工也對企業的永續表現十分重視。妥善處理與 ESG（環境、社會與公司治理）相關的議題將有助於提升企業聲譽，並創造長期價值。

特別是在 COVID 之後，對於高品質工作環境的要求也有所增加。空氣品質、光線條件，以及工作空間設置的靈活性已成為基本需求。值得注意的是，永續發展與員工福祉往往是相輔相成的。

本文將介紹如何為員工創造更好的工作環境，並為地球創造更好的設施，我們將帶您瞭解在規劃新設施或升級舊設施時需要考慮的一些方面。

- **環境：** 建築物在能源效率、耗水量、廢棄物管理、建築材料以及可再生能源的採用等方面的表現，都會對環境造成影響。其後的碳足跡需要評估、監控，並採取可行的步驟進行改變與改善。
- **社會：**建築設計可透過優良的室內空氣品質、自然採光及綠色空間等功能，促進使用者的健康與福祉。
- **治理：**提供建築對環境與社會影響的透明資訊，以及治理結構與實務，有助於利害關係人做出明智的決策，並使組織對其行動負責。

本文將特別介紹 RCI 的 Façade 太陽能整合系統，以及資料收集系統 ECON -「您的資料有更好的想法」，其獨特的功能可讓您在單一軟體應用程式中收集設施內不同系統的資料，有助於深入瞭解整個設施的運作情況，從而協助降低成本，並可進一步自動化以提高效率。

實施 ESG 實務需要將這些因素整合到公司營運和決策流程的各個方面。公司需要建立關鍵績效指標 (KPI) 和衡量標準，以追蹤其在減少環境影響、社會責任措施和治理方面的進展。定期報告 ESG 績效，通常是透過永續報告書或整合年報，協助利害關係人評估公司的永續努力與透明度。

# 設施

無論是選擇現有的設施作為工作空間，或是建立全新的設施，都要留意是否取得綠建築認證。以下是在台灣市場常見的各種認證，以及它們所涵蓋的範圍：

## 全球標準

LEED（能源與環境設計先鋒）是全球最知名、最具公信力的綠建築評鑑系統。由美國綠建築協會 (USGBC) 所提倡，其目的在於推廣永續設計與建築標準的實踐。LEED 由多個類別的分數組成，包括整合流程、位置與交通、永續場地、用水效率、能源與大氣、材料與資源、室內環境品質、創新，以及區域優先。

WELL 是一個綜合性的國際認證計畫，專為建築物和組織設計，以提供可增進使用者健康和福祉的空間。WELL 是一個以績效為基礎的系統，用來衡量、認證和監控建築環境中影響人類健康和福祉的特徵，並透過十個要素或概念來進行。它們包括空氣、水、營養、光、運動、熱舒適性、聲音、材料、心靈、社群和創新。

UL VHB（經驗證的健康建築）計畫為房地產行業提供了來自備受推崇的安全科學領導者的獨立保證。專注於室內空氣和水的品質，以確保未來居住者的健康和福祉。

EARTHCHECK 是全球領先的旅遊和酒店業認證和基準評比計劃。旨在協助企業、組織和目的地實現可持續發展目標。

## 台灣標準

EEWH 是台灣的綠建築認證系統，著重於提升建築物的效率、降低能源消耗和對環境的影響，同時也提供更健康舒適的室內環境。

台灣智慧型建築標章的目標是推廣永續環境、創造高效率的現代生活空間，以反映科技化的生活方式、建築空間和居住者之間的合作。

低碳建築評量系統 (LEBR)：台灣的低碳建築評量系統 (LEBR, Low Embodied-carbon Building Rating System) 可計算與評估建築物的內含碳排放量，並提供熱點診斷與減碳改善方法。

台灣的建築物能源效率評等系統 (Building Energy Efficiency Rating System, BERS) 主要目的在於鼓勵業主及開發商以更高的能源效率來設計、建造及營運建築物。

## 綠色空間

建築環境中的綠色空間在促進永續發展及提升住戶生活品質方面扮演重要角色。這些空間包括花園、綠化屋頂和景觀區，可透過蒸發散熱和遮陽提供冷卻，有助於減緩城市熱島效應。這不僅減少了對空調的需求，還降低了能源消耗和溫室氣體排放。此外，綠地還可為各種物種提供棲息地，從而支持生物多樣性，為城市地區的整體生態健康做出貢獻。綠地還能過濾污染物並產生氧氣，從而改善空氣品質，為人類和野生動物創造更健康的環境。

對人們來說，綠地提供了許多身心健康的好處。接近大自然已被證明可以減輕壓力、改善情緒並增強認知功能。綠地鼓勵步行、慢跑和騎自行車等體力活動，這可改善整體健康並降低醫療成本。此外，這些區域還能提供社交互動和社區建設的機會，培養居民的歸屬感和幸福感。藉由將綠色空間融入建築環境，我們可以創造更永續、更宜居、更有彈性的城市，讓地球與居民都能受惠。

## 廢棄物管理

對於嚴格執行環境、社會與治理 (ESG) 政策的公司而言，辦公室環境中有效的廢棄物管理至關重要。這些公司必須實施全面的減少廢棄物策略，以「廢棄物層次」為優先考量：減少、重複使用及回收。這包括透過有效利用資源、鼓勵材料再利用，以及確保適當的回收作法，將產生的廢棄物減至最少。此外，公司應建立明確的有害廢棄物和電子廢棄物處理規範，以防止環境污染。針對員工的定期訓練和認知計畫，對於培養永續文化和確保遵守廢棄物管理政策至關重要。監控和報告廢棄物管理績效也有助於保持透明度和持續改善。透過遵守這些實務，公司可以大幅減少環境足跡，並符合其 ESG 承諾。

## 收集您的資料

ECON 是 RCI 專屬的監控平台，專為收集建築物健康與效能的即時資料而設計。它能以簡單直接的方式來自不同來源的資料整合，協助用戶找出需要改善的地方。透過集中管理所有資料，例如室內空氣品質 (IAQ)、能源使用量、耗水量及其他指標，ECON 支援多種監控裝置和資料通訊協定，提供全面的解決方案。

RCI 提供諮詢服務，可根據您的特定需求自訂 ECON 面板。利用 ECON 收集的數據來控制您的環境，提高居住者的健康和福祉，減少對環境的影響，並優化運營成本。

# 為員工規劃

## 舒適與彈性

COVID-19 大流行不可逆轉地改變了工作模式，促使遠距工作的廣泛轉變。這一轉變強調了辦公室必須隨之演變，創造既支持面對面工作，也支持遠端工作生產力的環境。企業現在逐漸意識到靈活工作空間的重要性，這些空間能夠適應員工多樣化的需求。為此，辦公室正在重新設計，包含共享辦公區域，讓員工可以選擇在進入辦公室時工作，並設有隔音亭以供私人通話和視訊會議使用，確保遠距溝通能夠無縫進行。

為了打造這樣的靈活工作空間，企業可以採取多種策略。例如，投資模組化家具和可移動隔板，可以快速重新配置空間，以適應不同的任務和團隊規模。此外，整合高速網路、無線充電站和基於雲端的協作工具，確保員工無論是在辦公室還是居家工作，都能擁有高效工作的資源。通過創建一個動態且靈活的辦公環境，企業可以確保其具備應對現代勞動力不斷變化需求的能力。

## 室內環境品質

Covid 流行病的另一個後果是人們更加重視室內空氣品質和通風。除了限制病毒傳播之外，良好的室內空氣品質還有其他好處，例如增加辦公室內的氧氣和降低微粒含量，這將有助於員工的身心健康和生產力。

辦公室環境中的室內空氣品質是一個關鍵因素，可以顯著影響員工的身心健康和生產力。惡劣的空氣品質可能會導致一系列的健康問題，從頭痛、頭暈到呼吸道感染，進而導致缺勤率增加和工作表現下降。霉菌、灰塵、揮發性有機化合物 (VOC) 等污染物以及通風不足會導致僱員的認知功能下降，影響他們的注意力、準確性以及完成任務的速度。

相反，提升室內空氣品質可以改善健康、舒適度和工作效率。實施定期維護 HVAC 系統、使用空氣淨化機、引進室內植物以及確保適當通風等措施，都有助於減少污染物。這可創造出更健康的工作環境，從而增強認知功能、減少病假天數，並促進工作團隊更有活力和生產力。歸根結柢，投資改善空氣品質不僅有利於員工健康，也有助於組織的整體成功。

RCI 可以進行揮發性有機化合物 (VOC)、微粒物質、一氧化碳、二氧化碳等污染物以及其他潛在污染物的測試。

## 智慧型技術整合

辦公室環境中的智慧型技術整合已經徹底改變了我們與工作空間互動的方式。例如，智慧型照明系統利用感應器和自動化功能全天候調整亮度和色溫，提高舒適度並減少能源消耗。氣候控制技術也變得更加複雜，智慧型恆溫器和 HVAC 系統可學習使用者的喜好和佔用模式，以維持最佳的溫度和空氣品質，從而營造出更健康、更有生產力的辦公室氛圍。

除了照明和氣候之外，智慧型技術也延伸至其他各種辦公室管理需求。先進的保全系統具備臉部辨識與即時監控功能，可確保工作場所的安全；物聯網設備則可在問題升級前預測並處理，進而簡化維護工作。配備智慧預約系統和虛擬助理的會議室可促進無縫協作。總而言之，在辦公室整合智慧型技術不僅能提升效率與永續性，還能創造更具適應性、更愉悅的工作環境。

## 照明品質

辦公室環境中的照明品質對人員的健康和安全有重大影響。適當的照度（通常以勒克斯為單位）對減少眼睛疲勞、疲倦和頭痛非常重要。照明不足會因為能見度低而增加錯誤和意外，而照明過度則會造成眩光和不適。理想的照度水平因工作而異，一般辦公室工作需要約 300-500 勒克斯，而更仔細的工作則需要高達 1000 勒克斯。此外，顏色強度和溫度也扮演著重要的角色；較冷的光線（約 5000K）通常具有刺激效果，可提高警覺性和生產力，而較暖的光線（約 3000K）則可營造出較輕鬆的氣氛。

測試照明品質涉及多個步驟，以確保符合標準並優化工作環境。光度計用於測量辦公室不同區域的照度等級，確保光線均勻分佈，並為各種任務提供充足的照明。顯色指數 (CRI) 測試可評估光源顯示物件顏色的準確度，這對於需要區分顏色的工作非常重要。定期審核和調整是維持最佳照明條件的必要條件，並考慮到全天自然光的變化和季節性變化。透過優先使用適當的照明，組織可以提升員工的福祉、降低健康風險，並提高整體生產力。

## 晝夜節律照明

晝夜節律照明是一個概念，利用電燈來支持人體健康，將其對人體晝夜節律的影響降至最低。它的目的是模仿陽光在一天中的自然進程，幫助調節我們內部的 24 小時時鐘，影響身體、精神和行為對光暗的反應變化。

晝夜節律照明是一種創新的室內照明設計方法，它與人體自然的 24 小時節律一致。晝夜節律照明背後的理論根植於光是晝夜節律的重要調節器這一理解，晝夜節律是遵循每日週期的身體、精神和行為變化，主要對生物環境中的光線和黑暗做出反應。晝夜節律照明系統旨在模仿自然日光的模式，在一天中的不同時間提供適當的光強度和光譜，以支持我們的內在時鐘。通過調節電光的強度、光譜和顏色，使其與自然光照週期相協調，晝夜節律照明旨在提高舒適度、生產力和健康，而不會改變光色的視覺外觀。

在辦公室環境中，晝夜節律照明的應用可以對員工的健康和生產力產生深遠的影響。適當的晝夜節律照明可以改善睡眠品質，提高警覺性、情緒和工作時的專注力。它還能減少因暴露在不適當的光線或光譜下而造成的錯誤、事故和壓力。例如，早上使用明亮、富含藍光的燈光來抑制褪黑激素的分泌並刺激警覺性，而在一天的晚間則使用較溫暖的色調，以促進放鬆並讓身體為休息做好準備。這種與人體自然週期同步的照明方式，有助於調節睡眠模式、改善整體健康，以及創造更有活力和適應性的工作環境。

## 聲學 / 噪音

辦公室環境中的噪音水平對員工的表現和福祉有顯著影響。 高噪音水平會導致壓力增加、注意力下降和生產力降低。 辦公室噪音的常見來源包括談話、電話鈴聲、辦公設備和外部交通。 開放式辦公室尤其加劇了這些問題，因為缺乏隔音屏障。 研究表明，噪音干擾會增加錯誤率並降低認知表現。 測量噪音水平通常涉及使用聲級計來捕捉分貝讀數，以確保它們保持在推薦的限值之內，從而營造一個適宜的工作環境。

為了減輕辦公室噪音的負面影響，可以采取幾項措施。 聲學處理措施，如 吸音板、地毯和天花板瓷磚，可以幫助降低噪音水平。創建指定的安靜區域或私人工作空間，使員工在需要時能夠逃離嘈雜的環境。 此外，實施噪音消除技術並鼓勵使用耳機可以進一步減少干擾。 定期監測噪音水平並收集員工反饋可以幫助識別問題區域，並確保持續改進。 通過解決噪音問題，組織可以提高員工滿意度，減少壓力，並提升整體生產力。

# 為地球規劃

## 能源效率

建築的能源效率是可持續發展的基石，旨在減少能源消耗，同時保持或提高舒適性和功能性。 這可以通過多種策略實現，例如增強絕緣、使用節能窗戶，以及引入先進的供暖、通風和空調（HVAC）系統。 例如，高性能絕緣材料可以顯著減少冬季的熱量損失和夏季的熱量獲取，從而降低對供暖和制冷的能源需求。 此外，具有低輻射塗層的節能窗戶可以減少熱量傳遞，進一步提升建築的熱性能。

