NET ZERO by 2050

2050 淨零最佳實踐報告書

Best Practices Report

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

台灣中油股份有限公司
CPC Corporation, Taiwan

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Foreword

Preface

Chapter 1 — International Net Zero Carbon Emission Developments and Responses

Chapter 2 — Respond to the Global Net Zero Carbon Emissions

Chapter 3 — The High Profile Solution - Hydrogen Energy Applications and Development

Chapter 4 — Net Zero Carbon Emission - Public Aspirations and Commitment

Foreword

H. Henry Chang
Chairman, European Chamber of Commerce Taiwan

The ECCT's commitment to environmental protection and sustainability in Taiwan dates back over 30 years to 1989, when the chamber's Environmental Protection committee was established. Efforts have evolved over the subsequent years and took a significant step forward with the establishment of the Low Carbon Initiative (LCI) in 2012. Since then, the LCI has become a recognised champion of the multiple technologies, solutions and practices developed by its members that are needed to help realize a low carbon future for Taiwan. Europeans were pioneers and remain leaders in low carbon development. The European Union has played a pioneering role in creating a political and legal framework for sustainability and were the first to commit to reaching net zero by 2050. Meanwhile, European corporations have led the way in R&D and the development of low carbon energy solutions and technologies. In so doing they have created entirely new supply chains and business models.

The ECCT has welcomed and supported Taiwan's commitment to reach net zero by 2050 both via the ongoing energy transformation, and by developing systematic strategies to reduce emissions in sectors such as manufacturing, transportation, construction, and agriculture. Our members are actively helping Taiwan to reach its goals through their actions across all industry sectors.

Following successful cooperation in 2018 with CPC Corporation to jointly publish the "Energy Transition for the Next Generation Report", the LCI is once again partnering with CPC Corporation on this new report on the subject of Taiwan's path to net zero emissions by 2050. This report showcases some of the best practices and examples in Taiwan and globally provided by CPC Taiwan and ECCT members that are ready for Taiwan to adopt. To name just a few examples, Air Liquide and TotalEnergies have partnered to decarbonize hydrogen production and implement large-scale CO_2 capture and storage solutions (CCS). Bosch offers the technology needed to produce hydrogen, fuel cells for mobile and stationary applications and hydrogen filling stations while K&L Gates shares the hydrogen policy and development strategy of Australia. Ørsted provides a feasible strategy for developing renewable hydrogen and RWE Taiwan highlights the potential of floating offshore wind energy. Merck is active in developing materials that help to save energy and replace harmful materials with environmentally friendly alternatives. Michelin is producing tyres that reduce rolling resistance and therefore energy consumption. Taiwan Power Company outlines how it its building resilient infrastructure for the green energy transition. TCI has pledged to achieve zero-carbon factories and zero-carbon products

while Atlas Copco is committing to science-based targets for the reduction of greenhouse gas emissions in its entire value chain. Tonglit Logistics is part of an ambitious project to create a smart green carbon neutral logistics park. Standard Chartered is providing finance while the Renewables Consulting Group and TÜV Rheinland provide, respectively, valuable consulting and verification services to help their clients to transition to net zero. Additionally, the German Institute Taipei and French Office in Taipei also contributed to the report with national policies and strategies of reaching net zero targets.

Together with more investments in renewable energy, energy storage, grid infrastructure and building insulation to reduce carbon emissions, adopting these solutions will help Taiwan to make the transition to net zero more smoothly and rapidly, especially if done in partnership with the ECCT and our members. Together we can speed up Taiwan's transformation to a net zero economy and be an example for the world.

H. Henry Chang
Chairman
European Chamber of Commerce Taiwan

Foreword

Lee Shun-Chin
Chairman
CPC Corporation,
Taiwan

Towards Net Zero and Sustainability

With the escalation of global warming and the intensification of climate change, reaching net zero carbon emissions in 2050 has become a global consensus. Energy companies around the world are planning to restructure and transform, and CPC can't keep out of the affair.

In 2021, CPC established the Climate Change Response Team to conduct the company's energy transition plan. Under the "Pathway to Net-Zero Emissions in 2050" framework laid out by the government, CPC is working to comprehensively implement net zero policies, including "High-value Petrochemical", "Low-Carbon Emission" and "Lean-Renewable Energy", which are applied to imports, refining, and sales.

In terms of "High-value Petrochemical", CPC is developing gradual crude-oil-to-chemicals (COTC) products by boosting the ratio of crude oil to chemicals and improving their value, focusing on the development of basic materials. Another strategy is improvement in sales. CPC's smart & green e-stations will play host to solar power and hydrogen fuel cells, all managed through the cloud. Furthermore, hydrogen energy will also be adopted in the future.

On the "Low-Carbon Emission" aspect, CPC currently emits 7.11 million tonnes of carbon per year, which is a 38.6% reduction compared to 2005, and has further set the mid-term goal of reaching a 49.5% reduction by 2030. The company will continue to adjust its strategies so as to reach the long-term goal of net zero emissions by 2050. Meanwhile, it is also adopting carbon capture, utilization, and storage (CCUS) technologies, developing the catalysts which are crucial to carbon capture and utilization. Carbon captured at the refineries will be converted to methanol, effectively reducing carbon emissions. Additionally, CPC has procured five tankers of carbon-neutral liquid natural gas (LNG), employing a model that will continue to be used to support restoration and environmental restoration programs around the world.

For "Lean-Renewable Energy", CPC is developing geothermal generation and will also evaluate plans for the Hydrogen Energy Supply Chain Project (HESC). On the sales front, four smart & green demo e-stations have been built that combine energy generation, energy storage, and energy utilization. The first carbon-neutral gas station has officially been put into service at Qianfeng Station, Tainan.

CPC has long been committed to ESG and the pursuit of sustainable development. Confronted with the trend towards net zero, CPC

understands that this is a "Transform or Die" situation and believes that through these three strategic avenues, the company will be able to realize its vision of a new CPC, a Clean Power Company that is a new driving force for sustainable development in Taiwan.

Lee, Shun-chin

Lee Shun-chin
Chairman
CPC Corporation, Taiwan

Foreword

Wang Mei-hua
Minister
Ministry of Economic Affairs

The European Union has played a pioneering role in net zero transition. It is committed earlier than other major economies to becoming Climate Neutral in 2050. The EU has also proposed the "European Green Deal," setting out regulatory regime, policy framework and pathways necessary to the pursuit of net zero. Its approaches have become the benchmark for other countries. Low-carbon solutions and technologies developed by European businesses are also leading in the world, making them important partners for many countries, including Taiwan, in their own implementation of net zero transition.

The ECCT has long been dedicated to environmental protection and sustainability in Taiwan. In 2012, it launched the Low Carbon Initiative (LCI), with a focus on 7 core areas, including green energy, green finance, power efficiency, green transportation, smart cities, smart manufacturing, and circular economy. The ECCT has worked closely with Taiwanese businesses and government agencies, sharing Europe's best low-carbon solutions and regulations, enhancing awareness of sustainable development in Taiwan, and facilitating carbon reduction in both the public and private sectors.

In response to global net zero trends, the Taiwan government published "Taiwan's Pathway to Net-Zero Emissions in 2050" in March 2022. The blueprint outlines 12 key strategies such as wind power, solar photovoltaic, hydrogen power, innovative energy, power systems and energy storage, energy conservation, and carbon capture, utilization and storage.
Taiwan takes pride in its thriving semiconductor and ICT industries as well as robust technology and comprehensive supply chains in conventional industries. As the EU leads the world in creating net zero transition legal framework and leading edge solutions in renewable energy and hydrogen, I hope Taiwan and the EU can join forces together in developing low carbon technologies and commercial application towards the goal of net zero emissions on the globe.

Wang Mei-hua
Minister
Ministry of Economic Affairs

Foreword

Filip Grzegorzewski
Head of the European Economic and Trade Office

One of the first events I joined as Head of the European Economic and Trade Office (EETO) in Taiwan was the European Union Climate Action Week in 2019. Now I am pleased to demonstrate, once again, the European Union's commitment to climate issues in Taiwan.

The scale and severity of the climate challenges we face are clear. The adverse effects of climate change are felt around the world and threaten our planet and its people. Taiwan is no exception. As an island, Taiwan is especially vulnerable to the storms and floods that are becoming more severe as the climate changes.

The aim of the European Green Deal, presented by the European Commission in December 2019, is to overcome these challenges by transforming the European Union (EU) into a modern, resource-efficient and competitive climate-neutral economy by 2050. Achieving climate neutrality will not only secure a healthy planet for generations to come but will also help improve people's well-being today.

Over the last thirty years, the EU has been at the front line of the global fight against climate change. It has led the way by investing in realistic technological solutions, empowering citizens and aligning action in key areas such as industrial policy, finance and research, whilst ensuring social fairness. All sectors of society and the economy will play a role – from the power sector to industry, mobility, buildings, agriculture and forestry.

Despite not being a signatory to the Paris Agreement, Taiwan has persistently indicated that it would abide by its international obligations to reduce carbon emissions. I particularly welcome Taiwan's commitment to achieve net zero emissions by 2050. Climate change is a global threat and can only be overcome by a global response.

This is why the EU actively supports its international partners in climate action and why I am pleased to present the report "CPC – ECCT 2022 Net Zero Report ". The transition to a climate-neutral society is both an urgent challenge and an opportunity to build a better future for all. Together, we are able to showcase European low-carbon best practices and solutions across a wide range of industries and sectors to help Taiwan reduce its carbon emissions.

The launch of this report on the first day of the 2022 EU Climate Action Week symbolises our common efforts to advocate for a greener world. The strategies and initiatives shared in this report are merely the start of a sustainable future. I hope reading this will inspire new ways for us to work together toward our joint goal of achieving net zero by 2050.

It is high time to act and this joint initiative is part of the very necessary contribution to this action. The choices we make today will define our future. The road ahead is full of challenges but even greater opportunities. Working hard to find new ways to win this collective challenge and allow our children to enjoy a decent human life on a peaceful planet is not an idealistic or naïve pursuit. It is about staying true to our values, listening to science, strengthening our economies, and building a better future.

Filip Grzegorzewski
Head of the European Economic and Trade Office

Preface

Dr. Niven Huang
Managing Director
KPMG Sustainability Consulting

Net zero initiatives in developed countries have driven systemic industry transformation, encompassing renewable energy, low-carbon vehicles such as electric and hydrogen fueled vehicles, circular construction, low-carbon manufacturing, as well as smart information and communication technologies. As a result of emerging technology and solutions, market and policy dynamics, and changes in consumer behavior, the world is poised to enter a rapidly evolving net-zero transformation. To take part in this change, companies need not only to understand the importance of net-zero to their organizations, but also to plan net zero trends holistically and meticulously.

Throughout the International Energy Agency (IEA) Net Zero report, hydrogen energy occupies a significant role in global technological concerns and national strategies, emerging as a sought-after technology option for all sectors. Because of its zero-carbon molecular characteristics, high calorific value and fast combustion properties, hydrogen is currently regarded as the optimal solution to replace traditional fossil fuels according to international technological assessments.

Many challenges remain in the application of hydrogen energy. Above all, hydrogen generation and storage requires the conversion of energy from fossil fuels or renewable sources, and is essentially an "energy carrier". Meanwhile, the nature of hydrogen poses particular challenges in terms of transportation and storage. Therefore, the development of hydrogen energy application necessitates overcoming bottlenecks in terms of availability, transportation and storage, and energy costs. We are fortunate to have invited the European Chamber of Commerce Taiwan Low Carbon Initiative (ECCT LCI) partners to share their insights on the use and development of net-zero carbon emissions and hydrogen energy, from global initiatives, national policies to corporate initiatives.

Following the "The Path to Industrial Energy Efficiency in Taiwan – Partnering with the EU" and "Energy for the Next Generation – Shaping Taiwan's Energy Transition Net Zero by 2050- 2050" reports prepared in collaboration with the ECCT LCI in 2015 and 2018 respectively, we at KPMG are honored to partner again with ECCT LCI this year to prepare the "Net Zero by 2050- 2050 Best Practices Report". This report aims to call on the Taiwanese government and companies to invest more actively in forward-looking technologies such as hydrogen energy, carbon sequestration, carbon capture, utilization and storage (CCUS), hydrogen-fueled vehicles, and floating wind turbines through policy development and funding programs to support the national and corporate drive for a net-zero emissions pipeline. In addition, we have observed that the global financial industry has proposed net-zero transformation financial initiatives in response to policy, capital, and emerging market opportunities, particularly in hydrogen energy, battery storage, smart grid, and energy-saving technologies, which have

attracted multi-billion dollar capital investments. We hope that through this report's illustrations, governments and companies alike may adopt a more diversified perspective and work together to create cross-border and cross-domain partnerships to move toward a net-zero carbon emission future in 2050.

Dr. Niven Huang
Managing Director
KPMG Sustainability Consulting

Chapter.1

International Net Zero Carbon Emission Developments and Responses

Net-zero Carbon Emission Trends Approaching

The issue of climate change was first introduced at the Earth Summit in Brazil in 1992, and since then, the United Nations Framework Convention on Climate Change (UNFCCC) has been taken as the basis for the annual convening of the United Nations Conference of the Parties (COP). Since the third annual Conference of the Parties (COP3) held in Kyoto, Japan in 1997, which set an essential milestone for greenhouse gas reduction, the United Nations Intergovernmental Panel on Climate Change (IPCC) released its fourth assessment report in 2007, which explicitly pointed out that artificial greenhouse gas emissions are the leading cause of global average temperature increase, while scientific evidence also indicates that the negative impacts of global warming could adversely affect the impoverished population; and modelled reduction targets and relative economic impacts, and proposed adaptation and mitigation options.

After the establishment of man-made causes of greenhouse gas emissions and global temperature rise, the Kyoto Protocol has been the central axis of refinement in subsequent UN Conferences of the Parties, and finally reached a breakthrough at the 21st Conference of the Parties (COP21) in 2015, after political wrangling and tug-of-war among many countries. As a result, the conference adopted the Paris Agreement, agreeing to control global warming to within 2 degrees Celsius, and aiming for a carbon reduction plan within 1.5 degrees Celsius of the pre-industrial average, in the hope of jointly halting the global warming trend. In addition, the agreement also specifies that global greenhouse gas emissions must be reduced by 45% by 2030 and reach net zero emissions by 2050.

Following the IPCC's 1.5°C special edition report released simultaneously in 2018, the global climate goal was further set to limit warming to 1.5°C. In addition, the concept of Net Zero Emissions (Net Zero Emissions) was mentioned in the report, which also promotes the global net zero race from countries to corporations. In this edition of the report, the IPCC provides a clear definition of the standard Net zero CO_2 emissions, also known as Carbon Neutrality. Net Zero Emissions, on the other hand, covers the existing seven categories of greenhouse gases, and its scope of reduction is more extensive, as detailed in the list below.

Nomenclature	Definition	Greenhouse gas reduction scope
Net zero CO_2 emissions	IPCC defines net-zero CO_2 emissions as being achieved when human-induced CO_2 emissions are balanced in the atmosphere through human-induced CO_2 removal over a specified period of time, also known as Carbon Neutrality.	Applicable only to carbon dioxide in greenhouse gases.
Net Zero Emissions	Net zero emissions are achieved when global anthropogenic greenhouse gas emissions and removals balance each other in the atmosphere.	Covering 7 significant categories of greenhouse gases including carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF6), and nitrogen trifluoride (NF_3).

The Green Swan strikes a net zero wake up call for climate emergencies

With global temperatures continuing to rise, extreme climate events have been occurring in recent years. The Bank for International Settlements (BIS) released "The Green Swan Report," pointing out that climate shocks will create the subsequent systemic financial risk. According to Munich Re, the world's largest reinsurer, global losses from natural disasters in 2021 will reach US$120 billion, second only to the US$146 billion recorded in 2017, with nearly 10,000 people killed by natural catastrophes in that year, comparable to the figure for 2020. When uninsured losses are also included, the total disaster damage amounted to US$280 billion, the fourth highest in history. In the face of the extreme global climate green swan event, not only will it cause a large number of casualties and species extinction, but it will also test the response of enterprises in the face of climate risks. For this reason, the annual UNFCCC Conference of the Parties will continue to play an essential role in promoting policies and indicators to achieve net zero emissions.

International Policy Approaches to Net Zero Carbon Emissions

COP26 Meeting Resolutions and Implications

In November 2021, leaders at the 26th United Nations Climate Change Conference (COP 26) reached several resolutions, including the adoption of Article 6 of the Paris Agreement, which lays the foundation for future international carbon trading, and the Glasgow Climate Convention, signed by nearly 200 countries, which for the first time includes the "phasing out of fossil fuels" in the text of the resolution, signaling the imminent end of the coal era. It also requires countries to review the strength of their 2030 Nationally Determined Contributions (NDC) targets and to submit long-term low-carbon development strategies for 2050 by COP 27. The following table shows the net-zero carbon emissions-related treaties/commitments signed by countries and corporations at COP26.

Treaties/commitments	Description
Paris Agreement Handbook	The adoption of Article 6 of the Paris Agreement, which lays the foundation for future international carbon trading, resolves that future carbon trading will not be double-counted and that only Certified Emission Reductions (CERs) certified after 2013 will continue to be used.
Glasgow Climate Convention	・Phasing out "coal-fired power generation without carbon capture" ・Phasing out "inefficient fossil fuel subsidies" ・Request countries to review the strength of the 2030 Nationally Determined Contributions (NDC) target and submit a long-term low-carbon development strategy for 2050 by the 27th UN Climate Change Conference (COP 27) ・Developed countries have failed to meet their 10-year pledge to provide $100 billion per year to help vulnerable countries, and therefore urge developed countries to pay their arrears by 2025 and until 2025 to help developing countries address climate change ・Calls for rapid ramp-up of clean power systems and energy
Global Methane Pledge Global Coal to Clean Power Transition Statement	105 countries sign Global Methane Pledge to reduce current methane emissions by 30% by 2030. However, China, Russia, India, and Iran have not joined in. 46 countries (including the world's top 10 coal burning countries, such as South Korea, Indonesia, Vietnam, and Poland, among others) signed the agreement, including the following four terms: expanding the deployment of clean energy generation, phasing out coal-fired power generation, stopping the construction of new coal-fired power plants, and ensuring a just transition.
Statement on International Public Support for the Clean Energy Transition	25 countries (including the UK, US, Germany, and France) signed a pledge to stop overseas fossil fuel investments by 2022.
U.S.-China Glasgow Joint Declaration on Enhanced Climate Action in the 21st Century	In the 2020s, a clear framework and environmental standards will be established to manage greenhouse gases, strengthen clean energy transformation, promote industrial decarbonization and electrification, eliminate illegal deforestation, develop a circular economy such as green design and sustainable resources, reduce methane and carbon dioxide emissions, and exchange information and solutions to their respective emission reduction plans. For example, the US has pledged to achieve 100 percent carbon-free electricity by 2035, while China has said it will gradually reduce its coal use in the 15th Five-Year Plan (the 15th five-year plan, 2026-2030).
Glasgow Financial Alliance for Net Zero	The Glasgow financial alliance for net zero (GFANZ), representing 450 financial institutions with $130 trillion in assets, has signed on to sustainable finance principles to help move towards global net zero emissions.
Glasgow Leaders' Declaration on Forest and Land Use	Over 100 global leaders have pledged to end deforestation and land loss by 2030, and to raise nearly £14 billion ($5.2 trillion) in public and private funding to address the issues.

Treaties/commitments	Description
Glasgow Breakthrough Agenda	Leaders from more than 40 countries (more than 70% of the world's economies) signed on to the initiative, with signatories agreeing to prioritize five sectors - steel, road transport, agriculture, hydrogen and electricity - to coordinate and develop global standards and policies to drive up capacity and down prices, to make green energy an affordable, accessible and attractive option by 2030, and to create 20 million new jobs.
Zero Carbon Vehicle Commitment Green Shipping Commitment	Eleven car manufacturers, including Ford, General Motors, Jaguar Land Rover, Mercedes-Benz, and Volvo, have committed to selling all new zero-carbon vehicles in major markets by 2035, meaning that electric vehicles will become mainstream in the future.
Zero Carbon Vehicle Commitment	200 companies have pledged to scale and commercialize zero-carbon ships and fuels by 2030, and another 22 countries have signed the Clydebank Declaration, which plans to establish six green routes by 2025, with ships sailing on low or zero-carbon fuels on routes across Asia to the US, Saudi Arabia to China and India, and hopefully more routes after 2030.

In summary, COP26 not only formally announced the end of the fuel-fired era and laid the foundation for future international carbon trading, but also reached unprecedented progress on methane, forestry, energy, transportation, and climate finance issues that countries and companies must face on the path to net zero, with a global consensus of 1.5 degrees Celsius. As a result, it is expected that more countries will set more ambitious carbon reduction targets and adopt stricter regulations to accelerate energy transformation, impose carbon taxes, and encourage the electrification of transportation. At the same time, many companies will review their business strategies as soon as possible in 2020, especially in the five sectors mentioned in the Glasgow Breakthrough Agenda: steel, road transport, agriculture, hydrogen and electricity, which will lead to a rapid growth of global green financial investments in line with the global standards that the Glasgow Breakthrough Agenda will coordinate.

Description of the Current Status of the Declaration of Net Zero Carbon Emission in Each Country

As of June 2022, 129 out of the world's 198 countries, accounting for 90% of global GDP and covering 88% of total greenhouse gas emissions, have committed to net zero emissions, with 21 countries (such as the UK, EU, Canada, Japan, and Korea, among others) legislating net zero emissions (Source: NET ZERO TRACKER, retrieved from: https://zerotracker.net/, 2022). The carbon emission reduction targets by country / region are shown in the table below.

Country/Region	Description
UK	68% reduction in 2030 compared to 1990, net zero carbon emissions by 2050
UN	55% reduction in 2030 compared to 1990, carbon neutral by 2050
US	50%~52% reduction in 2030 compared to 2005, net zero carbon emissions by 2050
Canada	40-45% reduction in 2030 compared to 2005, net zero carbon emissions by 2050
China	Carbon emissions reach spike in 2030, carbon neutral by 2060
Japan	46% reduction in 2030 compared to 2013, net zero carbon emissions by 2050
South Korea	40% reduction in 2030 compared to 2017, net zero carbon emissions by 2050
Australia	26%-28% reduction in 2030 compared to 2005, net zero carbon emissions by 2050
India	45% reduction in carbon intensity by 2030 , net zero carbon emissions by 2070

The following section provides further insight into the national policies and guidelines of the key countries, the United Kingdom, the European Union, and the United States, to provide readers with a complete picture of net-zero development.

- **UK - The world's first country to include greenhouse gas emissions reduction in its legislation**

In 2008, the United Kingdom announced the Climate Change Act (CCA), establishing that by 2030 and 2050, greenhouse gas emissions in the United Kingdom should be reduced by 34% and 80%, respectively, and the competent authority - the Department of Energy and Climate Change (DECC), establishing a cap on greenhouse gas emissions. The UK also set up an independent Climate Change Committee (CCC), a think tank of academics and experts with backgrounds in energy, economics or technology, to advise officials on policy decisions. 2019 saw the organisation go further and announce that the UK will achieve net zero emissions by 2050, followed in 2020 by the Prime Minister's announcement of the Green Industrial Revolution, a 10-point plan that includes renewable energy, financial development and carbon sequestration technologies, and a strengthened effort to reduce greenhouse gas emissions by 68% by 2030 and to reach net zero by 2050, in the hope of playing a leading role in global change and developing important innovations through this policy. As host of the 26th Conference of the Parties (COP26), the UK also announced the establishment of the world's first net-zero financial center to support net-zero development through the power of finance.

- **European Union - Aiming to become the world's first climate-neutral continent by 2050**

The European Commission has launched the European Green Deal since the end of 2019, which includes a roadmap of 50 policies to be launched over the next three years, to promote sustainable economic development in the EU, turn climate and environmental challenges into opportunities in all policy areas, and achieving justice and inclusiveness during the overall transition. The European Commission set a medium-term goal to reduce greenhouse gas emissions by 55% by 2030, and aims to be the world's first climate-neutral continent by 2050. In 2021, in order to achieve its goal of reducing greenhouse gas emissions by 55% by 2030, the EU proposed the "Fit for 55 package," a total of 12 policy measures, including the expansion of the EU Emissions Trading System (ETS), the improvement of the EU Carbon Border Adjustment Mechanism (CBAM), banning the sale of fuel cars by 2035, increasing the proportion of renewable energy to 40% by 2030, phasing out tax exemptions for fossil fuels in the aviation and shipping sectors, developing natural carbon sinks, and implementing a just transition as well as establishing the Social Climate Fund (SCF). The most significant policy that is expected to affect Taiwanese companies is the CBAM, which is expected to be implemented on a trial basis in 2023 and will be implemented in 2026 for high carbon emission products such as cement, electricity, fertilizers, and other products. In addition, if a product is to be imported into the EU, a carbon quota must be purchased in order to sell it to the European market. This Act has further created the urgency of establishing a carbon trading system in Taiwan. The main factor is that importers can claim that their products have already paid carbon taxes or fees in their countries of origin, which can be credited against the number of CBAM certificates they need to purchase, showing that the issue of climate change has expanded beyond environmental issues to international economic and trade issues, which is relevant to the competitiveness of Taiwan's export industry.