此外，整合智能技術可以優化建築物的能源使用。例如：智能溫控器可以學習居住者的日程安排，並相應地調整溫度，確保在空間無人時不會浪費能源。建築自動化系統可以根據實時數據控制照明、暖通空調和其他系統，從而提高整體能源效率。實施這些技術不僅可以降低能源費用，還能減少碳足跡，支持全球應對氣候變化的努力。 通過優先考慮能源效率，建築可以在長期內變得更加可持續、韌性更強且更具成本效益。

## 可再生能源利用

台灣目前正面臨可再生能源短缺，導致可再生電力價格上漲。 為了解決這個問題，設施可以考慮幾種自我發電的方法。 除了普遍的屋頂光伏（PV）系統，還有兩種額外的替代方案值得關注。

首先，立面光伏技術通過將光伏電池集成到建築外部表面，提供了一種新穎的方法。這對於新建或翻新的建築特別有利，因為它將建築物外牆包覆的必要性與能源生成結合在一起，僅需承擔極少的額外成本。 安裝過程與傳統建築實踐相一致，便於與新建築或現有建築的整合。 此外，該產品提供了豐富的顏色和材料選擇，增強了美學靈活性。

其次，陸上風電為位於工業或港口地區的設施提供了可行的解決方案。 這個選項的可行性取決於監管支持的改善，特別是來自交通部 (MOTC) 和環境部 (MOENV) 的支持。在政府的加強支持下，陸上風能有望迅速發展成為一種具有成本效益的自發電途徑，成本可低於每千瓦時 2 新台幣。 當前的主要挑戰仍然是應對政府的許可流程。

## 水資源管理

建築中的水資源管理對於促進可持續發展和降低運營成本至關重要。 有效的策略包括優化水系統、檢測和修復洩漏，以及實施節水措施。 例如，安裝低流量的裝置，如水龍頭和馬桶，可以顯著減少水的消耗。 此外，雨水收集系統可以用來收集和儲存雨水，以供灌溉和沖廁等非飲用用途。 這些措施不僅節約了水資源，還減少了水加熱和抽水所需的能量，從而有助於整體能效的提升。

此外，智能水管理技術在現代建築中變得越來越重要。 這些系統利用傳感器和數據分析實時監測水的使用情況，識別低效之處，並自動採取節水措施。 例如，智能灌溉系統可以根據天氣條件和土壤濕度水平調整澆水時間表，從而確保水資源的最佳利用。 通過整合這些先進技術，建築可以實現更高水平的水資源效率，減少其環境足跡，並增強對水資源短缺的抵禦能力。

## 材料選擇

在建築中可持續材料的選擇是綠色建築實踐中的一個關鍵方面，旨在最小化環境影響並促進資源效率。 這個過程涉及選擇在整個生命周期中具有較小生態足跡的材料，從開採到處置。關鍵考慮因素包括材料的潛在能耗、可回收性和再利用的潛力。例如，竹子、回收鋼材和再生木材等材料因其低環境影響和可再生性而受到青睞。通過優先使用這些材料，建築項目可以顯著減少碳排放，節約自然資源，並減少廢物產生。

此外，可持續材料的選擇還考慮到建築使用者的健康和福祉。 為了確保室內空氣質量，優先選擇釋放低水平揮發性有機化合物（VOCs）和其他污染物的材料。 此外，還評估了材料的耐久性和維護要需求，以確保長期的可持續性。 例如，高性能絕緣材料可以提高能源效率，而像軟木或亞麻油地板這樣的耐用地板選項可以減少頻繁更換的需求。 通過整合這些可持續材料，建築行業可以為更健康的環境及更可持續的未來做出貢獻。

## 循環經濟

建築行業對環境消耗的影響重大，因其大量使用原材料和產生廢物。 在建築領域實施循環經濟對可持續發展至關重要。 這種方法優先考慮材料的再利用和回收，促進資源效率，並旨在最小化廢物的產生。通過將循環經濟納入考量，建築項目可以顯著減少其環境足跡，節約自然資源，並創造一個更可持續的未來。

在建築項目中實施循環經濟需要在項目規劃和執行上進行範式轉移。 這涉及到在設計建築時即考慮拆解的可能性、基於材料的生命周期和可回收性選擇材料，以及採用允許材料回收的施工方法。 在項目開始時，各利益相關者之間的合作，包括建築師、工程師、承包商和客戶，是將循環經濟原則融入項目的關鍵。 這種集體努力可以帶來創新的解決方案，支持建築行業的經濟、環境和社會可持續性。



## 結論

總之，為員工福祉和環境責任優先考慮的工作空間的創建，對於台灣的企業來說，已是必不可少的選項。 通過採用綠色建築認證、設計綠色空間、優先考慮室內環境質量、採用智能技術以及推行可持續做法，如能源效率、可再生能源利用、水資源保護、可持續材料選擇和循環經濟原則，企業可以獲得顯著的好處。 這些好處包括提高員工的生產力和福祉、降低運營成本、減少環境足跡，以及在日益關注環保的市場中增強品牌聲譽。 通過采取這些措施，企業可以創建既美觀又實用的辦公室，同時為所有人創造一個更健康、更可持續和更繁榮的未來。

## 總結

本文章探討了台灣企業如何創造有利於員工和環境的工作空間。 這些來源強調，在當今的商業環境中，將環境、社會和治理（ESG）原則融入辦公室設計至關重要，因為投資者、客戶和員工對可持續性的需求日益增加。 本文也強調了綠色建築認證（LEED、WELL、EEWH）的重要性，並提供了創建可持續和健康辦公室的實用步驟。關鍵考慮因素包括融入綠色空間的設計、建立有效的廢物管理系統、設計舒適和靈活的空間、重視室內環境的品質（包括空氣品質和照明），以及整合智能技術。 本文還詳細介紹了可持續措施，例如促進能源效率和可再生能源的使用、優化水資源管理、選擇可持續建築材料，以及擁抱循環經濟。 通過採用這些策略，企業可以創造出既環保又能提升員工福祉、降低運營成本、增強品牌聲譽的工作空間。








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智森永續設計顧問有限公司 (RCI Sustainability) 是一家專注於 ESG 策略諮詢、永續認證、碳與能源減排、測試與效能驗證，以及建築效能監測 的公司，在台中與台北皆設有辦公室。

智森永續設計顧問有限公司 (RCI Sustainability) 專精於 永續發展與 ESG 領域，致力於減少建築環境的碳排放，並邁向淨零未來。其團隊成員涵蓋 工程、建築、施工、設施運營及政策研究 等專業領域，具備跨領域的豐富經驗。

RCI 強調 永續發展是集體的目標，倡導建構更健康、更綠色的環境，並致力於讓永續生活更加普及，使人們的居住、工作與休閒環境均能受益。





# 升級暖冷空調效率，實現城市淨零未來

城市容納了全球一半以上的人口，消耗了全球近 45% 的可用能源，並佔全球二氧化碳排放量的 70% 以上。由於能源需求較高，城市建築是主要能源消耗者之一，其中供暖和製冷所佔比例最大。

建築物消耗的能源佔全球能源消耗的 30% 以上。為了改善我們的生活條件，我們設計了控制建築物內溫度、濕度和新鮮空氣流動的解決方案。而暖氣、通風和空調 (HVAC) 平均消耗建築物能源的 50% 左右。同時，在大型商業建築中，自動扶梯和電梯等用於運送人員的設備可能佔建築能耗的 2-5%。因此，提高這些系統的能源效率至關重要。

控制建築物內不同的系統已經存在了幾十年。然而，這些系統的能源效率還不夠。變速驅動器技術的發展使我們能夠解決建築物中的許多能量損失問題。由於 HVAC 等建築系統大部分時間都在部分負載下運行，因此與傳統的阻尼器或閥門控制方法相比，變速驅動器平均可節省 20% 至 60% 的能源。如此大規模的節能是可行的，因為驅動器能夠直接調節風扇、泵浦和壓縮機的馬達速度以滿足當前的建築需求。

變速驅動器有助於節省大量能源，但只需少量投資即可進一步節省能源。變速驅動器的最佳搭配是高效能馬達，例如 ABB 的 IE5 同步磁阻馬達。與 IE3 能源效率等級的感應馬達相比，它的能量損失最多可減少 40%，實現國際電工委員會 (IEC) 定義的超高效率水準。

這使得同步磁阻馬達成為滿足全球不斷增長提高能源效率需求的新首選。由於建築物大部分時間都在部分負載下運行，因此重要的是要考慮馬達的部分負載性能，而不是標準性能。同步磁阻技術將永磁馬達的性能與感應馬達的簡單性和維修方便性結合在一起。同步磁阻馬達中的轉子沒有磁鐵或繞組，幾乎沒有功率損耗，與傳統馬達相比，它所需的原物料也更少，這對於永續發展及環境友善來說是一個巨大的優勢。



## ABB 冷卻解決方案在新阿拉曼市每年可節省高達 30% 的能源

ABB 與系統整合商 Quasi Systems 合作，為新阿拉曼市開發案的主要建築提供 470 多台 ACH580 變頻器，包括總統府、阿拉曼大學、新阿拉曼市塔樓和一家豪華酒店。

新阿拉曼市是埃及西北部的一個新的第四代沿海城市，預計將為約 300 萬居民提供住房。這座新的沿海城市將包括一系列高品質的國際貿易中心、住宅大樓和豪華度假村以及現有的歷史遺跡。

此外，部分安裝的是超低諧波變頻器，表示不會污染電網，從而保證其穩定性。超低諧波也確保電氣系統本身不會浪費能源，進一步增強新城市基礎設施的節能潛力和永續性。借助 ACH580 變頻器解決方案，預計建築業主每年將能夠節省 25-30% 的能源使用和成本。







**作者**

**ABB Ltd.**

ABB 是技術領先的電力及自動化跨國工程公司，致力於推進永續社會及資源效率的未來。透過專業工程知識與軟體結合的解決方案，致力優化製造、移動、供電及運行方式。承襲超過 140 年的卓越成就， ABB 全球 105,000 位優秀員工，承諾持續推動加速工業轉型的創新科技。 按照所服務的客戶和行業組織，ABB 分為四個事業群。ABB 全球有 7 個研究中心，是我們開展研究和技術的重鎮，我們承諾繼續投資研發技術，以不斷地創新為我們企業的核心價值。ABB 所擁有的領先技術，帶動了現代社會的基礎，從革命性的高壓直流輸電技術、輪船渦輪增壓推進器。如今，ABB 更為工業馬達和變頻器、工業機器人的領導者之一。 ABB 1988 年於台灣正式設立分公司。經過多年拓展，ABB 台灣的員工分佈於台北、高雄及台中。在地化的團隊促進與台灣各產業的互動及多元發展，確立堅實的夥伴關係。ABB 在台灣特設立展示、訓練中心及運籌管理中心，都是專為有效的服務客戶所設立的，提供高效率專案工程管理、客戶培訓及準時交付產品及系統，使其客戶在提升工業生產效能的同時，更能降低對環境的影響。

農業部
林業及自然保育署
Forestry and Nature Conservation Agency,
Ministry of Agriculture



## 公私協力邁向淨零及生物多樣性永續目標

## 前言

2021 年第 26 屆聯合國氣候變化綱要締約國大會（COP26），呼籲各國應採取更為急迫之氣候行動，將全球溫室氣體排放量於 2030 年前減半，並在 2050 年達到淨零，方可將全球溫升控制在 1.5° C 以內，以因應全球氣候緊急之高風險衝擊，如森林野火、極端降雨頻率增加、野生物棲地喪失等。2022 年 12 月，聯合國《生物多樣性公約》通過「昆明 - 蒙特婁全球生物多樣性框架」（Kunming-Montreal Global Biodiversity Framework, GBF），以 2050 年人與自然和諧共生為願景，揭示各國須採取緊急行動停止和扭轉生物多樣性損失，達成回復自然的永續目標。

據世界經濟論壇（WEF）2020 年的研究指出，全球約有一半的 GDP 高度或中度依賴自然資源及其服務，一旦自然遭受破壞，包括農林業在內的多樣產業將受到嚴重衝擊，鑒於生物多樣性與企業經營關係的討論度日益升高，聯合國在「昆明 - 蒙特婁生物多樣性框架」目標 15 明確揭櫫企業應負起自然相關風險揭露的責任，並於 2023 年 9 月正式發布「自然相關財務揭露 (TNFD)」，顯見企業與金融體系在全球生物多樣性保育扮演舉足輕重的角色，亦為生物多樣性保育能否有效推動的重要關鍵。



## 推動國土生態綠網藍圖

臺灣獨特的地形與地理條件孕育了豐富的生物多樣性，綜觀臺灣陸域環境，中央山脈森林生態系多已透過國家保護區系統獲得有效保護，然而仍有約六成的保育類野生動物與受脅植物生活於受保護的國有森林以外。這些淺山、平原與海岸濕地多緊鄰人口稠密的都會環境，面對各類開發、農地利用型態轉變所衍生的棲地喪失與破碎化情勢，保育工作必須跨出圈地保護的思維。為此，農業部由林業保育署統籌、在行政院的支持下，自 2018 年起協調跨部會推動「國土生態保育綠色網絡建置計畫」，以低海拔淺山、平地及海岸為重點區域，串連與修復各類棲地，提升區域內生態系與里山社區之韌性與調適力，在相關政府機關、研究單位及各界專家學者合作下，已完成全臺 44 個國土綠網關注區域及 45 條區域保育軸帶的指認。將臺灣生物多樣性資訊為本的空間規劃，從國有森林，延伸到全臺包含淺山平原的國土範圍，涵蓋為串聯丘陵、溪流、平原、海岸與離島生態系，實務所需圖資以及保育對策，指引生態棲地復育與地景空間連結的投入方向。