- **US - Largest Climate Change Investment in History**

The US climate change efforts began during Obama's term with the Climate Action Plan, which includes measures to reduce greenhouse gas emissions by 30 percent by 2030, as well as to control methane emissions and improve fuel efficiency standards for vehicles, based on a 2005 baseline. Nevertheless, after the Trump administration the "America First Energy Plan" was adopted to accelerate the development of the fossil fuel industry, and even withdraw from the Paris Agreement. After the new President Biden assumed office in 2021, in addition to returning to the Paris Agreement, he also announced a 50% to 52% reduction in US greenhouse gas emissions by 2030 and a net-zero climate goal by 2050. Its climate-related policies include the $1 trillion Infrastructure Investment and Jobs Act, which drives the decarbonization of US manufacturing industries and promotes the development of renewable

energy industries and green jobs. Immediately following the release of the Build Back Better Act, the US announced the outline of the Build Back Better Act, which includes issues such as climate change, preschool education, and Medicaid. The Act provides tax credits to reduce the cost of clean energy and electrification for middle-class households, ensure the development of clean energy technologies and decarbonization of the US manufacturing sector, create green jobs, and maintain environmental justice. 40% of the proceeds will be redirected to building disadvantaged communities, investing in coastal restoration, forest management and soil conservation, and other related natural solutions.

Taiwan's Relevant Regulations and Acts in Response

In March 2022, Taiwan officially announced the "Taiwan 2050 Net Zero Emissions Roadmap," which provides an action pathway to net zero emissions by 2050 and is jointly promoted by the National Development Council, Environmental Protection Administration, Ministry of Science and Technology, Ministry of Economic Affairs, Ministry of Transportation, and Ministry of Interior jointly promoting four transformation strategies (energy transformation, industry transformation, life transformation and social transformation) and two governance foundations (technology research and development and climate governance) to lead Taiwan's net zero transformation by 2050. Among them, strengthening the legal basis of climate change, whether it is the amendment of the greenhouse gas reduction and management legislation, the implementation of the carbon pricing policy, or the promotion of green financial policies have all received public attention, among which the policies of the Environmental Protection Agency and the Ministry of Economic Affairs have received much attention.

• 1. EPA's Policy in Response to Taiwan's Net Zero Transformation

In Taiwan's past to promote low-carbon transformation and greenhouse gas reduction, "Greenhouse Gas Reduction and Management Act" was an essential source of legal basis. Moreover, at that time it was in accordance with the Paris Agreement, not to exceed 2° C temperature rise at the end of this Century as a planned result, so in the process of 2050 net-zero transition, our country also referred to the international control of 1.5 ° C as the goal, initiating the "Greenhouse Gas Reduction and Management Act" amendments in 2022, revised to "Climate Change Response Act," and explicitly amended the national long-term reduction target to 2050 net-zero greenhouse gas emissions.

Before setting a clear greenhouse gas reduction target, the most important thing is the inventory of greenhouse gas emissions data, without accurate data, it would be challenging to set an effective reduction target. Recently, the FSC officially launched the "sustainable development roadmap for listed companies" in March, requiring all listed companies to complete greenhouse gas inventory by 2027 and greenhouse gas data verification by 2029 at the latest, and to carry out gradual policy promotion in accordance with the industry and capital amount. Furthermore, in response to the needs of a large number of enterprises to conduct carbon inventories, the Environmental Protection Agency has released a new version of the greenhouse gas inventory guidelines in May 2022, in addition to the existing temperature control law announced that the inventory should be registered significant sources of emissions, for the demand for carbon inventories of small and medium-sized enterprises also proposed guidelines for inventory operations to provide the basis for the net-zero transformation of the industry.

In the process of net-zero transformation, carbon pricing is regarded internationally as an indispensable policy tool for greenhouse gas emission reduction, and with the announcement of the Carbon Boundary Adjustment Mechanism (CBAM) in the EU, the international community has accelerated the importance of carbon pricing. On the other hand, if our country does not have carbon pricing-related policies, the future export of products to the EU, will also be required to pay carbon tariffs required by the exporting country, may make the export of goods to reduce competitiveness, therefore, in the "Greenhouse Gas Reduction and Management Act" in the revision of the law, but also the carbon pricing as one of the critical points of the amendment. Therefore, the planning of the carbon pricing system is also divided into two directions:

(1) Carbon fees

The targets of these fees will be promoted in stages by different emission source types and national GHG control targets. In addition, it is planned to allocate funds exclusively for greenhouse gas reduction, development of low-carbon, negative emission technologies, among others. Pricing will consider the industry's competitiveness to determine the appropriate rate, which will also encourage carbon fee targets to put forward their own reduction plans, set reduction targets in line with the national carbon reduction path, and after approval will be applicable to preferential rates. However, the applicable carbon fee rate has not yet been agreed, pending subsequent amendments to the law to carry out appropriate carbon price rate planning.

(2) Establishment of carbon trading system

At this stage, in order to promote the development of carbon trading, the government continues to encourage enterprises to reduce their emissions and provide them with reduction credits voluntarily, and set up a trading platform for those who have the responsibility or demand for reduction. The initial stage of development will not be promoted in the form of financial commodities. In the future, we will also study the possibility of joint carbon reduction through international cooperation in accordance with the Paris Agreement international cooperation mechanism, and introduce it promptly to develop the carbon trading market gradually.

• 2. The Ministry of Economic Affairs policy in response to Taiwan's net zero transformation

The Ministry of Economic Affairs (MOEA) promotes net zero transformation through three main transformation strategies: net zero energy transformation, net zero industrial transformation, and social equity transformation. In terms of net-zero energy transformation, the current goal is to promote renewable energy, increase the proportion of gas-fired power generation, and reduce the use of coal-fired power generation, and to develop carbon-free energy and power systems further, maximize the use of renewable energy, and actively develop hydrogen energy and carbon capture and storage technologies as the long-term development direction. In terms of industrial transformation, industrial carbon reduction will be promoted utilizing equipment replacement, low-carbon fuel conversion, and intelligent energy-saving management. As a result, we hope to achieve a net-zero vision of industrial circular economy and the adoption of carbon-free fuels. In the process of net-zero transformation, different stakeholders will be affected. Furthermore, the Ministry of Economic Affairs plans to promote socially equitable transformation by analyzing the affected parties in advance, developing support mechanisms for assistance and protection, communicating possible misunderstandings, and building awareness.

In terms of the legal basis for climate change, the Ministry of Economic Affairs (MOEA) continues to improve the energy demand management and green energy development environment by promoting the amendment of the Energy Administration Act, the Renewable Energy Development Act and the Electricity Act, the critical points of which are listed below:

(1) Energy Administration Act

In addition to the existing control measures for energy saving requirements for large energy users and energy efficiency management of electricity appliances, the Act will also assist local governments and other organizations to improve the planning of energy management measures and efficiency analysis by mandating the energy supply industry to disclose energy sales statistics, and by raising penalties and publishing the names of violators to encourage compliance with energy-saving regulations.

(2) Renewable Energy Development Act

To reduce the space limitation of renewable energy installations and increase the flexibility of utilization, and to set up different procedures and adjustment mechanisms for different renewable energy characteristics in order to speed up administrative operations, increase the capacity and expand the installations of renewable energy.

(3) Electricity Act

To clarify the positioning of energy storage facilities, construct business models for energy storage, such as capacity market and auxiliary service trading, enhance incentives for energy storage construction, and continue to refine application procedures for renewable energy generation to facilitate the installation of renewable energy.

In terms of promoting zero-transformation and carbon-free fuels, a dedicated hydrogen energy management law will be enacted to promote the development of hydrogen energy fuels. For the time being, the Energy Management Act will be used as the basis for managing energy products before enacting a particular law. The Act will continue to pay attention to the development of global hydrogen energy technology and domestic use planning. In addition, it will promote the enactment of a particular law on hydrogen energy management, focusing on the application, change, revocation, and cancellation procedures for hydrogen energy import, export, production, and sales, facility installation conditions, safety requirements, and certification of carbon-free fuels.

• 3. Proposal on Taiwan 2050 Net Zero Emission Policy

Taiwan's 2050 net-zero emissions roadmap currently outlines a vision for a future net-zero society and sets out strategies to address critical issues in the transformation process. However, there are no clear planning goals and supporting measures for different near-term time scales, which may leave industries without a clear direction for implementation in the net-zero transformation. In addition, it is challenging to consider the structural problems between industries and to judge whether all industries are suitable for the currently announced roadmaps. Therefore, it is suggested that multiple communication sessions can be conducted for different industries, and companies of different sizes in individual industries and experts and scholars can discuss together to develop industry-specific guidelines for net-zero transformation further, in order to accelerate the net-zero transformation of the whole industry.

In planning power structure transformation, the future growth of electricity has been proposed, and the growth of renewable energy has been predicted. However, the stability of electricity is also a significant issue while vigorously promoting renewable energy development. Because of the seasonal and time difference of electricity, the power generation equipment has to be divided into three categories: baseload, medium load, and sharp load. Due to the intermittent and non-baseload nature of renewable energy, if there is no clear technological research and development and technological breakthrough to assess the feasibility of renewable energy as baseload power, the policy of gradually reducing thermal power generation and promoting renewable energy may also be affected, reducing the stability of power supply. Therefore, it is recommended to communicate more clearly with the industrial and commercial sectors on the assessment of energy storage technology and to work with the industries to promote renewable energy in order to gain their confidence in the future stability of electricity supply.

In the process of zero carbon transformation, it involves the transformation of technology, society, economy, politics, and other aspects, and the fair transformation naturally becomes one of the keys to promoting the net-zero transformation. Currently, in the Zero Emission Pathway blueprint, the social support system for implementing a just transition and citizen participation is mostly a governance mechanism for a just transition and citizen participation, stating that the governance principles of "balance of policy objectives," "fairness of social distribution," and "inclusiveness of interests" will be used to promote the transition, with no apparent response measures and time frame. It is suggested that further planning should be made for the fair transition of net zero promotion, such as reasonable compensation measures and incentive mechanisms, to avoid social inequality. Furthermore, in the process of policy implementation and formulation, the participation of the disadvantaged groups should be ensured so that the voices of different stakeholders can be heard, so that conflicts can be reduced and a fair and just zero-carbon transformation can be achieved.

Taiwan's Policy and Progress in Promoting the Standards, Testing and Certification of Electrical Energy Storage and Electric Vehicles

Government policy, net zero standards

The Bureau of Standards, Metrology, and Inspection, Ministry of Economic Affairs, has developed and established national standards, testing capacity and certification schemes for electrical energy storage and electric vehicles to ensure that Taiwan's implementation of a net-zero emission path is safe, fair and internationally equivalent.

According to Taiwan's 2050 net-zero emissions pathway and strategy, electrical energy storage and electric vehicles will be one of the necessary projects to implement low-carbon energy and vehicle electrification. The Bureau of Standards, Metrology, and Inspection (BSMI) of the Ministry of Economic Affairs (MOEA) has harmonized the standards of international standards bodies, such as the International Electrotechnical Commission (IEC), to ensure that Taiwan's zero-emission process is safe, fair, and internationally equivalent, and has established CNS national standards, localized testing capabilities, and promoted product certification schemes.

The following describes Taiwan's policy and progress in promoting standards, testing and certification of electrical energy storage and electric vehicle .

Grid-integrated electrical energy storage system

Due to the growth of the penetration rate of renewable energy and the impact on the stability of the power system, the electrical energy storage system has become one of the solutions to enhance the proportion of renewable energy and strengthen the power grid, but because of the high-density energy of the battery, if the quality is poor or improper system design, it will lead to short-circuit, fire and other accidents. BSMI therefore promoting related standards testing and certification schemes in electrical energy storage as the following:

(1) Standards

Important components of grid-integrated electrical energy storage systems (such as single cells and battery systems) National Standard CNS 62619 (Safety requirements for secondary single cells and battery packs containing alkaline or other non-acidic electrolytes - Secondary lithium single cells and battery packs for industrial applications) and CNS 63056 (Safety requirements for secondary single cells and battery packs containing alkaline or other non-acidic electrolytes - Secondary lithium single cells and battery packs for energy storage systems) were published on December 14 and December 7, 2020, respectively, based on the harmonization of IEC 62619 and IEC 63056. The national standard CNS 62933-5-2 (Safety requirements for grid-connected energy storage systems - electrochemical systems) is expected to be announced in June 2022, and is harmonized with IEC 62933-5-2 for adoption as a safety standard for electrical energy storage systems in Taiwan.

(2) Testing capacity

There are more than 6 testing laboratories accredited by the Taiwan Accreditation Foundation (TAF) for components testing of cell and battery systems. In addition, BSMI plans to

build a new large scale electrical energy storage battery testing laboratory in the Hsinchu Science Park – Tongluo campus with a testing capacity of 360 kW/360 kWH with special fire controls, explosion-proof, and test pollution prevention capabilities, and is expected to provide MW-level power conditioning system (PCS) in October 2024. In July 2025, we expect to provide electrical energy storage cabinet (Rack) and in December 2025, we expect to provide battery management system (BMS) testing services.

(3) Certification schemes

In order to ensure the installation and subsequent operation safety of the energy storage system, the project certification management framework will be introduced, and the relevant inspection technical specifications and certification system will be developed in accordance with national and international standards. Among the important components of the grid- integrated electrical energy storage system (such as a single cell, battery system and home energy storage battery system) voluntary product certification (VPC) system, has been announced and implementation on May 16, 2022. The VPC system for Outdoor Battery Energy Storage System Site is expected to be announced and implemented in November 2022.

Electric Vehicles - Rechargeable Energy Storage System

Among the net-zero path, electrification of vehicles is also one of the main ways to reduce carbon emissions. BSMI is promoting the testing and certification of electric vehicle battery-related standards as follows:

(1) Standards

The national standard for electric vehicle rechargeable energy storage systems, CNS 16160 (Specific Requirements for Electrical Safety and Rechargeable Energy Storage Systems for Electric Road Vehicles), was announced on December 24, 2021 and harmonized with UN/ECE Regulation No. 100, making the standard for electric vehicle energy storage comprehensive.

(2) Testing capacity

There is one laboratory certified by the TAF. In addition, BSMI has built a new large-scale battery safety testing laboratory, which is expected to provide full-size lithium battery pack testing service for electric vehicles from January 2025.

(3) Certification scheme

The VPC system for lithium battery packs for electric vehicles is expected to be announced and implemented in August 2022.

Electric Vehicle Supply Equipment

In the wave of electrification of transportation vehicles, the charging infrastructure is becoming more and more important. It is estimated that the number of electric vehicles in Taiwan will reach at least 164,000 by 2025, and the popularization of charging stations is one of the main factors for the success of the electrification of transportation vehicles, BSMI is promoting the standards, testing and certification of electric vehicle supply equipment as follows:

(1) Standards

The national standards for electric vehicle charging systems include two general safety requirements (CNS 15511-1, CNS 15511-23 Electric Vehicle Conduction Charging System - Part 1: General Requirements, Part 23: Electric Vehicle DC Charging Station + Supplementary Addendum 1), one communication requirement (CNS 15511-24 Electric Vehicle Conductive Charging System - Part 24: Digital Communication between EV DC Charging Station and EV Charging Control), Electromagnetic Compatibility Requirement 1 (CNS 15511-21-2 Conductive Charging System for Electric Vehicles - Part 21-2: Requirements for Conductive Connection of EVs to AC/DC Power Sources) Electromagnetic compatibility requirements for non-vehicle-mounted electric vehicle charging systems) and four plug and socket cable sets (CNS 15700-1, CNS 15700-2, CNS 15700-3, CNS 15700-3-1 Power end plugs, power end sockets, vehicle end plugs and vehicle end sockets - electric vehicles) Conductive charging - Part 1: General requirements, Part 2: Scale compatibility and interchangeability requirements for AC blade and conductive nozzle accessories, Part 3: Scale compatibility and interchangeability requirements for DC and combined AC/DC terminals and contact conduit type vehicle end couplers, Part 3-1: Vehicle end plugs, vehicle end sockets and cable sets for DC charging using thermal

management systems The standards have been announced from June to December 2021, and are harmonized with the IEC 61851 and IEC 62196 series of international standards. The standards include charging interfaces used in Europe, the United States, and Japan, which can be used by domestic consumers according to different vehicle brands. In order to protect the rights of domestic EV owners, the Tesla Proprietary Connector (TPC) charging interface will also be included in the national standard in 2021.

(2) Testing capacity

There are more than 3 laboratories accredited by the TAF.

(3) Certification scheme

The VPC system for electric vehicle supply equipment was announced and implemented on January 13, 2022.

Conclusion

In order to achieve the goal of net zero emissions, BSMI has been working on the national standards for electrical energy storage and electric vehicles, and has established testing capacities and certification schemes. The voluntary product certification (VPC) system for electrical energy storage systems and power supply equipment for electrical energy storage and electric vehicles is expected to be fully announced and implemented by November of this year (2022). Also, the ongoing construction of the laboratory for testing the battery electrical energy storage systems with special testing equipment and environment is expected to be completed and services provided from 2024 onwards. BSMI is committed to continue to support the national development strategy and to do a good job in planning and executing the business related to standards testing and certification.

Vision of the new construction of safety testing laboratory of battery electrical energy storage (Hsinchu Science and Technology Park - Tongluo campus Testing service is scheduled to be available in January 2025)

Taiwan Headed for 2050 Net Zero Transition

2050 net zero emissions, hydrogen energy, energy efficiency

In response to the global trend of net-zero emissions, Taiwan is maximizing renewable energy development and expanding the development potential and technology application of hydrogen energy through a "low-carbon-zero-carbon" and "energy-industry" net-zero transition framework, creating a carbon-free energy environment, improving energy efficiency in industry and manufacturing, strengthening industrial power saving measures, accelerating the comprehensive low-carbon transition of industry, and jointly helping the energy industry move toward the goal of net-zero transition.

Background

In 1992, the United Nations ratified the "United Nations Framework Convention on Climate Change", which aroused global attention to carbon reduction. Following the evolution of international conventions such as the Kyoto Protocol and the Paris Agreement, carbon reduction has become an inevitable responsibility of all countries. Since the G7 climate leaders meeting in early 2021, the pursuit of net zero emissions has become a common global goal and trend.

In response to the global trend of carbon reduction, countries have declared their net zero emission targets, and as of June 13, 2022, 132 countries, Taiwan and the European Union have declared their net zero emission targets. In addition to carbon reduction, each country's net-zero transition plan also regards net-zero as a new growth engine for the country's future economy, for example, the UK regards net-zero transformation as a "green industrial revolution" and Japan has formulated a "2050 carbon neutral growth strategy".

Taiwan 2050 Net Zero Transition Promotion Approach

On March 30, 2022, Taiwan officially announced the "2050 Net Zero Emissions Roadmap", which aims to combine the efforts of all sectors to make the net zero transition a new driving force for Taiwan's development, and to establish two foundational environments for technology research and development and climate laws, and to promote four major transition strategies for energy, industry, life, and society, to gradually realize a net zero emissions sustainable society in 2050.

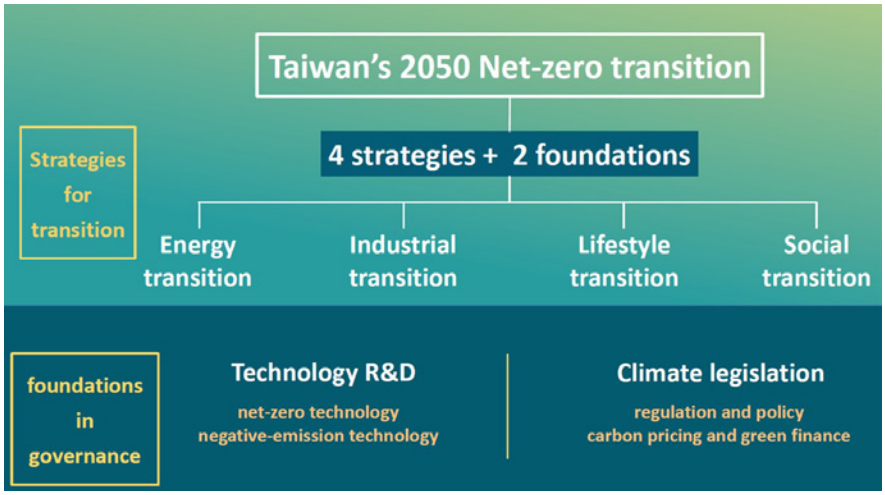
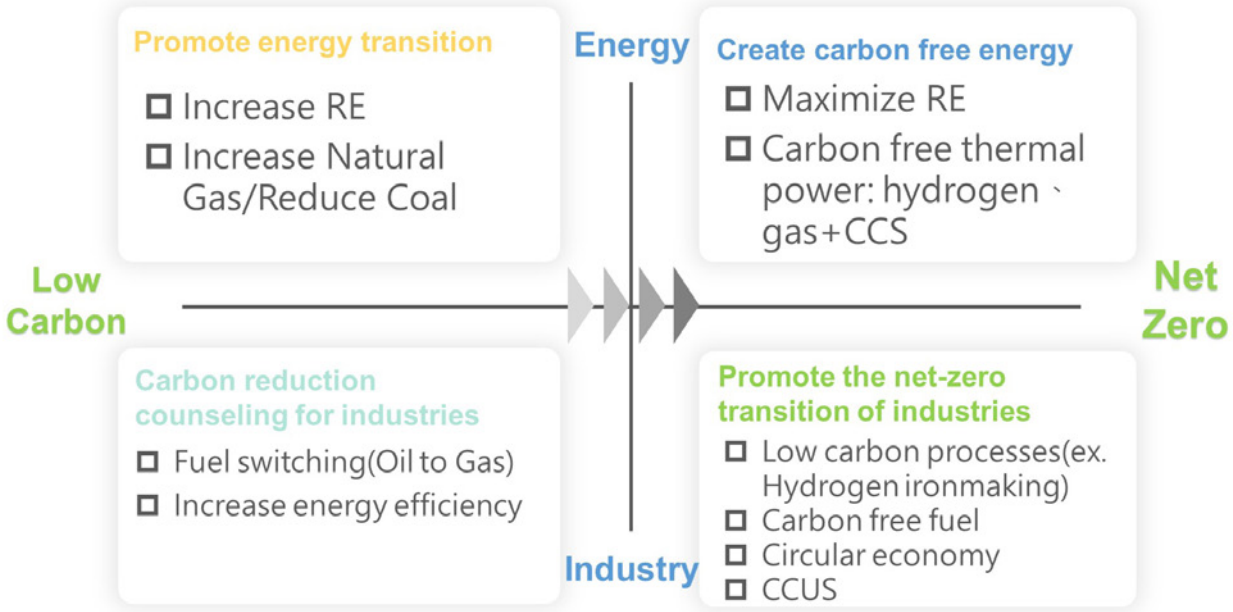


Figure 1: Taiwan's Net-Zero Transformation Promotion Approach
(Source: Taiwan 2050 Zero Emission Roadmap and Strategy Overview)

According to the EPA's 2021 National Greenhouse Gas Emissions Inventory Report, the energy and industry sectors are the main emitters. In order to move toward net zero emissions, Taiwan will adopt a 2x2 net zero transition framework of "low-carbon-zero carbon" and "energy-industry" to first achieve low carbon and then move toward zero carbon.

In the energy sector, in the short and medium term, priority will be given to developing solar power and wind power generation with matured technologies, while increasing natural gas and reducing coal combustion, and in the long term, maximizing renewable energy development and provided incentives to foster forward-looking energy like as geothermal, biomass and ocean energy with localized advantages. In the industrial sector, according to the different industries, through the strategy of "leading small industries with large ones ", we promote "carbon reduction through counseling" first, and then "industrial transition". We hope to build a zero-carbon energy system through the energy supply side, and to promote industries to improve energy efficiency through the energy demand side, to gradually move toward the goal of net-zero transition.



Low Carbon - Zero Carbon: Expanding the Potential of Hydrogen Energy Development

As countries regard hydrogen energy as the future technology for carbon reduction, Germany and the European Union, for example, are using off-shore wind power to produce green hydrogen from surplus electrolytic water for mobile vehicles such as hydrogen-powered vehicles, and are developing technologies for transporting, storing and distributing hydrogen mixed with natural gas pipelines as fuel. Japan, South Korea, China and other countries are aiming to develop mobile vehicles such as hydrogen vehicles and import hydrogen from Australia and other countries to increase the supply of hydrogen.

In Taiwan, hydrogen energy is a key technology on the 2050 Net Zero Roadmap, not only to provide carbon-free electricity (9-12% of electricity supply), but also to play an important role in reducing carbon emissions by replacing fossil fuels or raw materials for manufacturing industries. The Ministry of Economic Affairs (MOEA) has established the "Hydrogen Energy Promotion Team" to discuss the short-, medium-, and long-term issues and promotion strategies for hydrogen energy supply, application, and transmission and storage, and to initiate cooperation and dialogue with major hydrogen energy producing countries.

(1) Development of hydrogen energy supply sources

Considering that domestic renewable energy will be prioritized to meet the demand for electricity load and green electricity users, there is no excess renewable energy for the production of hydrogen yet. Therefore, in the short term, it is necessary to rely on the production of hydrogen from natural gas through steam reforming and the use of industrial hydrogen by-products, and to assess the feasibility of importing hydrogen through cooperation with foreign countries in order to meet the demand of hydrogen in Taiwan; in the long term, we will continue to pay attention to the development of hydrogen production technology in major hydrogen exporting countries (such as Australia) to ensure the supply of hydrogen as early as possible, and gradually expand the production of hydrogen from renewable energy as the installation of renewable energy in Taiwan accelerates.

(2) Development of hydrogen energy application technology

The development goals include all-hydrogen/hybrid hydrogen power generation, introducing hydrogen into the steel production process, and steel and chemical co-production. In the energy sector, we are planning to demonstrate hydrogen blending technology in the existing gas-fired or coal-fired power generation units of Taipower, and gradually increase the proportion of hydrogen blending. In the industrial sector, we are aiming at carbon neutrality by changing the fuel of steelmaking blast furnaces from pulverized coal to hydrogen-containing gas (using hydrogen as an alternative fuel) to low-carbon blast furnaces, such as the development of "hydrogen steelmaking" by CSC to reduce process emissions, and "steel and chemical co-production" technology to convert CO or CO_2 into high-value chemicals by adding hydrogen, and expanding industrial applications and timely assessing the feasibility of international cooperation or direct introduction of related technologies.