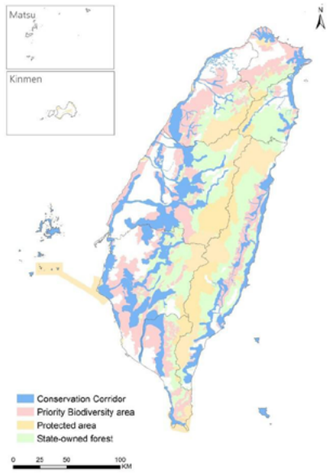
全球淨零排放及生物多樣性保護目標，必須政府部門攜手民間與企業公私協力始能達成。農業部林業及自然保育署刻正參考全球多樣性目標及 TNFD 等規範，就我國生物多樣性的整體空間規劃、自然環境、生態資訊及產業需求等條件，期能在 2025 年提出 TNFD 的在地操作指引，以協助企業進行自然相關財務的評估作業，在綠網藍圖下，公、私部門得以持續以空間聚焦開展行動，適地運用生態廊道建置、植被復育、生態服務給付、友善環境生產、生態友善治理工程等各項政策工具，協力促進並改善棲地的復育、串聯與管理。

## 鼓勵企業以公私協力方式參與 ESG 專案

與此同時我們歷時兩年多籌劃，並與國內上百家企業多次座談交流歸納意見，將淨零碳排與結合在地社區共同推動生物多樣性保育之國際趨勢，與企業落實 ESG 需求對接，規劃建置「自然碳匯與生物多樣性專案媒合平臺」( 網址 : https://esg.forest.gov.tw/ForestESG)，媒合企業與國、公、私有土地地主，鼓勵企業以公私協力方式參與森林經營或自然棲地復育與維護工作，並核予成果證明之制度，供企業作為 ESG 永續報告書之績效，期能藉由公私部門共同努力投入，增益自然碳匯、促進生物多樣性保育，落實永續發展及淨零目標。

林業保育署 ESG 媒合平臺針對企業所提供的專案，含括「自然環境」及「林業社會文化」兩大面向、共 11 個類型，涵蓋增加森林碳匯的造林專案；保育野生動植物與棲地的生物多樣性專案；保存重要林業文化資源或原住民族山林智識的社會文化專案，提供企業參與，更鼓勵企業運用自身專業與資源，主動提出對生物多樣性有助益的合作專案。

ESG 媒合平臺成果專區揭露所有專案資訊與成果；企業亦可透過國土生態綠網圖資平臺查詢功能顯示專案所在位置，並套疊綠網空間藍圖，提供企業瞭解生產基地周邊生態資訊及投入 ESG 與生物多樣性的空間指引，可更有系統地進行 ESG 與生物多樣性投入的空間布局。專案執行除了須達成自然正向改變的目標外，為了踐行聯合國「保護森林應先關注倚賴森林為生的社群生計」的呼籲，以及生物多樣性公約對社區參與的期許，更強調須對於當地社區部落發展有正面貢獻，包含由企業投入經費資源於標的區域所在的山村部落，藉此提供在地居民執行造林撫育或是保育監測巡守的工作機會，或企業可舉辦員工家庭日、農民市集等活動，促進當地消費或協助推廣林下經濟或其他環境友善之農產品，讓森林與生物多樣性所在地區的居民能因 ESG 浪潮而受惠，也更能確保專案成果與彰顯 ESG 的社會效益。




Taiwan Ecological Network

## 未來展望

鼓勵企業以公私協力方式參與林業保育署 ESG 媒合平臺上的專案，共同落實聯合國永續目標、生物多樣性目標及 2050 淨零碳排目標，除藉由專案提供企業實際參與森林經營、自然棲地維護、生物多樣性保育及林業社會文化保存等工作，並以國土生態綠網平臺作為跨域合作基礎，促進生物多樣性及改善偏鄉山村部落社區經濟，振興產業等環境及社會效益，同時有效處理社會、經濟與環境挑戰，串聯淺山平原重要棲地軸帶，從節點、成線、再到面，實踐自然解方。

### 專案類型

**自然環境 (E)**

**自然碳匯**

- 新植造林
- 再造林
- 中後期撫育
- 竹林經營
- 平地造林維護

**生物多樣性**

- 棲地營造
- 野生物保育
- 環境友善產業發展

**林業社會文化 (S)**

**林業文化**

- 林業文化資源保存與活用

**山林文化**

- 傳統山林智識重建及應用
- 山林開放社會服務發展





農業部
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Forestry and Nature Conservation Agency, Ministry of Agriculture

## 作者

### 林業及自然保育署

林業及自然保育署為臺灣林業與自然保育主管機關，秉持永續森林經營、維護自然生態的信念，從環境保護、經濟發展及社會公義三方面，持續不斷推動各項業務，近年來，更致力於營造健康的森林、創造林產價值鏈、打擊非法採伐、強化國有林治理、落實自然保護區域經營管理、促進山村生態經濟等工作。

面對氣候變遷帶來日益嚴峻的環境問題，林業保育署秉持自然資源永續利用的原則，持續推動兼顧生態及產業的政策，實踐「永續林業、生態臺灣」的願景目標。

國立中興大學
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# 生物多樣性保護作為淨零排放的關鍵面向

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## 透過基於自然的解決方案淨零

隨著全球氣溫上升以及氣候變遷影響日益嚴重，在 2050 年前達到溫室氣體淨零排放的迫切性變得愈加顯著。淨零已成為國際氣候政策的焦點，透過從大氣層中移除溫室氣體以平衡已產生的總溫室氣體排放量，來限制全球升溫至 1.5° C ( 圖 1)。對能源與氣候政策進行徹底改變，遠不足以減少化石燃料及密集地土地使用活動造成的溫室氣體排放，還需要通過技術創新與基於自然的解決方案來加強碳移除。

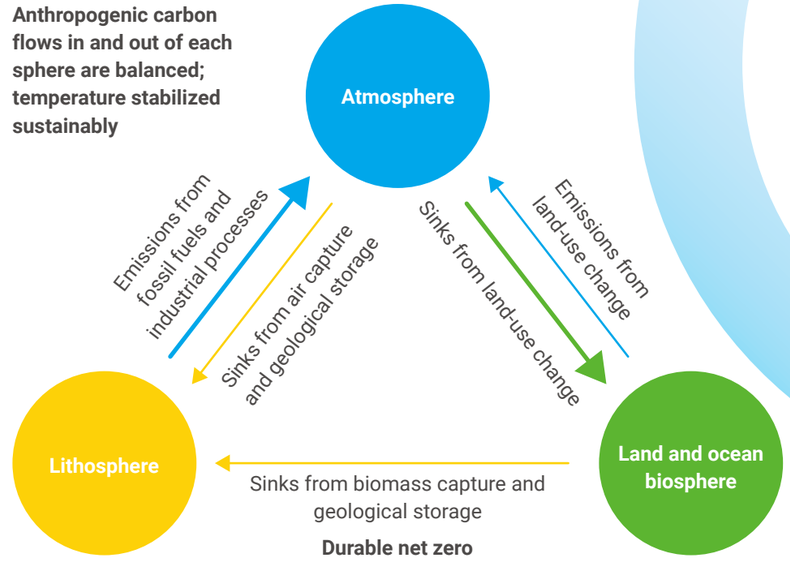



Figure 1 Framework for a durable net zero entails not only the aggregate balance of anthropogenic flows to and from the atmosphere but also the role of both biological carbon storage and longer-lived geological storage.

Source: Fankhauser et al. (2022). The meaning of net zero and how to get it right. Nature Climate Change, 12(1), 15-21.

基於自然的解決方案是歷史最悠久且最有效的溫室氣體移除方法之一，也能為生物多樣性、生態系統服務和人類提供益處。其活存的熱帶樹木中，所儲存的碳量大約佔大氣碳總量的三分之一。舉例而言，熱帶雨林的破壞不單造成溫室氣體的排放，也是廣泛認為是全球生物多樣性喪失和生態系統服務衰退的主要因素。原始天然林生態系統作為重要的碳庫，生物多樣性喪失與氣候變遷必須一同解決，因為它們代表著極為重要的地球限度，這些限度對地球系統的穩定性和運作有著顯著的影響，也確保地球資源能夠永續使用。

氣候行動與生物多樣性保育措施也緊密相連、相輔相成。尤其通過強調基於自然的解決方案實現淨零，可以吸引更多的關注與資金投入到造林、森林恢復和森林保護中，以支持生物多樣性的保育。許多政府與私營部門已採取果斷的行動，分配資金於景觀恢復、碳吸存及野生動物保護。反過來說，生物多樣性的保育亦是實現可靠的淨零目標的關鍵要素，因為它能增強碳抵換的環境完整性。碳抵消的環境完整性指的是所生成的碳信用確實反映出了真實的、額外的和可驗證的溫室氣體減排。

## 生物多樣性、生態系功能與碳匯

生物多樣性是地球生命的基石，生物多樣性的破壞可能導致全球生態系統的不穩定。從根本上來說，生物多樣性是由各種不同的生物組成，這些生物透過初級生產與分解，在調節大氣圈與生物圈的碳流動中，扮演至關重要的角色。生物多樣性錯綜複雜的網絡意味著，任何特定的過程，如植物生長，最終都會受到各種其他生物的影響。這種關聯性意味著，像土壤微生物、草食動物、授粉者和分解者等因子，在輔助和增強植物健康與生產力方面都扮演著重要的角色，從而提升基於自然的解決方案能夠對實現淨零的貢獻。

生物多樣性最常見的衡量方式是某一區域內的物種數量，而物種多樣性對生態系有重要影響，因為它會影響生態系的恢復能力與提供必須服務的能力。為了讓基於自然的解決方案能持續為人類帶來益處，相關的生態系必須健康且具備恢復力，能夠抵抗或從干擾中恢復。這種生態恢復力也受到橫跨多個營養層級的生態系連結、遺傳多樣性、功能多樣性和物種多樣性的影響。高度多樣化的生態系如果擁有多個重疊功能的物種，便能更好地從干擾中恢復。當其中一個物種消失時，另一個物種能夠承擔相似的生態角色，便能使生態系維持森林再生的關鍵生態功能，如授粉、養分循環和種子傳播。

相反地，由生物多樣性調節的關鍵生態系功能也受到了氣候變遷的威脅，這對生物多樣性產生了負面影響。氣溫上升、降水模式變化以及極端天氣事件改變了棲地並擾亂了生物的規律，例如微氣候的變化影響了蜜蜂的活動週期，從而導致授粉關係的不吻合，進而影響了授粉者和野生植物多樣性的繁殖成功率。植物多樣性本身就是生態系統功能和服務（如土壤碳儲存）的重要調節者。更高的植物多樣性與根圈碳輸入的增加相關，這些輸入的碳將與土壤微生物群落相互作用以促進碳儲存。因此，隨著生物多樣性的下降，生態系統提供這些必要服務的能力也會減弱，進而形成一個惡性循環，加劇氣候變遷帶來的挑戰。

## 地下生物多樣性的重要性

除了地表上存在的陸域生物多樣性之外，地表下的土壤微生物多樣性，透過土壤碳吸存以實現淨零目標，亦扮演著關鍵角色。土壤碳吸存已成為一種日益普及且無可否認的重要方法，用於長期捕獲和儲存大氣中的碳。土壤碳吸存的核心是微生物群落與土壤物理生物特性之間的相互作用，這些作用調節著碳儲量和碳通量。微生物群落之間的相互作用在肉眼看來顯得細微又微渺，但其影響在數量和時間尺度上卻遠遠大於其表面所顯現的。研究顯示，將微生物群落重新引入農業土壤對於提升土壤長期碳儲存潛力和穩定性至關重要。

土壤微生物多樣性的作用不僅限於碳儲存。土壤微生物群落藉由養分循環中的各種生化過程，如養分礦化、土壤有機物分解、固氮作用，以顯著增加土壤的生態系服務。宏觀和微觀生物體的多種代謝途徑，使它們能夠分解廣泛的有機材料。這一分解過程至關重要，因為它將複雜的有機化合物轉化為更簡單的形式，釋放出對植物生長至關重要的養分，同時將碳轉化為穩定的形式，儲存於土壤中。此外，多樣化的微生物群落還可以減輕土壤侵蝕和退化，這些都是碳儲存面臨的重大威脅。這些微生物通過形成複雜的真菌菌絲和微生物聚集體網絡，有助於將土壤顆粒結合在一起，改善土壤結構並防止侵蝕。生物和地質碳匯的穩定性和持久性對於實現長久的淨零是非常關鍵的（見圖 1），因為它們確保碳儲存在生態系統中能夠長期維持，而不是僅僅作為一個短期解決方案。



## 淨零最佳實踐需要考慮生物多樣性

遺憾的是，當碳匯成為焦點，並作為部分基於自然的解決方案，以實現淨零的目的時，生物多樣性往往遭受忽視。這將會局限健康且具恢復力的自然棲息地所能提供生態系的共同效益。在許多情況下，大規模的人工林或林地會以能快速創建高效的生物碳匯為優先，使用外來種或少數幾種能快速生長的物種來建立。這是一個需要被關注的問題，因為與其他生態系統服務之間存在著利弊權衡。強調基於生物多樣性的保護、恢復以及本地生態系的永續管理的基於自然解方，不僅能維護生態完整性，還能增強生態系適應變化的能力，從而在數十年內實現更具永續性的成果。

除了選擇適合的植物物種進行自然恢復工作之外，還必須謹慎地選擇能夠最大化緩解氣候和生物多樣性保育二者共同效益的恢復地點。森林覆蓋處、造林地、地上碳儲量的高解析度區域地圖，可以被用來鑑別恢復的可能，以支持實現淨零決策的資訊（圖 2）。例如，東南亞地區許多退化的森林區域提供了大量恢復機會，尤其是那些伐採嚴重而無法再作為木材生產作用，需面臨轉換的風險地區。此外，農業景觀中的嚴重退化的森林保留區，如河岸緩衝區和現有林地內的高保護價值和高碳儲量區域，也存在恢復機會。恢復河岸緩衝區可以創造重要的生態廊道，加強野生動物和依靠動物傳播種子的森林區域之間的連結性。淨零的最佳實踐還需要考慮恢復工作的規模。大面積恢復區可以減輕小片森林邊緣效應所導致較高的林木死亡率，而小型森林碎片則可以作為生物多樣性的重要跳板。

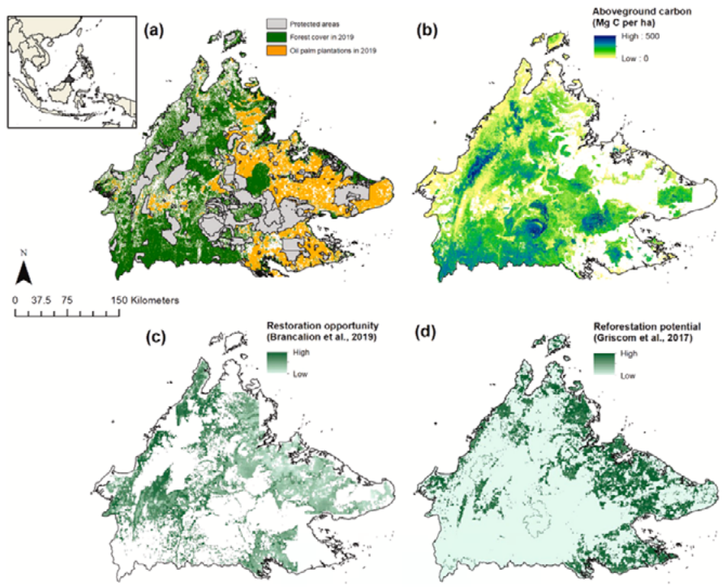



Figure 2 High-resolution regional map and information for Sabah (a-b) used to identify restoration (c) and reforestation opportunities (d).

Source: Scriven et al. (2022). Supporting decision-making by companies in delivering their climate net-zero and nature recovery commitments: Synthesising current information and identifying research priorities in rainforest restoration. Global Ecology and Conservation, 40, e02305.

## 總結

《生物多樣性保護作為淨零排放的關鍵面向》強調，實現淨零排放不能僅僅是靠著減少碳排放，還需要保護和恢復生物多樣性。擁有生物多樣性的生態系統能作為天然的碳匯，吸收大量的大氣碳，同時提供如授粉、氣候調節和養分循環等重要的生態系統服務。最終，若要實現全面且永續的淨零策略，必須在自然解決方案中優先考慮生物多樣性。雖然缺乏直接證據證明生物多樣性保護與碳吸收量之間的關聯，但本文強調了生物多樣性在促進生態系統韌性和穩定性中的重要性。自然可以成為對抗氣候變遷的強大助力，但錯誤的氣候行動可能會損害生物多樣性，甚至導致更高的溫室氣體排放。我們也應認識到，儘管自然解決方案為環境和社區帶來了諸多益處，它們並非解決氣候危機的萬靈丹。有效的氣候行動不只需要大幅減少排放，亦需同時實施這些解決方案。平衡的策略至關重要，必須認識到雖然大自然可以幫助緩解氣候變遷，但它無法取代我們在排放制度上進行系統性變革的迫切需求。




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柳婉郁博士出生於嘉義，現任國立中興大學特聘教授，主要專長在氣候變遷與碳吸存、自然碳匯與碳權、環境與資源經濟、森林資源評價等領域。利用自然科學與社會科學分析方法實際解決當前我國環境資源與碳匯規劃問題上，充滿熱情與理想，具體解決實際國際環境經濟問題與應用並提升自然環境資源效益。



圖 1 辦公室員工享用美味的永續午餐

# 從餐桌到社區：怡和餐飲集團的資源循環之路

**麥顯鋒** 怡和餐飲集團 供應鏈管理及永續發展董事

午餐時刻，位在香港鰂魚涌德宏大廈的辦公室裡，不時傳來歡笑聲。員工們三三兩兩走向擺滿中西式美食的餐桌，愉悅地享用午餐。這是怡和餐飲集團近期開展的永續午餐計畫「Show Me Your Love」，旨在透過資源循環策略，創造餐飲永續價值鏈的同時，也將美食回饋給在地社區。

作為亞洲領先的餐飲集團，怡和餐飲集團經營廣為人知的 KFC 肯德基及 Pizza Hut 必勝客品牌，業務遍佈香港、澳門、緬甸、台灣及越南等 5 個市場，擁有超過 1,000 家分店，員工人數約 25,000 人。我們深知餐飲業所能發揮的獨特影響力，因此致力於將資源循環的理念深入到各個市場以及所在社區，讓循環成為消費者與員工們的日常。

## 永續午餐盒：資源循環的起點



根據聯合國政府間氣候變遷專門委員會（IPCC）數據，全球溫室氣體排放量中有近三成來自於餐飲產業，艾倫・麥克阿瑟基金會（Ellen MacArthur Foundation）則指出，食物系統若能導入資源循環，可減少將近一半的溫室氣體排放量。

有鑑於此，自 2022 年開始，怡和餐飲集團即在辦公室內透過循環午餐盒的計畫，推廣可重複使用的餐盒替代一次性包裝；這項計畫隨後發展成為「Show Me Your Love」永續午餐計畫，加入食物循環和廢棄物管理元素，目標是實現餐飲價值鏈的零浪費。

在香港，我們與怡和集團的其他機構成員合作，將營運過程中所產生的廚餘（如富含鈣質的蛋殼），轉送至當地再生農場合作社，為農場提供養分。這些栽培的農產品則成為我們永續午餐計畫中的菜單食材。每月，怡和餐飲集團的主廚們根據當季所收成的農產品，設計多元菜單，將再生農業所帶來的生物多樣性融入其中。

在推動循環經濟的同時，我們每售出一份循環午餐，便透過支持身心障礙者的非營利組織「 Dignity Kitchen」同步捐贈一餐給長者或弱勢族群。自 2024 年 6 月計畫試行以來，已經捐出超過 800 份餐點。此外，永續午餐計畫也做為資金來源，為安寧關懷之家的病患和家屬提供下午茶，當計畫累積到足夠的「愛心」（即訂單數量）後，下午茶活動便會啟動。我們已於 2024 年 7 月至 9 月間舉辦了兩次下午茶活動。

## 循環創新：減少溫室氣體排放量




圖 2 台灣和越南必勝客改用六角形披薩盒，和 2021 年尚未採取行動時相比，塑膠支架消耗已減少九成以上




圖 3 於 2024 年間 ，台灣肯德基透過可重複使用的循環杯和內用杯，共計減少超過 111 萬個一次性飲料杯的消耗

IPCC 的報告顯示，餐飲業的溫室氣體排放中約有 5% 來自食品包裝。自 2022 年起，怡和餐飲集團將台灣和越南必勝客的披薩盒重新設計，由原先的四角形改為六角形，重新設計後的披薩盒不僅增加了承重力，盒子在堆疊時也更加穩固，不容易塌陷。

這項行動使得原先用於支撐披薩盒中心、防止塌陷的一次性塑膠支架得以移除，不僅減少廢棄物，還降低了包裝成本。目前，除了部分期間限定產品仍需要使用少量支架之外，這項行動和 2021 年尚未採取行動時相比，已經減少台灣和越南必勝客九成以上的塑膠支架使用量。怡和餐飲集團將持續就現有的包材，在各地市場尋求更多減少一次性浪費的解決方案。

同時，台灣肯德基自 2022 年起推出循環杯服務，提供外帶飲品的顧客可租借的循環杯，讓顧客在自備環保杯之餘，也有更多環境友善的消費選擇；截至 2024 年底止，全台共有 62 家肯德基餐廳的顧客得以使用循環杯服務。

為了進一步減少一次性容器的消耗，台灣肯德基也逐步重新規劃門市空間，騰出內場空間來安裝容器清洗設備，以便讓在餐廳內用的顧客也能選用可重複使用的飲料杯；於 2024 年間 ，台灣肯德基透過循環杯和內用杯共減少超過 111 萬個一次性飲料杯的消耗。

## 協力各方：以資源循環實現減排承諾

怡和餐飲集團已完成全集團範疇一、二、三基準年溫室氣體盤查，並承諾在 2033 年以前，將範疇一及範疇二的溫室氣體絕對排放量在 2023 年的基礎上減少 54.6%，同時將範疇三的溫室氣體絕對排放量減少 32.5%。此外，我們也承諾在 2033 年以前，將範疇三中森林、土地及農業排放量（FLAG）在 2023 年的基礎上減少 39%，並在 2025 年之前，針對毀林相關的初級商品實現零砍伐目標。

我們已將此目標提交科學基礎減量目標倡議組織（Science Based Target initiative，簡稱 SBTi ），並於 2024 年 11 月獲批准，成為在怡和餐飲集團所營運的市場（即香港、澳門、緬甸、台灣、越南）中首家達成此里程碑之餐旅業者。

怡和餐飲集團深知，若要逐步朝淨零碳排邁進，我們必須連結價值鏈中的每一位夥伴，包括員工、顧客、政府、社區團體等各方利害關係人，以資源循環創造最大的永續價值。我們將持續尋找志同道合的夥伴，攜手合作打造永續餐飲生態圈。




## 作者

**麥顯鋒**

**怡和餐飲集團**

**供應鏈管理及永續發展董事**


麥顯鋒現為怡和餐飲集團供應鏈管理及永續發展董事，負責集團旗下香港、澳門、緬甸、台灣及越南的供應鏈及永續發展策略。他於 2020 年加入公司擔任項目董事，隨後被任命現職。過去 15 多年以來，麥顯鋒於亞洲餐飲業擔任過不同職務，從業務開發、營運、行銷以至供應鏈管理，皆一直致力在商業及環境的永續發展找適當的平衡點。麥顯鋒在加入怡和餐飲集團以前，曾於太平洋咖啡、威尼斯人及峰景餐廳集團擔任管理職位。

麥顯鋒持有工商管理學士學位，也是一名註冊會計師。他亦是精品咖啡協會（Specialty Coffee Association）及葡萄酒與烈酒基金會（Wine & Spirit Education Trust）認證的鑑賞家。

DFI RETAIL GROUP
An IKEA retailer



## 臺灣家具產業發展循環商業模式的跨界合作

**艾斯本** DFI IKEA 集團（香港，台灣，澳門）餐飲創新與企業永續發展經理

**趙怡茜** DFI IKEA 集團（香港，台灣，澳門）企業永續發展專員

隨著線性生產和消費模式對環境造成的影響日益顯著，循環經濟的概念在商業界獲得越來越多的關注。循環商業模式專注於通過減量、回收、翻新和再利用來延長產品的生命週期，為更具永續性和韌性的經濟模式開創了新契機。2022 年，臺灣家具產業的產值約為 30 億美元，在這股轉型趨勢中具有領導地位的潛力。然而，要成功推行循環商業模式，製造商、消費者、零售商、政策制定者和廢棄物管理單位等多方利害關係人，必須展開前所未有的密切合作。

臺灣是亞洲較為先進的國家之一，其製造業以卓越品質和創新設計聞名，而家具產業在其中扮演重要角色。2021 年，臺灣家具出口額超過 15 億美元，主要市場包括美國、日本和歐洲。然而，與許多產業一樣，家具業仍主要遵循「開採 - 製造 - 丟棄」的線性經濟模式。這種模式導致大量浪費， 根據環境部資料，台灣的廢棄物總量在過去五年增長了 7%，到 2023 年達到 3,219 萬公噸。近年來，消費者對平價家具的需求增加，進一步加劇了這個問題；產品壽命縮短，環境足跡不斷擴大。在臺灣，家具廢棄物佔都市固體廢棄物的比重顯著，對垃圾掩埋場容量和廢棄物管理系統造成巨大壓力。這對環境的影響也日益凸顯：原材料開採、能源密集型的製造過程，以及家具在掩埋場的最終處置，均加劇了資源耗竭、溫室氣體排放和環境污染等問題。要解決這些挑戰，我們需要從根本改變家具的設計、生產、消費和處置方式，朝向重視永續性和資源效率的循環經濟模式發展。

## 多元合作夥伴協作的必要性

要在臺灣建立起家具的循環模式，多元合作夥伴齊心協力、共同尋找具成本效益的解決方案至關重要。

### 1 家具製造商

在循環經濟轉型中扮演關鍵角色，他們擁有重新設計產品的專業知識，能提高產品的耐用性、模組化和可回收性。透過採用永續材料（如木材）和創新生產技術，製造商可以生產出更容易維修、翻新或回收的家具。然而，這種轉變需要大量投資，包括開發新材料和生產技術。財務考量在這個過程中至關重要。研究顯示，由於需要引入新技術、採用永續材料和重新設計產品，轉向循環模式的初期成本可能比傳統生產方法高出 20-30%。不過從長遠來看，原材料使用減少和廢棄物處理成本降低所帶來的效益，能夠平衡前期的額外投入。此外，與各方合作夥伴的協作也有助於克服部分挑戰。若從設計階段就開始著手，便可以推動模組化家具的開發，使家具的零組件易於更換或修繕，從而延長產品壽命。艾倫・麥克阿瑟基金會的研究就指出，在家具行業採用循環原則，不僅可將材料成本降低高達 30%，還能顯著減少碳排放。

### 2 零售商

在塑造消費者觀念和行為方面扮演著關鍵角色。他們不僅是連接製造商和消費者的橋樑，還會通過行銷策略、產品展示和店內體驗影響消費者的購買決策。通過積極推廣循環家具的選項，零售商能夠有效引導消費者的選擇，加速永續行動被更多人實踐。商業模式的創新帶來了許多令人期待的機會，其中最引人注目的是「家具即服務」模式（furniture-as-a-service, FaaS）。在這種模式下，消費者選擇租賃家具而非直接購買。這不僅為消費者提供了經濟實惠且靈活的選擇，還確保家具在租期結束後能夠回到零售商手中，用於重複使用、翻新、轉售或回收。歐洲市場中，宜家家居已經試行了類似計劃並取得積極成果，臺灣也已開始進行相關測試。另一個零售商和製造商之間明顯的合作領域是推出舊家具回收計劃。通過提供折扣或商店積分等優惠，鼓勵消費者歸還使用過的家具。這種做法不僅促進了資源回收，還為製造商提供了穩定的翻新或再生材料來源。然而，目前這個構想在實施上仍面臨諸多挑戰。