(3) Constructing hydrogen energy transmission and storage infrastructure

In response to the demand for hydrogen application infrastructure, CPC utilizes existing natural gas facilities to assess the location of hydrogen import and transition storage facilities in the short term to meet the needs of the industry and power generation; and in the medium to long term, to build hydrogen infrastructure to meet the needs of the hydrogen application fields.

"Energy-Industry": Improving energy efficiency in industry and manufacturing

According to the IEA's 2050 Global Energy Sector Net Zero Emissions Roadmap report, energy efficiency is the fastest and most cost effective measure. Considering that energy consumption in the industrial sector is much higher than other sectors in Taiwan, the promotion of energy efficiency in the industrial and manufacturing sectors is also a priority, with mandatory regulations and incentive mechanisms as the direction of promotion.

(1) Regulations

In order to strengthen the 1% annual energy saving effect of large energy users, according to the "Energy Users Set Energy Saving Targets and Implementation Plans", an energy auditing system is established annually, and energy saving targets and implementation plans are set.
The average annual energy saving rate of large industrial energy users from 2015 to 2020 is 1.76%, which is 0.79 times higher than the average annual energy saving rate (0.98%) before the implementation of the aforementioned measures (2010~2014).

From 2012 to 2016, Taiwan announced energy efficiency regulations for six major industries: petrochemical, electronics, steel, cement, textile, and paper, and gradually strengthened efficiency management for the above-mentioned industries in terms of unit product energy consumption standards or the efficiency of major energy-consuming equipment.

(2) Incentives

To promote energy efficiency and competitiveness of enterprises, we promote energy saving improvement subsidies, introduce professional technologies for energy technology service industry, and encourage accelerated replacement of old equipment and subsidize the purchase of high-energy-efficient air compressors, fans and pumps to improve production efficiency and equipment energy efficiency; we also guide large users to increase the effectiveness of energy saving through mechanisms such as

industrial process improvement, public equipment replacement, equipment maintenance and repair, as well as strengthen the energy-saving technical services for small and medium-sized energy users.

Conclusion

Faced with net-zero transition in 2050, Taiwan will maximize renewable energy development and continue to assess the international supply of hydrogen and establish an environment for the development of hydrogen energy in the country, along with information on the infrastructure required for the construction of hydrogen energy applications, international safety standards and regulations, and continue to refine various regulations and incentive mechanisms for energy conservation, and continue to improve energy efficiency in industry and manufacturing. We will guide resources into the net-zero transition of energy and industry, create a zero-carbon energy system, accelerate the research and development of key technologies, and promote industry leaders and large enterprises to assist small and medium-sized enterprises in building carbon reduction capabilities and sharing carbon reduction technologies through the supply chain system, to accelerate the comprehensive low-carbon transition of industry and achieve the long-term vision of net-zero transition.

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| Specialty |

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- Industry planning
- Industrial safety and Environmental protection
- Planning, development and management of Industrial zones

Chapter.2
Respond to the Global Net Zero Carbon Emissions

Science-based Targets: Raising Our Ambition

Energy efficiency, compressed air solution

Atlas Copco

To help create a more sustainable future, we are committing to science-based targets for the reduction of greenhouse gas emissions in our entire value chain.

our innovations are enabling the transformation. Our technologies are critical in existing low-carbon technologies like electric vehicles and solar power, and they are part of emerging low-carbon technologies for energy production, energy storage, smart manufacturing processes, transportation, and much more.

As a leading and global supplier, we can also make a big positive impact through our operations, transportation, product design, and through the source of energy needed to power our products. In fact, almost all the greenhouse gas emissions that we generate, more than 90%, com from when our products are in use.

To ensure that we fulfill our climate ambitions, the Group has set two science-based targets to reduce our greenhouse gas emissions in line with the Paris agreement.

Setting science-based targets means that you commit to take action in line with the Paris agreement goal to keep the global temperature rise to well-below 2 °C , and preferably not higher than 1.5°C .

Unlike our precious Group climate goals, our science-based targets are set for the entire value chain, including the user phase. They are also set for absolute reductions, not in relation to cost of sales.

"This signals our commitment to real change. By raising our ambition, we will challenge ourselves and help our customers and other business partners do the same. This will in turn open new business opportunities, help us attract the talent we need and establish us as technology drivers." says Mats Rahmström, President and CEO.

The Group's science-based targets are set for 2030, with 2019 as the base year. They have been vetted and validated by experts at the Science Based Targets initiative.

Science-based targets are validated by the

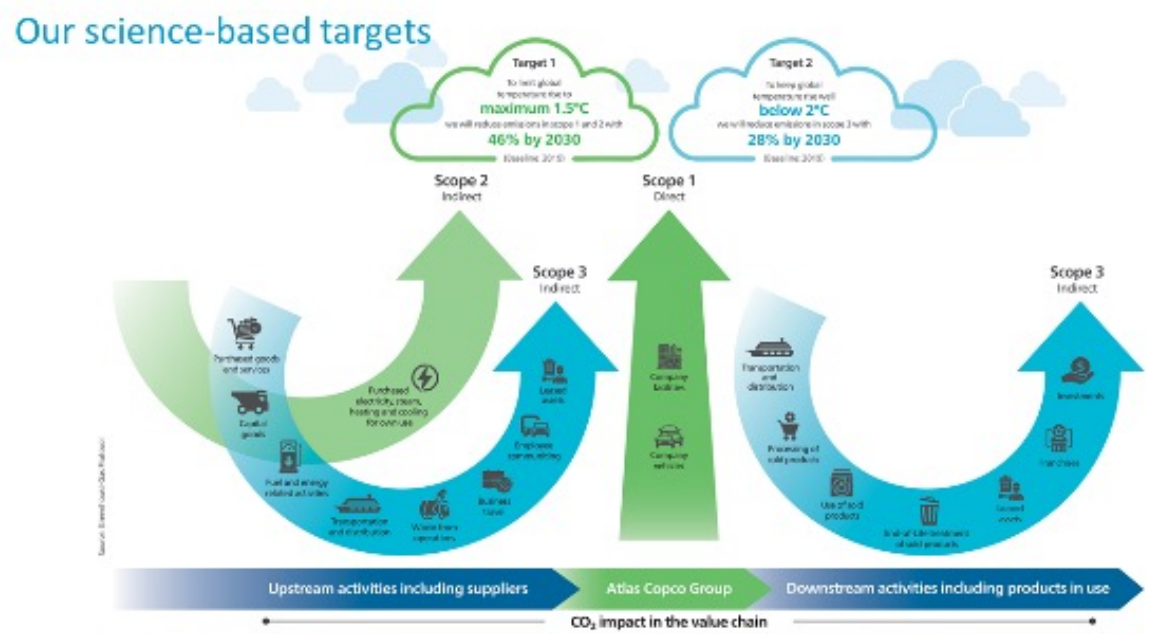
independent organization Science Based Targets initiative, which is backed by UN agencies. WWF and other climate leaders. The targets are divided in 3 scopes and often cover a company's entire value chain.

Scope 1 focuses on the direct climate impact a company has through its own operations. It can be emissions generated by company vehicles or during industrial processes, for example.

Scope 2 focuses on indirect emissions coming from the energy needed to power your own operations.

Scope 3 focuses on indirect emissions in up-and downstream activities. It can be emissions coming from business travel, purchased material and components, transportation, leased assets etc. Scope 3 also covers emissions from sold products that are in use by customers.

Companies who commit to science-based targets are expected to address all relevant emissions.



Target 1: Emissions from purchased energy and our own operations

Our first target concerns emissions from our own operations and the energy we purchase(scope 1 and 2). Here we will reduce our greenhouse emissions in line with the Paris agreement to limit the global temperature rise to maximum 1.5C (2.7F)

To do this, we have set a goal of reducing emissions generated in these parts of the value chain by 46% by 2030.

We will mainly focus on:
• Switching to fossil-free energy in our facilities, and use power from solar, wind, or other fossil-free sources.
• Using low-emission vehicles in our service fleet and other company cars.

Target 2: Upstream and downstream activities

Our second target concerns emissions generated outside of our own operations, in up-and downstream activities (scope 3).

Here we will reduce emissions in line with the Paris agreement to keep global temperature rise at well below 2C (3.6F), as these parts of the value chain are outside of our own control.

To achieve this, we have set a goal to reduce our indirect emissions from up-and downstream activities by 28% by 2030.

As most of our emissions come from when our products are in use, we will primarily focus on:

- Continuously increasing our products' energy-efficiency and ensure that they are used and maintained in an optimal way.
- Designing our products to be increasingly powered by electricity, instead of by diesel or air for example.
- The biggest reduction would come from our products being powered in the most climate-friendly way. This will be a challenge but could be achieved by supporting our customers in the shift to fossil-free energy sources. We could for example collaborate with local energy providers to increase the access to fossil-free energy in local and global electricity grids.

A joint effort

The baseline for our science-based targets is set to 2019, but both the Vaseline and the targets will be reviewed at least every five years to make sure that they will be in line with the latest climate science and that they are relevant to the nature and size of our operations.

"It is important to note that we commit to finding ways to reduce our emissions in absolute terms, regardless of how much we sell our grow." says Sofia Svingby, VP Sustainability for the Group.

"Achieving these targets will be a joint effort that involves all parts of the Group. Our two scientific-based targets are consolidated and based on each Business Area's and division's individual climate ambitions and performance. This means that each entity must take ownership and do what it takes to make the changes and improvements needed," says Mats Rahmström.

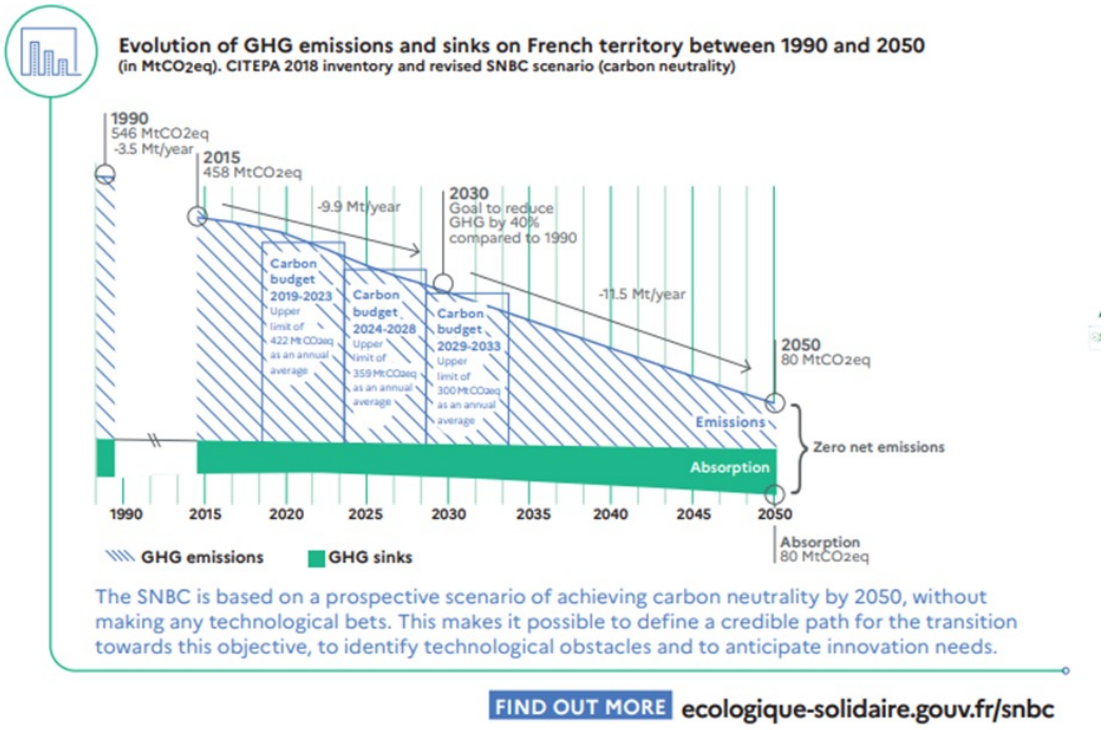
"Playing a leading role in the transformation to a low-carbon society in fully in line with our company purpose. It is our innovation power and industrial ideas that empower our customers to grow and drive society forward. This is how we create a better tomorrow." Mats concludes.

France Ecological and Inclusive Transition Towards Carbon Neutrality

BUREAU FRANÇAIS DE TAIPEI 法國在台協會

By signing the Paris Agreement, countries have committed to limiting the increase in average temperature to 2° C, and if possible 1.5° C. To this end, they have committed themselves, in accordance with the IPCC's recommendations, to achieving carbon neutrality during the second half of the 21st century at the global level. Developed countries are called upon to achieve carbon neutrality as soon as possible.

France committed itself by law to reaching carbon neutrality by 2050. This ambitious goal adopted in 2019 implies a division by 6 of greenhouse gas emissions on France's territory compared to 1990. In concrete terms, this means reducing France's emissions to 80 MtCO2e, compared with 458 MtCO2e in 2015 and 445 in 2018. This objective will require major efforts and a profound transformation of lifestyles, consumption and production. But it is also a major opportunity for our creativity and our capacity to innovate: this challenge allows us to rethink our economic model, while maintaining its capacity to create jobs, and to make it more sustainable, more circular, more resilient and more respectful of our health. The National Low-Carbon Strategy provides the public policy guidelines to follow in order to make a successful transition to this new economy.