### 3 消費者

在循環商業模式的成功中扮演關鍵角色，但需要提高人們對永續家具益處的認識，以改變消費者行為。根據 PwC「2024 全球消費者洞察調查」，為了減緩氣候影響，46% 的受訪者計劃購買更環保的產品以減少環境足跡，而 43% 的受訪者打算更謹慎消費以減少整體支出。消費者平均願意為永續產品多支付 9.7% 的溢價，其中最具吸引力的永續要素是：降低生產過程的消耗和回收利用（40%）。這些數據顯示，雖然消費者願意接受永續產品，但仍需要加強消費者教育和獎勵機制。例如，廢棄物管理單位必須與家具製造商密切合作，開發高效的系統來收集、處理和回收廢棄家具。目前，只有約 20% 的家具廢料被回收或再利用，這顯示出了巨大的改進空間。

### 4 政府和產業團體

由政府和產業團體主導的教育活動也可以讓消費者了解循環家具的環境和經濟效益。此外，提供回購計劃或翻新商品折扣等獎勵措施可以鼓勵消費者參與循環經濟。例如，宜家家居的循環計劃（包括家具回收和修繕翻新服務）在實施地區的客戶參與度增加了 50%。而當消費者要求永續產品或服務時，他們同時也為製造商創造了創新和採用循環實踐的市場激勵。

政府政策是促進循環商業模式的強大工具，但也可能成為主要障礙。若要擴大循環經濟規模的轉型，政府需要提供明確的方向和長期的可預測性，以促進轉變商業模式所需的投資。政府政策必須提供一個清晰的藍圖，包括建立有效的廢棄物管理生態系統，設定使用可回收材料的要求，為實踐循環的公司提供稅收優惠，或實施延伸生產者責任（extended producer responsibility, EPR）計劃，使製造商對其產品的生命週期終端管理負責。

投資先進的回收技術和基礎設施對於處理家具製造中使用的多樣化材料是必要的。預計到 2025 年，全球回收木材和家具材料市場可能達到 200 億美元，顯示出巨大的經濟潛力。臺灣在推動其他行業的循環經濟原則方面已經取得了進展。「資源回收再利用法」和「四合一回收制度」成功地將臺灣的廢棄物回收率提高到超過 55%；將這些政策擴展到家具行業，可以進一步提高循環性。此外，政府可以投資研究和開發以支持循環經濟。通過資助探索家具生產新材料和新技術的計劃，政策制定者可以促進更永續的產業轉型。與製造商和研究人員合作可以幫助確保法規切實可行並有利於創新。

### 5 研究機構和非政府組織（NGOs）

在推進循環經濟方面也扮演著關鍵角色，它們提供寶貴的見解、數據和最佳實踐。例如，研究機構可以發掘設計、生產和回收家具的新方法，而非政府組織則可以倡導永續的消費和生產模式。這些組織可以充當橋樑，促進製造商、政策制定者和消費者之間的對話和知識交流。

因此，為建立家具的循環經濟，臺灣必須培養一個協作生態系統，讓各利害關係人積極參與並相互支持。這可能涉及形成多方利害關係人聯盟或工作小組，專注於家具行業的循環經濟倡議。這樣的平台可以促進對話、分享知識，並找出能夠推動進展的共同項目。

例如，製造商和廢棄物管理公司可以共同開發舊家具回收計劃，確保材料被回收和再利用。政策制定者則可以透過制定參與獎勵和法規來支持這些倡議。最後，透過把消費者也納入討論中，我們就能根據市場的實際需求和喜好來調整做法，讓更多人願意接受並參與在循環經濟當中。








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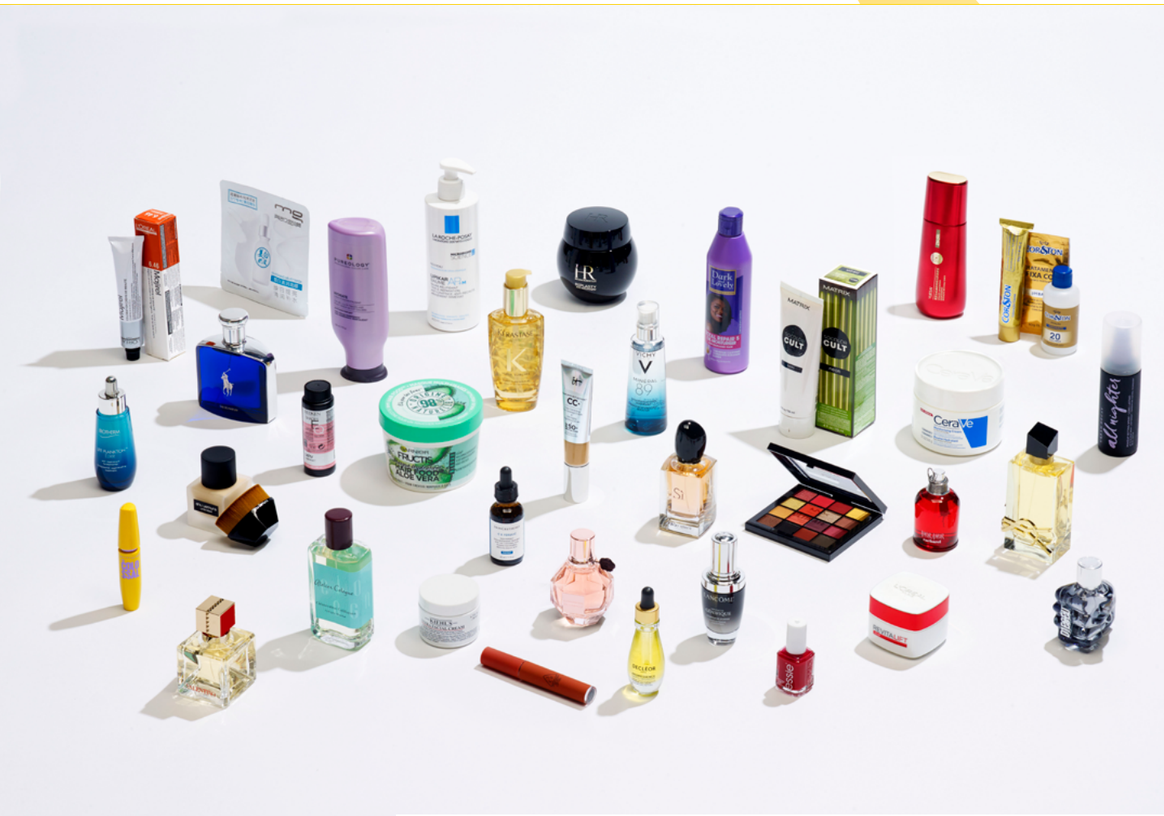
**企業永續發展專員**


宜家家居的願景是「為大多數人創造更美好的生活」。我們提供設計優良、實用且價格親民的家具及家飾用品，讓每個人都能打造理想的家。這個理念來自創辦人英格瓦・坎普拉德，他建立了宜家家居獨特的營運模式：從自主設計、全球生產、集中採購配送，到自助購物系統。

在宜家家居，所有商品都遵循「民主化設計」的五個原則：設計精美、實用、耐用、可負擔得起和永續環保。透過持續創新，我們在每個生產環節精益求精，讓更多人都能擁有優質且設計精良的家居用品。

2019 年，宜家家居制定「循環設計原則」，以 2030 年為目標，致力讓所有商品符合循環經濟概念。這項計畫著重延長產品使用壽命，減少原物料使用，為永續發展貢獻力量。秉持民主化設計和循環經濟的理念，宜家家居將持續為大眾提供時尚、實用、價格實惠的家具用品。我們不斷創新求進，致力為顧客創造更好的生活，同時實踐環境永續。

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## 萊雅對永續包裝的承諾：致力減少廢棄物和塑膠

萊雅集團是全球美妝業的領導者，長期致力於環境的永續發展。萊雅在 2020 年提出「萊雅迎向未來」第二階段永續計劃，以目標 2030 年的積極承諾，進行企業永續轉型，盡力減少對環境的影響，藉由強化其商業生態系統的影響力，來應對全球環境和社會挑戰。這項承諾不僅僅涵蓋減少公司的直接環境足跡，還包括其對整個供應鏈和產品生命週期的間接影響。以下簡述萊雅的全球倡議，以及台灣萊雅在減少塑膠與廢棄物的行動，並朝向循環模式方向的期許。

## 萊雅的全球永續發展目標

萊雅永續發展著眼地球限度的維護，確保其運營與資源的運作切合地球永續發展的環境臨界值。“萊雅迎向未來”的主要永續目標包括：

- 至 2025 年：100% 的塑膠包裝將是可再填充、可回收、可重複使用或可堆肥的。
- 至 2030 年：包裝中使用的塑膠將 100% 是回收或生物基塑膠（2025 年達到 50%）。
- 至 2030 年：與 2019 年相比，包裝使用強度降低 20%。

這些目標推動了自 2007 年以來實施的三管齊下的生態設計政策：**減少**、**替代**、**回收**。

1. 減少：萊雅通過降低包裝大小、優化重量（2022 年與 2019 年相比減少 3%），以及創新的包裝設計致力減少使用塑膠材料。公司還擴大了其可重複使用和可再填充的產品範圍，例如香水補充機、以及台灣上市多項可再填充的彩妝盒、補充包等，以進一步減少整體包裝數量。

2. 替代：創新是替換高環境衝擊材料的關鍵。萊雅正在用再生塑膠取代原生塑膠，例如某些卡詩產品和 Elvive 洗髮精已使用了 100% 回收 PET 包裝瓶。此外，還開始用紙素材代替塑膠，Garnier 的固體洗髮精就是一個例子。與 Albéa 等合作夥伴的合作促成了紙軟管為基礎的包裝發展，顯著減少了塑膠用量，已引進台灣的理膚寶水的 Anthelios 系列防曬乳產品就是一個應用的例子。

3. 回收：策略合作夥伴關係對於發展循環經濟至關重要。萊雅積極參與麥克亞瑟基金會（Ellen MacArthur Foundation）的“新塑膠經濟”（New Plastics Economy）和化妝品永續包裝倡議（SPICE），以促進美妝業的合作。萊雅循環創新基金成立於 2022 年，投資 5000 萬歐元，進一步支援擴大循環經濟解決方案的規模。2017 年，萊雅與 Carbios 聯盟，開發一種酵素塑膠回收技術，可以製造出類似原生塑膠品質的回收 PET 塑膠，從而生產出世界上第一個由 100% 生物回收 PET 製成的美容產品瓶。

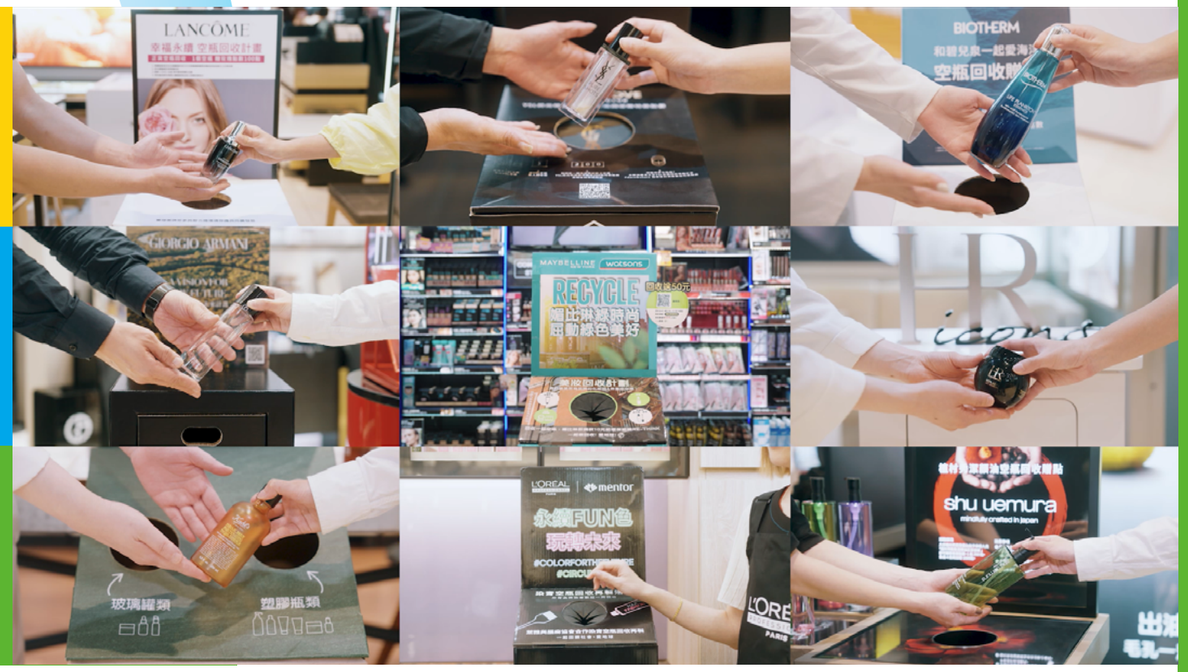
## 台灣萊雅「愛再生」空瓶回收計劃



台灣萊雅獨特的“CircuLove”「愛再生」空瓶回收計劃展示了對永續發展實踐的堅定承諾。這項跨品牌計劃於 2022 年啟動。計畫背景緣起於臺灣有良好回收模式，但消費者對材質設計較複雜的美妝產品空瓶，需要更多教育以妥善處理美妝品包裝，避免造成廢棄物。為了簡化回收美妝品包裝時清洗、拆解分類等處理並協助消費者做好美妝空瓶回收，「愛再生」空瓶回收計劃鼓勵消費者將用完的美妝空瓶，帶到品牌銷售的百貨公司萊雅品牌專櫃和屈臣氏，進行收集與回收。

這項計畫不僅僅是單純的回收收集空瓶；它也積極讓弱勢群體參與回收後的空瓶清潔和分類等再生製作前置作業，提供弱勢就業機會。台灣萊雅與 FNG 合作將整理後的可再利用的空瓶材料，製成可重複使用的再生材料，應用到如圍裙、毛巾、提袋和手機時尚配件等再生物件。目前已有九個萊雅品牌參與全年回收的計劃，持續堅定空瓶回收與再生的方向。