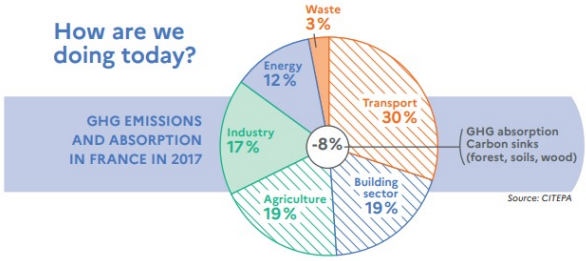


The National Low Carbon Strategy (SNBC for Stratégie Nationale Bas-Carbone) describes a road map for France on how to steer its climate change mitigation policy. It provides guidelines to enable the transition to a low carbon economy in all sectors of activity.

It sets out objectives for reducing greenhouse gas emissions in France in the short/medium term - carbon budgets - and has two ambitions: to achieve carbon neutrality, i.e. zero net emissions, by 2050 (an objective introduced by the July 2017 climate plan and enshrined in law), and to reduce the carbon footprint of the French people. Every five years, the low carbon strategy is subject to a complete revision.

1- The transport sector: the largest greenhouse gas emitting sector in France (30% of national emissions in 2015)

As all of these emissions are energy-related, the strategy aims for a 28% reduction in emissions in 2030 compared to 2015 and a complete decarbonisation of transport by 2050.



This assumes an average annual decrease in emissions of 3.8 Mt CO_2 eq/year between 2015 and 2050, whereas on average annual emissions increased by 0.5 Mt CO_2 eq/year between 1990 and 2015, and decreased by only 0.8 Mt CO_2 eq/year over the most recent period 2005-2015.

In 2017, the transport sector represented 29.9% of national emissions, or 139 Mt CO_2eq, rising sharply between 1990 and 2004 (+ 18.9%) then falling by -7.9% between 2004 and 2009 before a slight increase of +2.0% between 2009 and 2016. This progression is due to the increase in road traffic. It has not been offset by the decrease in unit emissions of new vehicles or the development of biofuels, whose strong progression since 2005 has nevertheless resulted in a significant decrease in road sector emissions.

The objective of neutrality by 2050 implies a near-total decarbonisation of the transport sector by switching to electric motors, biofuel and biogas depending on the mode of transport. A share of non-bio-based fuels is however reserved in 2050 for air transport and international marine bunkers.

The scenario assumes that demand for mobility will grow but will be uncoupled from economic growth compared to the current trend. It also includes strong assumptions in terms of engine efficiency and type. The scenario mobilizes all of the following five levers: decarbonisation of the energy consumed by vehicles; energy performance of vehicles in order to limit energy consumption; control of demand growth, in particular by strengthening the circular economy; modal shift; and optimising the use of vehicles for both passenger and freight transport.

Electrification is approximately two to three times more efficient than thermal solutions in terms of fuel efficiency for vehicles. This option is prioritized in the long term, particularly for cars (100% of sales for new cars will be electric after 2040). This option should be developed ambitiously since it requires a five-fold multiplication of electric vehicle sales by 2022 (corresponding to the commitment in the Strategic Contract for the Automobile sector 2018-2022). In 2030, the scenario attains a 35% share for private electric cars and a 10% share for private rechargeable hybrid cars in sales of new vehicles. Significant efforts should also be made in terms of vehicle efficiency, particularly for thermal vehicles. In particular, the scenario targets a level of 4L/100km in real consumption for new vehicles sold in 2030. New electric vehicles should reach a performance level of 12.5 kWh/100 km by 2050 (about 40% less consumption in comparison to current levels).

A more balanced mix (renewable gas, electricity, biofuels) is sought for goods transport because of the greater constraints in the engines used in this type of transport. Electrification for these vehicles will be slower than for cars. Significant efforts in energy efficiency will also be made for heavy goods vehicles: depending on the type of engine, improvements in efficiency of 35-40% will be obtained by 2050.

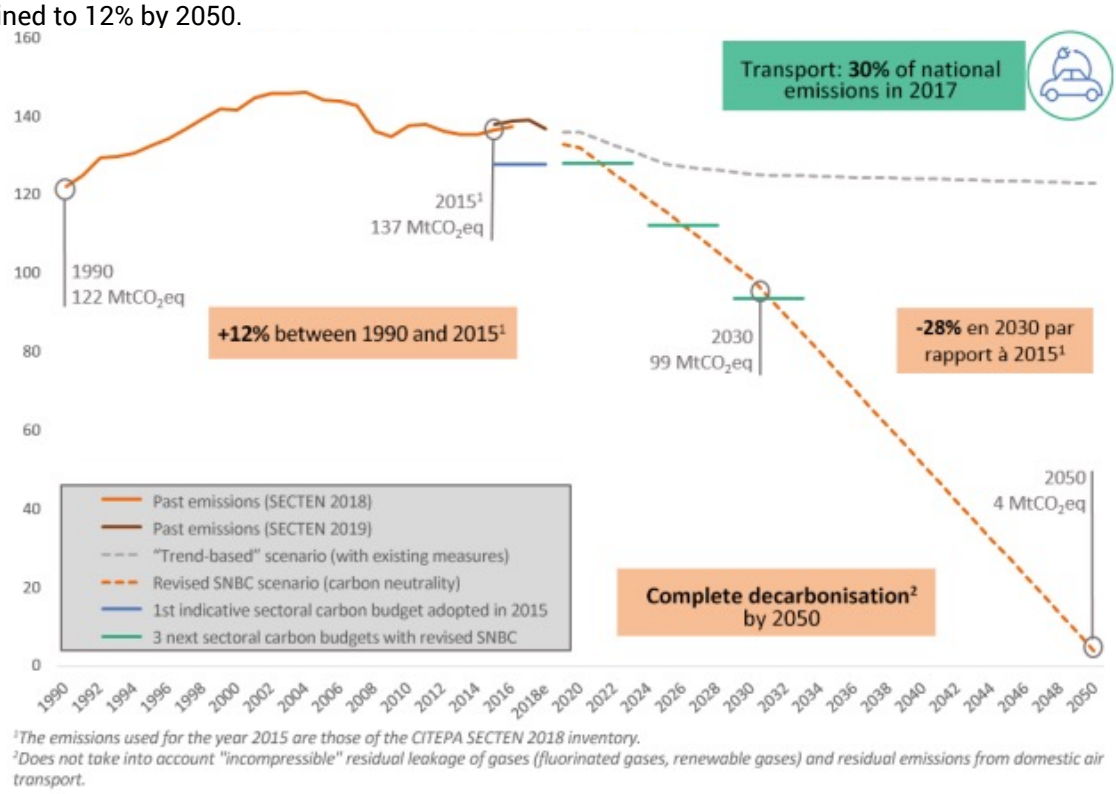
The improvements in energy efficiency and decarbonisation will concern all modes of transport. The scenario notably envisages a progressive development of biofuels in aviation to reach 50% by 2050.

Sea and river transport will be entirely carbon-free for domestic emissions by 2050 and 50% decarbonised for the international bunkers.

The scenario assumes that the rise in traffic both for the transport of people and for the transport of goods will be controlled, that a modal shift will occur towards active means of transport, public transport and bulk transportation and that vehicle use will be optimized.

Passenger traffic in passenger-km for all modes together will rise by 26% between 2015 and 2050 but at a more moderate rate than in the business-as-usual scenario, notably because of the increase in teleworking and a limitation of urban sprawl. The modal share of cycling will be multiplied by 4 after 2030. Public transport will develop significantly with a progression in its modal share of 7 points, this will also apply to shared transport and car-sharing. In total, this will allow a limitation of private car traffic which will decrease by around 2% between 2015 and 2050.

Goods traffic in tonnes-km will grow by 40%, but at a lower rate than in the business-as-usual scenario because of the development of a circular economy and local supply circuits. Rail and river freight will develop. The loading rates of heavy goods vehicles will increase. The growth of heavy goods traffic will be contained to 12% by 2050.



¹The emissions used for the year 2015 are those of the CITEPA SECTEN 2018 inventory.
²Does not take into account "incompressible" residual leakage of gases (fluorinated gases, renewable gases) and residual emissions from domestic air transport.

Figure: Past and projected emissions in the transport sector between 1990 and 2050 (in $MtCO_2eq$)

2- What the National Low Carbon Strategy and its baseline scenario say:

- Give the sector price signals that encourage the development of low-carbon mobility (standardizing fuel tax rates between European countries, internalizing external costs for road use, etc.) and strengthen existing market mechanisms (European Emissions Trading Scheme - ETS, International Emissions Trading Scheme for Aviation - CORSIA), in order to accelerate the decarbonisation of air transport.

- In line with the sector's energy transition, set ambitious targets in terms of the energy performance of vehicles, both for passenger cars (targets of 4 L/100 km in 2030 in real conditions for internal combustion vehicles and 12.5 kWh/100 km by 2050 for electric vehicles, compared with around 17.5 kWh/100 km today), heavy goods vehicles (target of 21 L/100 km in 2040 in real conditions, i.e. a drop of almost 40% compared with 2015)and sea and air transport. In addition to energy efficiency gains, set ambitious targets for the decarbonisation of energy consumed by vehicles, such as
  - By 2040, 100% of light vehicles sold will have to be zero-emissions.
  - For domestic maritime transport that is 100% carbon-free in 2050, develop low-carbon in all French ports and facilitate conversion to other low-carbon technologies (batteries, biofuels, hydrogen, sailing, etc.).
  - For air transport, replace a very large proportion of fossil fuels with biofuels (50% in 2050) and develop

hydrogen or electric-powered aircraft.

• Support the development of all modes of transport, in particular by providing aid for vehicle renewal and by adapting infrastructures (infrastructures for bio-NGV refueling or electric recharging).

• Support local authorities and businesses in setting up innovative initiatives and involve them in clean mobility policies (deployment of low-emission zones, development of action plans for reducing emissions and fleet renewal, etc.).

• Spur a modal shift to modes of transport that consume the least energy and produce the lowest emissions, such as rail or public transport, and support active modes, such as cycling (with an objective of 12% of the short distance modal share by 2030, and 15% by 2050), which can also improve health through regular physical exercise.

• Optimize the use of vehicles in terms of volumes and weight of goods loaded so as to make logistics operations more fluid (increasing the current loading rate of heavy goods vehicles from 9.8 to 12 tons per vehicle in 2050).

• Control the growth in demand for passenger transport (+26% between 2015 and 2050 for all modes of transport combined12) and freight transport (+40% between 2015 and 2050-2013), in particular by promoting working from home, carpooling, short routes and the circular economy.

Transition in this sector must be scaled quickly while taking into account air quality issues - an area in which major co-benefits should be obtained. The transition should also make it possible to reduce land take by limiting construction of new infrastructures.

TRANSPORT

GHG EMISSIONS REDUCTION TARGETS COMPARED TO 2015

2030: -28%

2050: **Complete decarbonisation** (with the exception of domestic air transport).

HOW?

- Improve the energy performance of light and heavy vehicles, with a target of 4l/100 km in 2030 for private combustion vehicles.
- Decarbonize the energy consumed by vehicles and adapt infrastructures to reach 35% of sales of new electric or hydrogen-powered passenger cars in 2030 and 100% in 2040.
- Control the growth in demand for transportation by promoting telecommuting, car sharing, short routes and optimising the use of vehicles.
- Encourage a shift towards the least emitting modes of passenger and freight transport (public transport, train) and support active modes (cycling, etc.).

Promoting Human Progress with Sustainability

Corporate strategy, technology, and net zero standard

With science and technology at its core, Merck is an enterprise that spans three major fields, namely healthcare, life science, and electronics. From facilitating the technological development of genetic editing to treating the toughest diseases, and even developing next-gen smart devices, Merck is dedicated to developing high-tech that brings positive impact on human lives. For the past 354 years since its establishment, Merck has implemented the philosophy of sustainable operation in all actions and has continued to create a corporate model that achieves common prosperity with society and the environment.

In response to the global sustainability trend and to confront the climate crisis, Taiwan joined the ambition of achieving "Net Zero Carbon Dioxide Emissions by 2050," alongside 197 members worldwide in 2021. Furthermore, the EU will impose carbon tariffs starting in 2026 to contribute to a sustainable transition in the world. Under this pledge of net zero emissions, environmentally-conscious economies are no longer options for consideration but necessities. Historically restricted by past technological limitations, the environment often fell victim to economic development. However, as an outstanding problem-solver tackling the world's toughest issues, Merck began considering solutions to environmental and social challenges through technology early on.

Promoting Human Progress through Three Overall Sustainability Goals

In true Merck spirit as "curious minds dedicated to human progress," the company has established three overall sustainability goals (as shown in Figure 1): dedicated to human progress, creating sustainable value chains, and reducing our ecological footprint. From production operations to assisting customers in promoting environmentally-friendly end products, Merck provides green solutions by leveraging its science and technology capacities.