「愛再生」空瓶回收計劃不僅促進了有效的資源回收，也建立了更永續的消費者行為，同時加入了社會參與關懷。藉由「愛再生」空瓶回收計劃，台灣萊雅為臺灣美妝業的永續展現了新的做法，期望增進回收和再生運用，致力減廢減碳。








在萊雅，我們期許做好管理自然資源的使用，以確保我們的營運，在資源受限的地球得以永續共成長。我們持續推動使用永續來源或源自綠色化學的可再生原料。與此同時，我們仍在努力尋找更多解決方案，以實現更多的回收成效並促進循環經濟的發展。

有關萊雅永續發展更多詳細資訊，請參見 loreal.com。

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**作者**

**萊雅集團**

115 年來，引領美妝產業的萊雅集團致力於一個目標：滿足全球消費者對美的渴望。我們的使命是創造美力，感動世界。我們對美的定義是多元共融、符合道德、包容並蓄並致力於對社會及環境的永續承諾。透過我們 37 個多元的國際美妝品牌，以及「萊雅迎向未來」永續計畫的積極承諾，我們為全世界的每個人提供在品質、功效、安全性等方面的最佳產品，並支持每個人多樣的美。

由集團 90,000 名敬業的員工，平衡的區域發展和遍及各銷售通路（包括：電子商務、大眾消費市場、百貨公司、藥局與藥妝店、美髮沙龍、品牌零售店以及旅遊免稅零售點）的銷售，萊雅集團 2023 年的銷售額達 411.8 億歐元，萊雅在全球 11 個國家設有 20 個研究中心，以及由 4,000 名科學家與 6,400 名數位專家組成的創新研究團隊，萊雅致力於開創美妝領域的未來並成為美妝科技的發展動力。

有關更多的資訊，請瀏覽：https://www.loreal.com/en/mediaroom/

雀巢 Nestlé Good food, Good life




## 歐洲商會 2050 淨零願景

## 永續消費浪潮

**羅台青** 台灣雀巢 董事長兼總經理

## 設計與製造

### 手沖咖啡的永續革新！台灣雀巢攜手 MIT 供應鏈打造「雀巢好好咖啡」讓世界看見台灣生生不息的創造力

國際食品龍頭雀巢以「創造共享價值」的商業哲學，從全球到在地持續驅動創新。台灣雀巢在深耕台灣 40 年之際，攜手在地產學及供應鏈夥伴，從設計、研發、生產製造，耗時 15 個月打造出全球首創的「雀巢好好咖啡」，不但方便攜帶並將一次性耗材最簡化，隨時隨地都能來一杯好咖啡，重新定義手沖咖啡的永續價值，更榮獲全球最權威的設計獎之一德國 iF 設計大獎肯定，讓世界看見台灣在永續發展的創造力。

### 集團策略在地實踐 台灣雀巢以 BEST 四大永續催生「雀巢好好咖啡」

台灣雀巢董事長兼總經理羅台青表示：「雀巢秉持『Good Food Good Life』的核心理念，始終『相信一杯好咖啡的力量』，在全球，雀巢透過『咖啡永續計畫 (Nescafé Plan 2030)』，從土地、種植、咖啡豆採收到包裝，攜手價值鏈夥伴打造更具韌性的咖啡產業鏈。而台灣雀巢持續推進 BEST 四大永續行動，『雀巢好好咖啡』在實現商業永續的同時，更對地球環境、台灣的社會及人才發揮正向影響力，具體實踐企業與在地供應鏈、學界、消費者共享價值的商業哲學。」



台灣雀巢與成功大學進行產學合作，激盪在地設計人才的創新想法，攜手 MIT 供應鏈將創意具體實踐，集結眾人之力打造出「為你好，為地球也好」的「雀巢好好咖啡」。並貫徹 5R 概念，包含「重新思考 (Rethink)」、「重新設計 (Redesign)」、「重新使用 (Reuse)」、「減量包裝 (Reduce)」、「全可回收 (Recycle)」，重新定義手沖咖啡永續的新樣貌，透過可隨身攜帶、重複使用的不銹鋼品飲杯、手沖壺和濾杯，取代一次性碳紙、濾掛耳包，且全紙盒的外包和咖啡濾渣都是 100% 可回收，不僅減碳，也大幅減少原生塑膠的使用量。





## 雀巢攜手永續夥伴邁向共好 首批限量 5,000 組的「雀巢好好咖啡」售罄

台灣雀巢集結眾人之力打造出「為你好，為地球也好」的「雀巢好好咖啡」，在雀巢永續夥伴的支持下，首批限量 5,000 組的「雀巢好好咖啡」甫上市就售罄。除了向世界展示台灣於設計、生產、製造的頂尖實力之外，也期盼透過這一杯好咖啡的力量，讓各界重新思考永續的無限可能。

# 消費行為與教育







## 雀巢健康兒童計畫 - 攜手在地夥伴 共同培育更健康下一代

台灣雀巢長期關注食育素養與環境永續議題，2010 年將全球執行的「雀巢健康兒童計畫」帶進台灣，自 2010 年起與董氏基金會合作，深入全台灣國小校園，宣導均衡飲食：鼓勵孩子「每天兩杯奶」「全穀蔬果多多益善」「天天吃健康早餐」、「健康動」；迄今已深入全台逾 1,000 所小學，培育約 4,800 名種子教師、累積超過 15 萬名學童受惠；2022 年起更將營養知識結合永續，結盟台灣最大數位學習平台—均一教育平台，開發「永續食代新素養」系列課程，上架 5 支影片迄今於均一平台共累積 7.8 萬觀看人次、Youtube 平台觀看人次為 11 萬人次，並獲得平均 4.5 顆星的回饋 ( 高於平台平均的 4.2 顆星 )，2024 年更將推出最新的永續飲食影片，並進一步將 6 支影片整合國中小的課綱，期能引領師生和家長，更全面的將永續深植於生活。雀巢攜手均一將持續發展全面公開的數位課程資源，擴大受眾並提升老師、家長、學童的教學及自主學習動能。





# 關於雀巢

雀巢 (Nestlé) 是源自瑞士的國際食品龍頭，提供人們「優質食品、美好生活」(Good Food, Good Life)。雀巢旗下達 2,000 多個品牌，遍及全球逾 180 個國家，走入數十億人的日常生活。**雀巢的品牌宗旨：發掘食物的力量，提升每個個體的生活品質，不論是當下還是未來。**從全球到在地，雀巢以「永續」開展各項行動，深耕台灣逾 40 年，承諾持續推進 BEST 四大永續行動，包括：

1. 商業永續 (**B**usiness): 將世界級兼具營養及永續的產品及服務帶進台灣家庭，提升 0-99 歲全家人與毛小孩的生活品質。
2. 環境永續 (**E**nvironment): 攜手在地價值鏈夥伴，全力推動食品包裝改革及台灣在地循環經濟。
3. 社會永續 (**S**ociety): 針對社會缺口，運用雀巢營養、永續優勢，攜手利益關係人培育更健康的下一代。
4. 人才永續 (**T**alent): 接軌國際化的職涯機會，培養台灣下一代年輕人。



## 作者

**羅台青**

**台灣雀巢**

**董事長兼總經理**

台灣雀巢董事長兼總經理，是雀巢在台耕耘近 40 年來第一位本地董事長。羅台青女士上任以來推動「One Nestlé One Life」整合旗下事業體，促進跨品牌間合作交流，增加集團經營綜效，持續深耕台灣並帶動業績成長。




米其林 VISION 概念輪胎，，詮釋米其林的永續發展模式

VISION 概念輪胎展現了米其林集團對於未來永續交通運輸的構想，也將推動米其林研發團隊繼續創新案。

## 米其林「一切皆可持續」的輪胎

當今世界面臨許多前所未有的環境和社會挑戰。2050 年，全球人口預計超過 90 億，地球正處於緊急狀態，部分維持地球系統運作的關鍵閾值已經超過臨界點。米其林深知人類的未來取決於保護地球資源，因此採取全面的方法減少環境足跡，在地球的承載範圍內兼顧企業營運成長。

## 使用 100% 可持續材料生產輪胎的挑戰

當我們提到輪胎時，或許腦海中浮現的是生活中隨處可見的簡單黑色橡膠物體。然而，深入研究會發現，輪胎的複雜性遠超我們的想像。每一條輪胎都是由超過 200 種材料組成的精密技術傑作。這些組件必須和諧地協同工作，才能創造出符合嚴格性能標準的產品。

輪胎的製程是一個漫長而精細的過程，涉及硫化和品質控制等多個階段。在這個複雜的工程環節中，必須確保輪胎能兼顧多種表現：抓地力、耐用性，並在不同氣候和地形下展現韌性。輪胎的性能不僅僅關乎物理性質，也牽涉在不同面向中尋求平衡，例如：抓地力與磨耗速度、靈活性與堅韌度之間的平衡點。

當前的環境問題使輪胎設計變得更加複雜。在這個「永續」至關重要的時代，輪胎產業面臨著雙重挑戰，既要開發出高性能的產品，又要最大限度地減少資源消耗和碳排放。使用可持續材料製造輪胎不僅是一種趨勢，更是一種必然的方向。 100% 可持續材料輪胎的願景不再是遙不可及的夢想，而是產業正積極追求的具體目標。

## 使用可持續材料生產輪胎是否可行？

開發 100% 可持續材料輪胎在技術上是可行的；挑戰在於選擇符合嚴格永續標準的材料。「綠色材料」一詞經常被使用，但它可能產生誤導。例如，沙子是一種自然資源，但從沙子中提取生產輪胎使用的二氧化矽是不可再生的，一旦耗盡，將無可替代。因此，它無法滿足永續發展的要求。

另一方面，從柑橘類水果中提取材料，提供了一條更具潛力的途徑。這些可再生的生物基材料可以從柑橘皮等廢物中重新利用，在不影響糧食供應的前提下支持循環經濟。確保輪胎製程中使用的任何生物基材料不會與糧食資源競爭極其重要。



可持續材料

2022 年底，米其林發表了含有 45% 和 58% 可再生及回收材料的乘用車輪胎和巴士輪胎，並獲准使用於公共道路。這些技術也會被應用在 2025 年上市的輪胎。



71% 可持續材料輪胎

在 2024 年利曼賽中，米其林推出至今為止比例最高的 71% 可持續材料輪胎，搭載於 H24 氫能源原型車和高性能純電動保時捷 Cayman GT4 ePerformance。

輪胎製造除了生物基材料外，回收材料也是一個重要選項。雖然並非所有材料本質上都是可持續的，但回收利用這些材料有助於實現更循環的生產模式。簡而言之，永續輪胎生產的兩個關鍵規則是：材料必須是非糧食相關且可再生的、或來自回收資源。

目前，對於「可持續材料」一詞的使用，尚無明確定義或法規規定。米其林認為，只有那些在人類生命週期中可回收或再生的材料，才能被真正稱為可持續材料，這樣才能最大限度地提高環境指標。

在尋找輪胎製造的替代材料時，米其林面臨的主要挑戰之一，是要確保這些替代材料不會降低輪胎的品質和性能，尤其是安全性。米其林憑藉在高科技材料方面的豐富專業知識（截至 2021 年底申請了 3,678 項材料相關專利）。同時也透過投資新創公司來建立多種合作夥伴關係：加拿大塑膠回收公司 Pyrowave（回收苯乙烯）、法國生技公司 Carbios（回收 PET）、瑞典 Enviro 公司（回收炭黑等），以加速顛覆性技術的發展。米其林對其採購過程也非常重視，並在過去十多年來持續評估供應商的企業社會責任表現。截至 2022 年底，87% 的主要供應商已達到米其林集團制定的標準。

可再生或回收材料的定義（根據米其林集團準則）：

- **回收材料：**由廢棄聚苯乙烯 ( 如：優格罐、食品托盤、包裝等等 ) 重新轉化再生的苯乙烯、從 PET[1] 廢棄物 (如：寶特瓶、塑膠桶等等) 中再生的紡織品、從報廢輪胎中回收的炭黑。
- **再生材料：**來自負責任產業的天然橡膠、丁二烯 (或生物丁二烯)、生物質 (植物廢棄物) 製成的產品。

2022 年底，米其林發表了含有 45% 和 58% 可再生及回收材料的乘用車輪胎和巴士輪胎，並獲准使用於公共道路。這些技術也會被應用在 2025 年上市的輪胎。

2023 年賽季，米其林為 MotoE ™ 世界錦標賽提供含有 52% 可再生和回收材料的輪胎，並且能在賽道上達到時速 250 公里。此外，在 2024 年利曼賽中，米其林推出至今為止比例最高的 71% 可持續材料輪胎，搭載於 H24 氫能源原型車和高性能純電動保時捷 Cayman GT4 ePerformance。

要實現真正一切皆可持續的輪胎，必須考慮整個生命週期。不僅要在輪胎生產中使用 100% 可持續材料，還需要全面考慮輪胎生命週期。這包括確保製造和運輸過程中使用的能源來自永續來源。儘管挑戰巨大，但酶和熱裂解等技術的進步，為未來材料回收和再利用帶來了新的希望。

## 從生命週期評估邁向「一切皆可持續」的輪胎

對於米其林來說，僅僅在輪胎中使用可持續的材料是不夠的。輪胎在其整個生命週期中需要盡可能減少對環境的影響。所有永續輪胎的設計都必須實現從第一里到最後一里的持久性能，消耗更少的材料和能源，並避免過早更換輪胎。此外，所有「一切皆可持續」的輪胎都必須提供與當今輪胎相同甚至更好的安全性能。