Figure 1: Merck's Three Overall Sustainability Goals

Benefiting the Humankind through Sustainable Technology

The first aspect, "dedicated to human progress," aims to benefit the one-billion global population through innovative sustainable technologies by 2030, through developing green product solutions to help customers, and reducing environmental footprints. Take Merck's "licrivision® Liquid Crystals for Windows" as an example; utilizing the features of liquid crystal materials, Merck injects the special liquid crystal materials in between two pieces of transparent glass conductive films. When prompted by an electrical charge, the random configuration of the liquid crystals align neatly within one second. This instantaneous ordering of the liquid crystal positions enables customizable control of sunlight penetration rates through the window, effectively blocking heat generated from strong outdoor light, and thus maintains a comfortable indoor temperature and saves up to 30% of power. The "licrivision® Liquid Crystals for Windows" and its technology are well suited for next-gen green buildings, and is further applicable to different scenarios, such as modes of transportation, to create energy-saving and comfortable spaces, and in turn, unlock new business opportunities for a maturing display industry.

Creating Sustainable Value Chain

The second aspect, creating a sustainable and transparent supply chain, works towards the goal of achieving a sustainable supply chain by 2030. Merck closely connects with its upstream and downstream suppliers to jointly build a green supply chain and adopt Together for Sustainability (TfS) audit standards, ensuring suppliers can meet the globally-recognized ESG standards. In recent years, Merck has also been committed to digitalization; it introduced the Manufacturing Execution System (MES) at its production centers and successfully implemented manufacturing procedure improvements through automation in processes from order-placing to shipping. These measures allowed this aspect of operations to become paper-free, while water and power consumption at its plants recorded significant decreases, and production

and shipping progresses can now be instantly tracked. Merck will continue to digitalize its global production and R&D procedures and systems, which will also help solve the ongoing challenges faced by the global semiconductor supply chain.

Reducing Ecological Footprint

For the third aspect, Merck set its target to realize climate neutrality by 2040, a decade earlier than other enterprises, and to comprehensively reduce its ecological footprint. Previously, Merck's GHG target passed the review of Science Based Targets Initiative (SBTi), the most stringent science-based carbon dioxide reduction target, confirming that Merck helps keep the global average temperature increase within 1.5oC. To this end, Merck has committed to reduce the scope 1 (direct emission) power consumption emission and scope 2 (indirect emission) GHG emission intensity by 50% and reduce the carbon dioxide emissions per Euro on the value chain under scope 3 by 52% by 2030. To further demonstrate its determination, Merck has tied its scope 1 and scope 2 target realization with the remuneration of the Executive Board of Merck Group.

With over 30 years of operation in Taiwan, Merck possesses four production centers in Taiwan and continually examines its own manufacturing procedures to continuously and comprehensively implement the sustainable spirit throughout its plant establishment, product manufacturing, waste reduction and recycling practices. On the front of production, Merck established an energy-use recording and monitoring system to improve power and water use efficiency; in addition, it successively adopts green chemical alternatives in its production process to minimize the production of hazardous chemical compounds. Through other diverse measures, Merck recorded multiple, substantial achievements including a reduction in carbon dioxide emissions equivalent to a volume that would take 21 Da'an Parks to reduce, a reduction in water usage equivalent to 31 Olympic-sized swimming pools, and a reduction in environmental waste index to 21% in 2021.

Improving local operations and examining logistics practices have tremendous potential to contribute to reducing the collective carbon footprint. In December 2021, Merck announced its investment to build the first large-scale semiconductor material production and application R&D center worldwide, in Kaohsiung. Such an act not only reinforces the stability of the semiconductor supply chain but would also reduce the carbon footprint through localized production. In consideration of preexisting nature in the science park, Merck would preserve or fully integrate over 1,800 species of flora and fauna on the site, leaving it undisturbed to the maximum extent. In addition, as global logistics make up approximately 8% to 10% of worldwide carbon dioxide emissions, Merck's shift of major parts of its healthcare medication transportation from air to sea further significantly reduces its carbon footprint.

The circular economy model is also a favorable method for sustainability. Through the innovation and passion of Merck's own employees, the novel practice to recycle waste gallium-aluminum alloys for rare minerals regeneration serendipitously made Merck the first enterprise within the semiconductor industry to seemingly turn waste into gold. In 2021, Merck's Kaohsiung Plant produced 215 tons of iodine solution and 470kg of gallium alloys, allowing the strategic metal to return to the production supply chain and further extend its lifecycle.

Bolstering an Internal Culture of Sustainability

Merck's realization of all its great achievements and prospects depends on its employees' daily efforts. In Taiwan, Merck initiated the sustainable development project, which apart from continuing to organize a series of sustainable measures, also set out to strengthen the sustainability mindset of employees by cultivating daily, green behaviors.

For instance, Merck fulfilled its pledge to turn off its office lights for one hour for two consecutive years, which reduced approximately 36 tons of carbon dioxide emissions. Another example includes employees donating second-hand clothing, shoes, and bags through our partnership with Step30. Merck's employees also participate in nurturing scientists of the next generation. Through the SPARK, a global volunteer project, over 38% of Merck's employees have presently volunteered for the "Taiwan Railways of Popular Science" organized by the Ministry of Science and Technology and "Chemistry On The Go" in collaboration with Tamkang University, both educational programs to bring popular science experiments to schoolchildren in remote areas of Taiwan.

In line with the global wave of net zero emission strategies, Merck leverages its scientific and technological expertise to promote comprehensive, active practices of sustainability. For its achievements, Merck Group in Taiwan was granted opportunities to receive notable recognition from different sectors, including awards such as the honorable First Prize from Global Views Magazine's CSR and ESG Award in the Foreign Enterprise category for two consecutive years.

Dr. John Lee
Managing Director of
Merck Group in Taiwan

Author

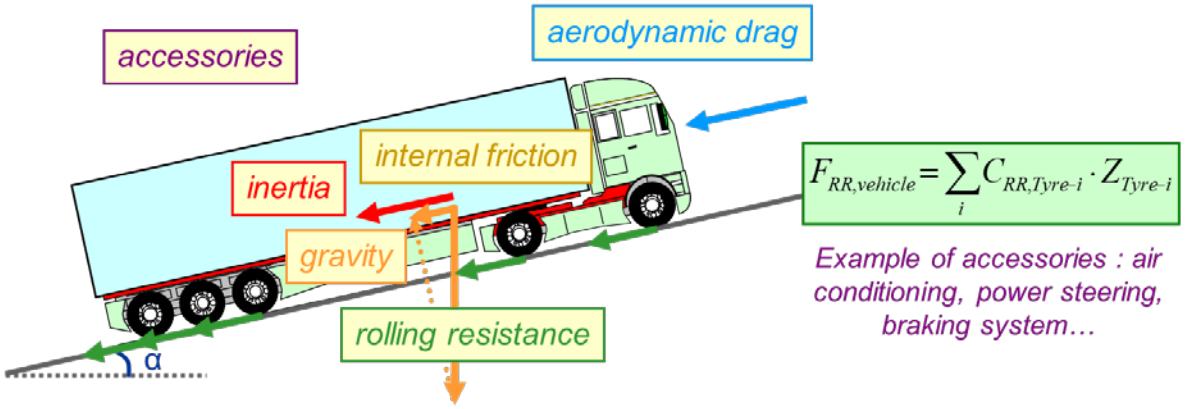
Dr. John Lee is theof Merck Group in Taiwan, responsible for the development strategies of Merck Group and its subsidiaries in Taiwan. Dr. Lee also serves as a Governor of AmCham Taiwan, Managing Director of Taiwan Display Union Association and Taiwan Flat Panel Display Materials & Devices Association, as well as a representative of European Chamber of Commerce Taiwan and German Trade Office Taipei.

How Tires Contribute Reducing Carbon Emissions

Fuel efficiency, all sustainable vision

Five Types of Forces which Resist the Movement of a Vehicle

To move ourselves or an object, we have to apply force and thus expend energy. In a motor vehicle, energy expenditure dictates fuel consumption. Let us take a simple example. To move a wheelbarrow forward you have to push it, in other words, make an effort. The required effort increases if the load is heavier, if you are pushing it up a steep incline, against the wind or if the wheelbarrow hub has not been greased. We have already mentioned four forces which will resist the movement of a vehicle:



Driving with 10kg/t tyres is as if the vehicle was climbing a permanent 1% slope

- inertial forces, which depend on the vehicle's mass and variations in speed,
- gravitational forces, which depend on the slope and mass,
- aerodynamic forces, which depend on the wind, the speed of movement and the vehicle's shape,
- the internal friction of rotating parts.

The effort to be made also depends on the ground and the wheelbarrow wheel. We all know that it is easier to push a wheelbarrow over hard ground than over soft ground. Similarly, a wheelbarrow with a metal-rimmed wheel or a properly inflated pneumatic tire is easier to push than one with an under-inflated tire. This is where the fifth resistive force comes in: rolling resistance.

What is Rolling Resistance?

Rolling resistance (RR) has a significant impact on the energy a vehicle needs to move. Hence a direct link with fuel consumption for combustion-powered cars - around 20% - or range for electric vehicles. Tire design can help reduce rolling resistance.

Let's make sure we understand the idea of tire rolling resistance. As its name would suggest, rolling resistance refers to the resistance experienced by your car tire as it rolls over a surface. The main causes

of this resistance are tire deformation, wing drag, and friction with the ground.

The higher the rolling resistance is, the more energy to overcome it is needed. Hence a considerable impact of tire rolling resistance on fuel consumption (and on how long your tires will last). A 30% increase in rolling resistance generates between 3 and 5% of fuel overconsumption.

There are several elements that affect the rolling resistance of a tire under the same road surface and conditions: tire pressure, tread, diameter, width, or the materials used in tires or their construction. Regarding tire pressure, for instance, studies carried out on French roads[1] have shown that more than 50% of cars run at least 0.3 bar below the required tire pressure. This results in a considerable increase in rolling resistance: +6% for an underinflation of 0.3 bar and +30% for an underinflation of 1 bar[2].

[1] Data collected on French motorways in 2000, during MICHELIN "Fill up the air" operations.
[2] 1 bar = 14.503773773 psi

Regarding Fuel Consumption, How Much Difference Do Low Rolling Resistance Tire Make?

Low Rolling Resistance tires – also known as LRR
- are designed to reduce energy dissipation
- and therefore save fuel. This is done through innovations applied to all aspects of the tire:
- Tire construction, shape, and tread pattern: the structure of the tire through the geometry and nature of the internal plies and the design of the treads have a huge influence on the extent of the deformations undergone by the tire, and thus on rolling resistance.
- The weight of the tire: for the same deformation, the more massive an object is, the more it heats up.
- The optimization of rubber mixtures and the various components used in the tire: it's a major source of progress in reducing the energy absorbed by the tire.

"A tire's fuel consumption represents one full tank in five" Cyrille Roget, Science and Innovation Communications Director at Michelin, explains. "This is linked to the tire rolling resistance. And it's not insignificant if you think about the amount of fuel we put in our tanks."

It's not just your wallet that benefits from improvements in fuel efficiency thanks to low rolling resistance tires. They are also a step towards more eco-friendly driving. When it comes to a combustion engine, by reducing fuel consumption, you also cut down on your use of fossil fuels. And, for an electric motor, a greater range means less demand on the electricity grid which, in Europe, gets 40% of its energy from power stations burning fossil fuels.

MICHELIN'S "All Sustainable" Vision

The "All Sustainable" vision commits the entire Michelin Group to the constant search for a fair balance between people, the planet and economic and financial performance. It is translated into actions for each of these three pillars: People, Profit, and Planet.

Regards of Planet, Michelin's ambition is to reach carbon neutrality by 2050 (manufacture and energy) and also contribute to reaching carbon neutrality (usage).

An example of Michelin's "All-Sustainable" vision becoming reality is unveiled MICHELIN e PRIMACY in 2021. MICHELIN e PRIMACY is the first Michelin tire to be eco-designed and "CO_2 neutral" at the time of purchase [3]. Moreover, MICHELIN e PRIMACY is also the first tire on the market for which an environmental product declaration (EPD) has been published [4].

Another example of truck tires is the MICHELIN X® LINE™ ENERGY™ range. It minimizes CO_2 emissions throughout the lifespan of the tire thanks to lower rolling resistance and its ability to be regrooved and retreaded throughout its use.

[3] Michelin has cut CO_2 emissions from all its industrial sites by 25 % since 2010 and aims at their carbon neutrality by 2050. Michelin is engaged in funding projects designed to absorb or avoid CO_2 emissions and draws upon the carbon credits stemming from these projects up to the level of residual emissions linked to the production of MICHELIN e.PRIMACY tires (from extraction of the raw materials to the transport to the customer). Program done

in partnership with Livelihoods carbon fund

[4] www.environdec.com/Detail/?Epd=19867

Promote the Creation of a Low-Carbon and Environment Friendly "Ecosystem"

- **Establish a tire labeling system**

When purchasing a tire in Europe, consumers can find the rolling resistance grade on the label with classifications ranging from A to E, this helps tire users find out the rolling resistance of a tire. Tire labeling rules help consumers make an informed purchase decision when they replace their tires, as the label highlights the performance of the tire in terms of fuel efficiency, safety and noise. At the same time, the labels drive manufacturers to innovate and strive to have their tires classified in the top classes in the different categories.