生命週期評估

對於米其林來說，僅僅在輪胎中使用可持續的材料是不夠的。輪胎在其整個生命週期中需要盡可能減少對環境的影響。

在**設計**階段，米其林作為建模和模擬系統的先驅，使用虛擬測試來加速輪胎開發。我們能夠模擬輪胎在極端情況下的表現。這意味著使用更少的輪胎原型和實地測試，從而減少二氧化碳排放。這些模擬技術也應用在米其林為法拉利、Mercedes-AMG、保時捷、雪佛蘭 Corvette、Lexus、福特性能車款等車廠開發的最新輪胎系列（Pilot Super Sport、Pilot Sport Cup）。

在**製造**方面，米其林承諾降低其工廠對環境的影響，並計劃在 2050 年實現所有工廠的二氧化碳淨零排放、確保營運地區的水資源供應零影響，此外，我們還計劃完全消除輪胎製程中的溶劑使用。

在**運輸**方面，米其林的目標是到 2030 年將物流中的二氧化碳排放量比 2018 年減少 15%。為了這一項重要承諾，我們會在靠近市場的地方生產和供應，以減少長途運輸。

在輪胎生命週期評估中顯示，光是輪胎的**使用**階段就佔整體環境影響的 75% 至 90%。

「優異性能直到最後一里」是米其林 DNA 的一部分，也是其競爭優勢之一，這歸功於我們在材料和胎面設計的專業知識。僅在歐洲，如果所有輪胎都能被使用至法定溝深 1.6 mm[3]，就能減少 1.28 億條[2] 輪胎和 660 萬噸[2] 二氧化碳排放量。

事實上，過去 30 多年來，米其林一直系統化地優化輪胎滾動阻力，為節約能源和消費者成本做出了重大貢獻。輪胎滾動阻力約影響了 1/5 內燃機驅動車輛的耗油量。

米其林正在積極投資於用於輪胎生產的再生材料，並將這些材料重新引入新輪胎的生產中，積極促進**回收**業的發展，並與各合作夥伴攜手推動顛覆性技術的出現。

最後，所有「一切皆可持續」的輪胎必須適合大規模生產，而不僅僅是小批量或特定型號。 米其林在考慮輪胎生命週期每個階段對環境影響的同時，也確保生產流程能規模化，使每個人都能受益，而不是炫耀一個展示的輪胎樣品。

## 米其林的整體環境方法

米其林集團正全力推動「一切皆可持續」的 2050 年願景和「淨零排放」的承諾，以循環經濟作為環境管理的總體理念。同時，尊重環境也是米其林集團的核心價值之一。米其林開發高效的分析工具、利用獨特的創新能力和技術合作夥伴關係，來減少對地球的影響。

米其林採取的行動涵蓋了以下三個面向：

### 1. 透過生命週期評估進行環境足跡分析

米其林評估產品生命週期不同階段對環境影響的 16 項指標，涵蓋 4 大面向：健康、氣候變遷、化石資源的使用和生物多樣性。

目前，輪胎仍無法生物降解。 輪胎的抓地力對於行車安全極其重要，但同時也會產生磨損顆粒。從製造到運輸、使用和報廢處理，每一個階段都會涉及能源和水等資源消耗，並伴隨二氧化碳排放。

減少輪胎對環境的影響需要精確的數據支持。米其林利用生命週期評估 (LCA) 這一個強大的工具，可根據 16 種環境衝擊評估產品從設計到廢棄（原材料、運輸、製造、使用和報廢處理）生命週期的每個階段遵循歐盟委員會 (EU 2021/2279) 定義的方法。

LCA 清楚描繪了環境足跡，並指出產品、服務或活動在輪胎生命週期產每個階段的環境影響，使我們得以在研究和設計階段優先考慮可行的解決方案。這也是我們行動計畫的重點階段；80% 的環境影響是在構思階段確定的。

這個方法將於 2030 年全面使用在所有新產品和服務專案。事實上，截至 2021 年底，已經有一半的新輪胎專案接受了 LCA。自 2023 年以來，所有新專案都必須嚴格控制對環境的影響。

### 2. 生態設計是米其林創新策略的核心

根據法國能源轉型部的定義：

「生態設計是一種設計商品和服務時，從一開始就在考慮環境影響的方法。這種方法旨在減少產品在其生命週期每個階段對環境的影響。生態設計是一種多步驟、多維度的方法，涵蓋生命週期的每個階段和各種影響因素 ( 材料和能源消耗、釋放到自然環境中的物質、對氣候和生物多樣性的影響）。

生態設計深植於米其林集團的創新策略。米其林相信生態設計不僅是一個優秀的創新框架，更是在尋求環保解決方案時提供了明確的目標和邏輯。

生命週期評估 (LCA) 精確地闡明了輪胎、服務或活動對環境的影響。生態設計方法作為米其林集團策略的一部分，旨在減輕輪胎的負面影響，同時保持其品質和持久性能。我們不僅在設計或輪胎製程中考慮環境影響，更在產品或服務整個生命週期中致力於減少任何負面環境影響。

生態設計考量包括材料和能源消耗、向自然環境釋放的物質、氣候影響以及對生物多樣性的影響。產品的所有負面影響都經過仔細研究，以找到減輕這些影響的解決方案。

這種方法看似抽象，它涉及圖表、生態設計策略輪、百分比和微觀經濟數據。然而，其影響是真實而深遠的，對保護環境做出了重大貢獻。我們的主要目標是設計出性能相同且對環境影響更小的產品，並確保沒有任何負面影響轉移 ( 例如：提升某個性能的同時，卻造成另一種性能的退化 )。這一點可以透過對傳統產品 / 服務與生態設計的產品 / 服務進行環境比較分析來驗證。

在米其林，生態設計是多步驟、多維度和多學科的過程，這意味著公司內部許多不同的部門必須共同努力，協力改進產品或服務的設計。

米其林的目標是到 2030 年，所有產品和解決方案均採用生態設計。為此，集團制定了一個生態設計憲章，自 2022 年 6 月 30 日起在旗下所有公司生效。

以歐洲製造的 MICHELIN PRIMACY 4 輪胎為例。我們確定其「使用」階段佔其整體環境影響的 84%。借助生態設計工具和數據，工程師們選出了三個可執行的驅動因素來降低這一數字並提高產品的能源效率：優化滾動阻力、延長使用壽命和降低輪胎磨損。

「原材料」佔環境影響的 13%。為了減少這一影響，我們採取了多項措施，包括減輕輪胎重量，用回收或再生材料取代化石原料，選用低碳原料和零件，以及延長輪胎使用壽命並確保其更容易修復。



MICHELIN PRIMACY 4

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米其林集團也與 act4nature 國際組織攜手，加強對生物多樣性的承諾，以減少企業活動及其整個價值鏈對自然環境的壓力。

## 3. 面向 2030 及未來

米其林的整體方法更進一步，使我們能夠識別集團的主要環境影響，並將其轉化為 2030 年以後的具體目標。其中包括應對全球暖化、減少使用化石原料以及保護生物多樣性。

米其林為應對全球暖化，制定了到 2050 年實現淨零排放的目標，並積極推動低碳出行。我們在輪胎生產中使用越來越多可再生和回收材料，這也是米其林克服挑戰並保護自然資源的具體實踐。

米其林集團也與 act4nature 國際組織攜手，加強對生物多樣性的承諾，以減少企業活動及其整個價值鏈對自然環境的壓力。

作為全球最大的天然橡膠採購商之一，米其林深知全球需求的成長可能引發有害的做法。因此，集團致力於促進公平且對生態負責的橡膠產業，並透過吸引產業主要營運商加入，實現零森林砍伐的目標。

到 2030 年，米其林集團的所有生產工廠都將恪守在場地維護作業中不使用殺蟲劑或除草劑的承諾。

最後，米其林正在透過五個優先計劃來減少其工廠的影響：取水、有機溶劑的使用、產生的廢物量、能源消耗和二氧化碳排放。自 2005 年以來，我們的製造工廠一直以與能源消耗或二氧化碳排放相同的方式評估水消耗。

15 年來，米其林將用水量減少了 43%，節省了 1.78 億立方公尺的水資源，相當於法國等國家 330 萬人一年的家庭用水量。根據每個工廠的水資源壓力係數，我們計劃在 2019 年至 2030 年間進一步減少 33% 用水量。

米其林的策略和措施與 2015 年《巴黎協定》等國際環境原則一致，我們是聯合國全球契約的簽署國，並加強應對全球暖化的各種呼籲。米其林已加入「零砍伐」運動，並支持歐洲綠色協議以及歐盟關於零森林砍伐產品的法規。

[1] PET：聚對苯二甲酸乙二醇酯
[2] 數據取自安永「Planned obsolescence is not inevitable」報告 - 2017 年 5 月
[3] 輪胎的使用需在輪胎磨損均勻且符合輪胎製造商和汽車製造商的建議下進行。如有疑問，請諮詢專家。此為歐盟法定溝深。台灣《道路交通管理處罰條例》亦有明文規定，汽車輪胎胎紋深度不得少於 1.6mm。

**作者**

**米其林**

### 關於米其林

米其林致力於成為全球領先製造商，為人們提供改變生活的複合材料和非凡體驗。作為一家在工程材料領域創新超過 130 年的企業，米其林在推動人類進步和塑造可持續未來方面獨具優勢。

憑借對聚合物複合材料領域的深厚專業知識，米其林不斷創新，製造高品質的輪胎和零件，以滿足各種嚴格領域的關鍵應用需求，包括交通、建築、航空、低碳能源和健康醫療等領域。

米其林對產品的精益求精和對客戶需求的深入了解，持續激勵自身為人們提供最優質的體驗。米其林不僅為專業車隊提供基於數據和人工智慧的解決方案，還通過米其林指南推薦卓越的餐廳和酒店。

### 關於台灣米其林

米其林集團於 1972 年正式進駐台灣市場，公司位於新北市汐止區，其業務為米其林集團轎車胎、輕卡車胎、卡客車胎、捷運輪胎、工程車胎、農耕機胎、自行車胎以及摩托車胎之在台行銷業務。（具體詳情請訪問 www.michelin.com.tw）

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# 願景到實現 Vision to Reality：如何形塑臺灣永續未來？

安永聯合會計師事務所

經濟學家傑佛瑞・薩克斯（Jeffrey D. Sachs）提及：永續發展必須試圖理解三個複雜系統的互動，包括世界經濟、全球社會與地球的實體環境（傑佛瑞・薩克斯 , 2015）。並試問當數十億人透過市場、技術、金融、社群網路連結在一起，會發生什麼事？所得、財富和權力分配嚴重不均的全球社會，該如何運轉？當世界經濟與實體環境相互衝突，又會發生什麼事？

因此探討人類的永續發展，必須交互檢視環境、社會與經濟之間的關聯，而淨零作為環境維度的核心目標，仍需與其他永續議題，如經濟繁榮、社會公平協調推進。然而正當全球埋首推動永續工程的同時，是否意識到潛藏的危機？

**“永續發展在過去幾年轉動了巨大齒輪，但規模和速度仍然不足以因應我們面臨的危機。歸根究柢，我們仍在一個無法永續的系統上……高談永續轉型！”**

安永 2024 年《A New Economy》報告指出，當前世界正面臨生態、社會和地緣經濟三大系統危機，其交織效應正將全球經濟體系推向不穩定的邊緣，引起全球經濟體系的多重危機。我們已經超越了九大地球生命維持系統中的六大邊界，氣候變遷和生物多樣性喪失帶來的後果不僅無法逆轉，且愈發嚴峻。此外，COVID-19 疫情、能源危機以及多國間的地緣政治緊張局勢更進一步加劇了全球社會的不平等與脆弱性。

## 從全球三大系統危機映照臺灣現狀

### 1. 生態系統危機

- 全球氣溫升高 1.2° C，是有紀錄以來最熱的 10 年。根據中央氣象局的數據，自 1911 年以來，臺灣地區平均氣溫已上升約 1.6° C，超過全球平均升溫值（1.2° C）。
- 全球 1970 年以來野生動物數量下降 69%。臺灣的生物多樣性也受到顯著衝擊，自 1970 年代以來，臺灣特有種石虎的數量下降超過 70%，現存不到 500 隻，多種鳥類和兩棲動物（如臺灣藍鵲與臺灣鈴木氏赤蛙）的數量也大幅減少。
- 全球 1/10 人口遭受前所未有的高溫。2022 年，臺灣北部地區經歷超過 20 天高於 37° C 的極端高溫，與高溫相關的疾病與死亡率在臺灣逐年上升。
- 全球 2022 年因氣候變遷導致 GDP 損失 1.8%。綠色和平組織推估 2030 年極端海平面上升與風暴，可能影響亞洲地區 7 個沿海城市的人口、土地與 GDP；其中臺北市受影響人口約 43 萬、影響 GDP 約 24%（占臺北市總 GDP 之百分比）。

## 2. 社會系統危機

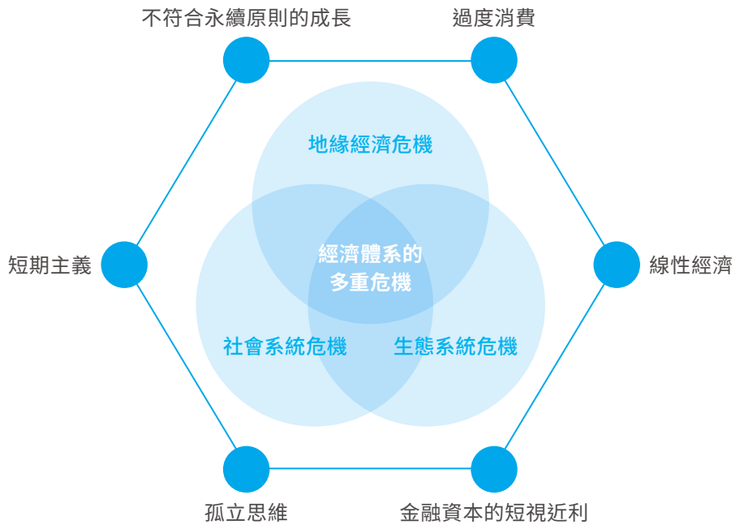
- 全球 1/8 的人都患有心理健康問題。根據臺灣衛生福利部統計，約有 15% 的臺灣人在其一生中會經歷某種心理健康問題，例如憂鬱症或焦慮症。特別是 COVID-19 疫情以來，心理健康相關的門診需求增加約 20%。此外，2022 年臺灣因心理健康問題申請的長期病假人數創歷史新高。
- 全球調查 45 個國家的年輕人有 30%~35% 因壓力而請假。根據臺灣人力銀行調查，2022 年臺灣 33% 的年輕勞工（18-34 歲）曾因心理壓力或倦怠而請假。主要壓力來源包括工作過度、薪資壓力及升遷瓶頸。此外，約 40% 的受訪者表示「心理壓力影響工作表現」，但僅有 25% 的人尋求專業協助。
- 中國、印度、美國、歐洲和拉丁美洲的老年人有 20%~34% 感到孤獨。在臺灣，孤獨感在老年人口中也是一個嚴峻問題。根據聯合國 2019 年出版的全球高齡人口報告（United Nations, World Population Ageing 2019），列出從 2019 年至 2050 年間全球高齡人口比率成長最快的國家與地區，臺灣僅次於南韓與新加坡，名列全球第三！衛生福利部統計 2023 年推動老年憂鬱症篩檢，共進行 62 萬人次篩檢，轉介就醫 2,800 人次、轉介心輔 1,553 人次、轉介其他心理衛生資源 3,606 人次，也首次讓老年自殺率下降。

## 3. 地緣經濟危機

- 低收入國家因 COVID-19 的死亡人數是富裕國家的 4 倍。在臺灣，COVID-19 的死亡率雖遠低於低收入國家，但根據衛福部調查，低收入家庭因疫情造成的醫療負擔及經濟壓力更為嚴重。此外，疫苗接種初期因全球分配不均，臺灣面臨疫苗短缺，使得部分高風險族群未能及時接種。
- 全球自 1960 年以來的新疾病中，超過 30% 可歸因於土地利用變化。臺灣的都市化與農地開發導致登革熱等病媒蚊傳染病在南部地區頻繁爆發，林務局報告也指出，棲地破壞增加了人與野生動物的接觸，更提高來自動物傳染疾病的風險。
- 全球自 2008 年以來，3.76 億人因自然災害和生態威脅而被迫流離失所，預計到 2050 年將有 12 億人流離失所。臺灣由於地理位置特殊，自然災害頻繁，特別是颱風和地震。依據國家災害防救科技中心的莫拉克颱風社會衝擊與復原調查（第一期），2009 年的莫拉克颱風造成 1,177 戶被迫遷移。隨著氣候變遷影響加劇，未來自然災害導致的人口遷移風險可能進一步上升。
- 2024 年世界經濟論壇全球風險報告，州際武裝衝突被列為第五大風險。臺灣素有科技島之稱，對臺灣造成影響的三大關鍵因素為科技板塊、能源安全及 ESG 政策；地緣政治風險將衝擊供應鏈穩定、能源進口，影響企業營運生產，因此更須加速落實 ESG 政策，實現能源轉型與自主。

綜上所述，根據安永觀察，促使全球經濟體系彼此交纏出的多重危機，來自 6 大根深蒂固的系統性缺陷，包括：

1. **不符合永續原則的成長：**經濟成果分配不均，不平等現象加劇，儘管經濟成長提高生活水準，但也推升對能源和資源的需求，將付出可怕的生態代價。
2. **短期主義：**從政策、商業規劃和投資視野，到多種認知偏見，導致優先考慮眼前事物，使我們對數百萬人的苦難麻木不仁。我們正在消費未來，轉嫁給尚未出生的未來世代，而他們卻無力阻止這種情況的發生。
3. **孤立思維：**面對複雜挑戰，傾向於將事物分解為更小、更易於管理的部分。導致無法考量整體系統當中某一部分的變化如何影響其他部分，並錯過識別轉型的機會。
4. **過度消費：**根據人類目前的消費模式，到 2030 年我們需要兩個地球，2050 年更需要三個地球才能滿足需求，背後隱藏著社會上最富有的人過度消費，而最貧窮的人卻在努力滿足基本需求。
5. **線性經濟：**循環利用方面沒有重大突破，將面臨食物、水和關鍵礦物等基本資源競爭。價格波動、供應鏈不穩定和潛在侵犯人權的行為都將加劇資源爭奪的緊張局勢。
6. **金融資本的短視近利：**持續高估短期財務績效和回報，而低估其他重要資本（如：自然資本、人力資本、社會資本）。導致誤判無法標價的事物的價值，忽略價值的真正意義。

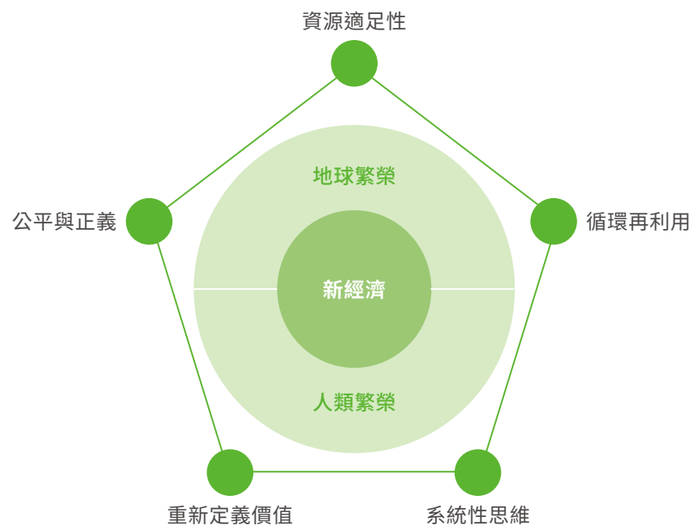



圖片來源：Regenerative principles to unlock a sustainable future, 2024, EY Global

## 安永的新經濟論述

要將上述危機轉化為具體行動需要全球政府與企業有意識地合作，消除結構性障礙並轉變為有利條件，在人類和地球繁榮基礎上創造新的、永續的經濟體系。為了加速轉型，安永建議制定的戰略和決策需要遵循五項原則：

1. **重新定義價值：**須將人類和地球的繁榮置於創造價值的核心，政策制定者、標準制定者及企業應重新定義無法用價格衡量的社會價值。
2. **公平與正義：**為實現全人類的永續繁榮，公平和正義是擺脫多重危機不可或缺的原則，公平分擔責任與利益，讓所有人過有尊嚴的生活，企業也可以為更公平的經濟做出貢獻，讓整個價值鏈共同參與，促進氣候與社會正義的改革。
3. **系統性思維：**找到連接點，催化系統變革！專注事物的整體及其一小部分之間的因果關係，識別其中關鍵，促進整體的變革。
4. **循環再利用：**確保生產消費與自然協調！只生產所需的產品，製造耐用的產品，並確保材料可以保留其內在價值或以安全的方式循環再利用。
5. **資源適足性：**足以在唯一的地球過上美好生活！在生態系統和社會可以承受的範圍進行消費。優先考慮滿足基本需求，而非服務不公平且過度消費的市場。




圖片來源：Regenerative principles to unlock a sustainable future, 2024, EY Global

## 臺灣的淨零政策

面對全球和本地的多重挑戰，臺灣政府於 2021 年提出了 2050 淨零排放目標及其實現路徑。2024 年，賴清德總統進一步提出「國家希望工程 2050 淨零轉型五大策略」，包括：

1. **二次能源轉型：**加速推動再生能源開發，優化電網基礎設施，提升能源效率與儲能，並逐步淘汰燃煤發電。
2. **數位與綠色產業雙軸轉型：**綠色金融助力，支持智慧與淨零科技技術研發，推動碳定價及市場機制及農業永續轉型。
3. **淨零永續的綠生活：**倡導全民節能減碳行動，提升公共低碳運輸使用率，推廣智慧居住與低碳飲食文化。
4. **政府作為淨零轉型最強而有力的後盾：**推動各產業建立技術服務團隊，研擬並定期公布行動指引，健全相關管考機制。
5. **不遺落任何人的公正轉型：**完善淨零轉型爭議處理機制、將氣候變遷化為區域發展的契機，打造公平與綠色的美好未來。

金融監督管理委員會隨後於同年公告「綠色及轉型金融行動方案」，彰顯國家希望工程當中金融將扮演重要的助力，同時開始推展轉型金融，意謂企業需揭露轉型計畫、資金使用和減排進展，讓金融業能確保資金的正確用途並避免漂綠風險。根據安永 2024 年全球氣候行動晴雨調查表（Global Climate Action Barometer）發現，全球只有 41% 的企業有轉型計畫，21% 的企業尚未制定計畫，可以預料的是，有轉型計畫的企業通常具有更高品質的氣候相關資訊揭露！

安永也發現企業在採取因應氣候危機的行動時，缺乏急迫性！在財務報表中提及氣候相關財務影響的進展仍相當有限！全球只有 36% 的企業揭露，雖然整體氣候相關資訊揭露方面取得了一些進展，但在很大程度上是由當地政府監管發展所推動，也呼應了國家希望工程所提及政府仍須扮演強力的後盾，安永建議應當立即採取行動，並提出警示，如果不採取進一步的氣候行動，到 2100 年，所調查的 51 個國家（包含臺灣）平均 GDP 預計將下降 35%。

## 安永建議：採取六項核心行動來加速變革

1. **制定轉型計畫，作為業務核心議題：**應以科學基礎設定目標，並為範疇一、二、三的排放量設定清晰的短中長期目標。此外，計畫應建立在嚴謹的情境分析上，並為供應鏈規劃脫碳策略。

2. **在財務報告中納入氣候風險，並尋找潛在商機：**評估氣候相關風險與機會，確保與財務報導緊密連結。除了量化氣候轉型相關的財務風險，還應探索新的商業模式等潛在機會。

3. **充分利用數據揭露，實踐氣候行動：**正確蒐集並運用永續相關數據，以支持決策：例如，全面報告 TCFD 的四大支柱，有助於企業因應未來的氣候挑戰；報告溫室氣體數據有助於設定淨零排放的目標；策略面向的揭露有助於設計減緩氣候風險的方法；建立適當的治理結構則有助於落實氣候政策，更能預測和因應市場風險與機會。

4. **為永續發展團隊提供充足資源：**團隊需要足夠能力管理合規事宜，領導整體永續發展策略，並在氣候風險分析等關鍵領域進行深入的探討，確保永續發展理念融入不同業務單位。

5. **讓董事會成員具備理解和因應氣候風險的能力：**透過培訓和教育，招募具有相關專業知識的董事會成員來達成。還需要將永續發展的績效與高階管理層的薪酬連結，激勵優先考慮並實現氣候相關目標，並將這些目標融入決策和日常營運。

6. **探索跨部門合作的可能性：**企業應超越其供應商和合作夥伴的生態系統，創造獨特的價值，讓多元利害關係人受益。由於政府在推動實現淨零目標扮演關鍵角色，企業應積極與監管框架保持一致，提升透明度，倡導永續政策。

這些行動不僅為企業提供了具體的方向，也為臺灣在全球氣候治理中提供戰略指引。作為一個高度外向型經濟體，臺灣在全球淨零轉型中扮演著重要角色，不僅應分享綠色科技經驗，也應積極參與國際氣候治理，藉由國際合作推動區域內的低碳經濟發展。

## 從願景到實現

全球三大系統危機雖然為當前經濟體系帶來巨大挑戰，但也提供了重新定義價值的契機。安永 A New Economy 報告提出的五大原則：重新定義價值、公平與正義、系統性思維、循環再利用與資源適足性，為永續與低碳轉型指明了方向。

在臺灣，淨零轉型不僅是一個環境目標，更是重塑經濟核心價值的機會。我們應以創新為基石，結合政策與商業的深度整合，實現能源轉型、資源循環與社會公平。這不僅關乎一個國家的未來，亦關乎全球共同體的永續發展。

未來的經濟轉型需要全社會的共同努力。我們需要問自己：我們希望為未來世代留下什麼？我們在其中的角色又是什麼？在這些問題的驅動下，攜手將願景化為實際可實現的目標，為臺灣打造一個更加永續且繁榮的未來。

Disclaimer: The views reflected in this article are the views of the author and do not necessarily reflect the views of the global EY organization or its member firms.



EUROPEAN CHAMBER OF COMMERCE TAIWAN
歐洲在臺商務協會

# 歐洲在臺商務協會

## 關於歐洲在臺商務協會

歐洲企業一直是臺灣最主要的外商投資來源，其直接投資規模約 700 億歐元。歐洲在臺商務協會（歐洲商會）的創建宗旨，在於促進歐洲企業在臺之權益。歐洲商會的會員約有 1000 位，分別來自 450 家公司與機構。透過 29 個產業委員會及 2 大平台形成的關係網，歐洲商會已成功因應不同產業的特殊議題，為各級政府提供改善臺灣經商環境的具體建言。歐洲商會每年均提出建議書，內容涵蓋各委員會提出有礙自身產業進一步發展的議題，亦針對一般議題與各產業的特有問題，向臺灣政府提出多項改善經商環境的建言。建議書亦協助歐洲執行委員會、歐洲議會與歐盟各會員國政府瞭解臺灣的經商環境。

## 關於歐洲商會 - 低碳倡議行動

歐洲商會 - 低碳倡議行動（ECCT LCI）於 2012 年 6 月成立，是跨產業、跨委員會的最佳實踐平台，旨在展示來自歐洲的國際最佳實踐與低碳解決方案，並與歐洲商會的重點倡導議題保持一致。該倡議由會員公司與相關機構支持，任何願意參與的商會會員皆可加入。

LCI 的目標是提升對永續發展重要性的認識，並促進低碳解決方案的落實，以協助台灣減少碳排放，實現 2050 年淨零排放的目標。

此外，LCI 為會員公司提供分享最佳實踐的機會，並透過聯名活動和長期合作夥伴關係，與歐洲駐台代表機構、台灣政府、產業界夥伴及非政府組織攜手合作，共享資源，提升對永續發展及循環經濟的認識，並促進彼此的交流與合作。

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