- **Favor low rolling resistance tire users on a carbon tax or carbon rights, especially in the transportation sector**

In the roadmap to reach net zero carbon emission vision for Taiwan, low rolling resistance tires can significantly reduce carbon emissions in the transportation process; therefore, we suggest formulating promotional policies to encourage transporters to use lower rolling resistance tires to reduce carbon dioxide emissions.

- **Gather the power of all stakeholders**

To truly achieve a zero-carbon future, it is inseparable from the joint efforts of all stakeholders, including governments, enterprises, research institutions, investment institutions, non-profit organizations, universities, individuals, etc. Over the years, In addition to developing low-carbon and green products and services, Michelin Group strives to promote the creation of a sustainable green ecosystem, including Movin'On Summit, Movin'On Lab, etc. More companies and individuals are participating in energy conservation and emission reduction, making carbon emission reduction more sustainable.

Jay Mao
Chairman
Michelin Taiwan

Author

Served at Michelin since 1993, experienced in finance, credit, logistics and information management, as well as sales executive of different product lines. With the growth of the Taiwan market and strengthening the determination of the Michelin brand to deeply cultivate Taiwan, Jay took the lead in the tire industry in 2008 and introduced the auto warranty franchise brand – TyrePlus Auto Service Center to create a brand new consumer experience that is completely different from the traditional tire industry. In 2012, Jay transferred to Greater China, and his performance was well received. In 2016, he was appointed as the first Taiwanese chairman of Michelin Taiwan, leading Michelin to become the most well-known tire brand in Taiwan.

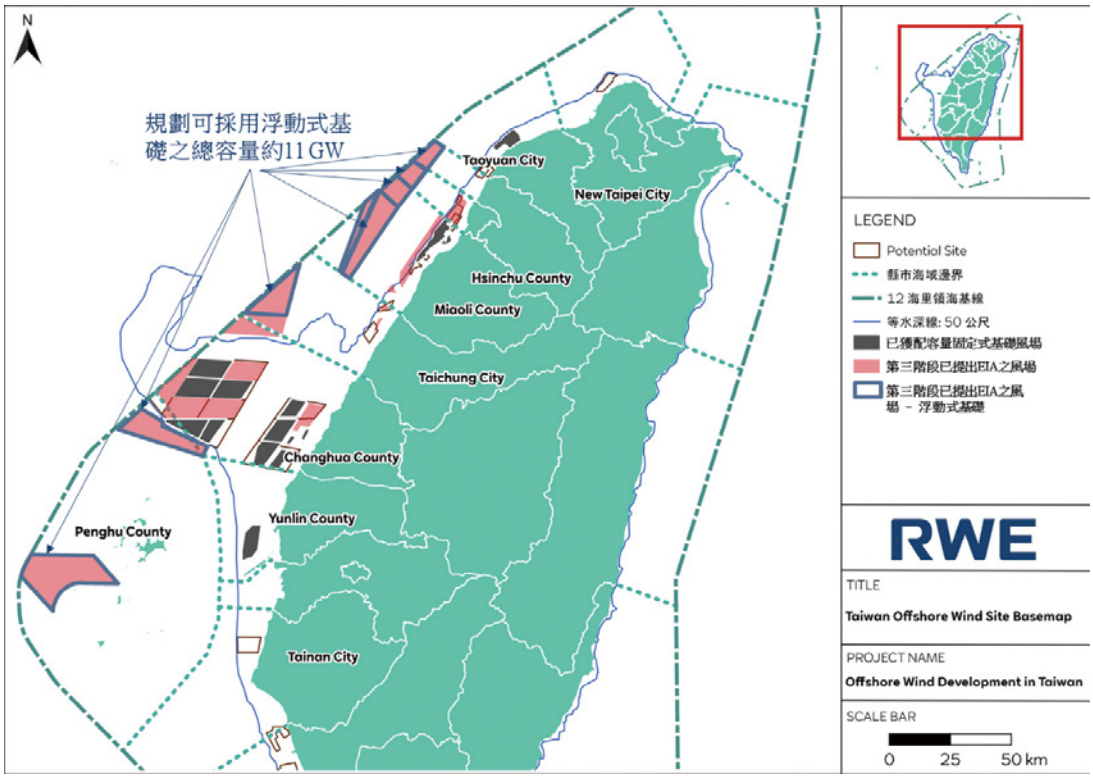
Clear Policy is the Key for Floating Offshore Wind Helping to Achieve Net-Zero Transition

Floating offshore wind

RWE

We suggest the government launch commercial-scale floating demonstration wind farms of more than 100MW per project by 2022, following by selection of projects in 2023. It can improve large scale commercial floating wind farm development for accelerating Net-Zero Transition.

According to "Taiwan's Roadmap to Achieve Net-zero Emissions by 2050", the government set up a 40-55 GW target for offshore wind. It's one of the key technologies to achieve net-zero transition. As of May 2022, there are c.16GW (overlapping sites have been deducted) of offshore wind sites are in the EIA process and will join phase 3 auctions according to the published information. More than half of these projects are in deeper waters, as illustrated in the figure below, resulting in many needing to use floating foundations due to limitations on the depths for conventional bottom-fixed foundations. Based on current auction rules of 3GW being auction each year, we can expect all the sites which can use fixed-bottom will be awarded across 2022 and 2023. It means that floating offshore wind projects will be the main technology of the market from 2024 onwards to help achieve Net-Zero transition.



However, in the absence of clear policy guidance, the development and construction of floating wind farms in Taiwan are highly uncertain.

Even though some developers including RWE have mentioned in the EIA process that they will use floating technology, it doesn't mean that the complete information is sufficient to reduce the development risk and enough ability to complete the construction of the floating wind farm. Each offshore wind power project only conducts a preliminary assessment from the perspective of environmental impact, and uses this to communicate with the EIA committee about possible issues. Also, even the floating wind turbine technology has been verified and feasible abroad, it doesn't mean that it can work in Taiwan. Taiwan's environmental and geographical conditions, local supply chain energy, regulatory and procedural limitations, etc. will all affect the construction progress. The construction progress may be delayed due to various potential development risks, which will affect the achievement rate of the offshore wind power construction target set by the government, as well as the efficiency and stability of power supply in the future.

In the meanwhile, there are 5.9GW floating offshore wind farm has obtained Electric Business License in Korea. The 1st phase (504MW) will start the construction works in 2024. It's the largest FOW(floating offshore wind) project in the world. Japan government also has saved the budget for floating offshore wind turbines demonstration project by 2025. Under the advice of industry, it is possible to set a target of 2-3GW for floating wind farms in 2030 and will keep FIT(Feed-In Tariff) rate for it. As a result, the two countries have successfully gained the attention of global transportation and installation companies, and are also the target markets of floating supply chains in the APAC region.

In order to maintain Taiwan's leading position in the offshore wind market in the APAC region, and to enable Taiwan's supply chain, which has invested a lot of money, manpower and resources, to have a longer-term future, we suggest the government to clarify the floating offshore wind power policy as soon as possible. We especially suggest that the government can refer to the successful policy experience of the development of fixed-bottom wind farms in Taiwan, adopt the demonstration wind farms to guide the development, and propose regulations for commercial-scale floating demonstration wind farms of more than 100MW per project by 2022, following by selection of projects in 2023. According to RWE's floating experience, we think this policy has the following advantages:

1. The promotion of the demonstration wind farm will be regarded as an official declaration of Taiwan's development in the field of floating wind turbines, attracting the attention of global engineering technology companies, supply chains and construction companies to put resources in Taiwan.

2. Help the government to get comprehensive information on wind farm development, construction and grid connection. This information can not only be used by the government to check whether relevant policies need to be adjusted, but also provide developers with a reference for large-scale wind farm development planning. It can help to reduce development risks and ensure the wind farms can complete as scheduled, then to keep stable power supply.

3. The difference between a fixed-bottom wind farm and a floating wind farm is not only the form of the underwater foundation, but also the various components must be adjusted accordingly to meet the more severe environmental conditions of the wind farm and the floating platform. The demonstration wind farm will give Taiwanese manufacturers a clear motivation and incentive to join the floating wind turbine industry chain, get learning experience, improve product proficiency and reduce costs, and industrial upgrading and

transformation.

We have already seen that the offshore wind power project in phase 2 have been challenged by pandemic, limit capacity of the local supply chain, and incomplete environmental survey data, even they have been guided by demonstration wind farms. These challenges make the construction progress being less than expected. Therefore, if the floating wind farm is not guided by the demonstration wind farm, it will face more severe development challenges.

It is hoped that the government will consider to launch the floating demonstration wind farm project as soon as possible, so that the floating wind farms allocated in the near future can be constructed and connected to the grid as scheduled, which will become an important boost for Taiwan's net-zero transformation.

Wei-Ting Syu
Senior Regulatory Affairs Manager
RWE Taiwan

Author

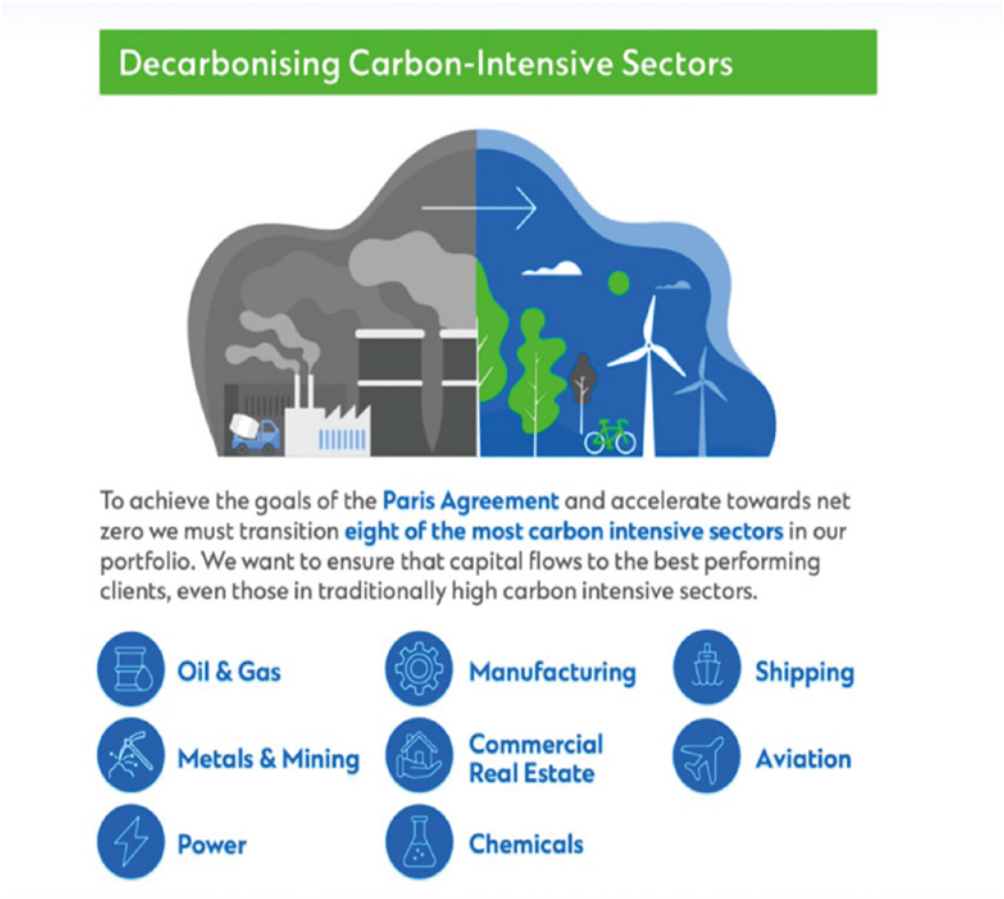
Wei-Ting Syu, RWE TW Senior Regulatory Affairs Manager with more than 10 years policy communication experience, has great passion for energy transition, and specialize in renewable energy policy and regulation. She has worked for NGO, political party, consultancy, and think tank in the past and has published five policy-related books.

It's now or never, the Transition Finance Imperative by Standard Chartered

On 13 May 2021, Standard Chartered launched the Transition Finance Imperative as part of our drive to become The World's Most Sustainable Bank.

The global transition to net zero carbon emissions is the biggest challenge that we face today. According to our Zeronomics report, 55% of executives told us their companies are not transitioning fast enough to net zero, while 78% of investors said most business leaders are failing to take the action needed. With more than half of the CAPEX required to finance the net zero transition expected before 2030, we must act now.

The Transition Finance Imperative is our commitment to facilitating the net zero transition. Our objectives are to reduce our financed emissions and help clients transition, with extra focus on eight of the most carbon-intensive sectors in our portfolio, in the regions of the world that need this most. We want to ensure capital flows to clients who are the best performers in the climate transition, even those in carbon-intensive sectors.



Where others see challenges, we see opportunities to partner with our clients

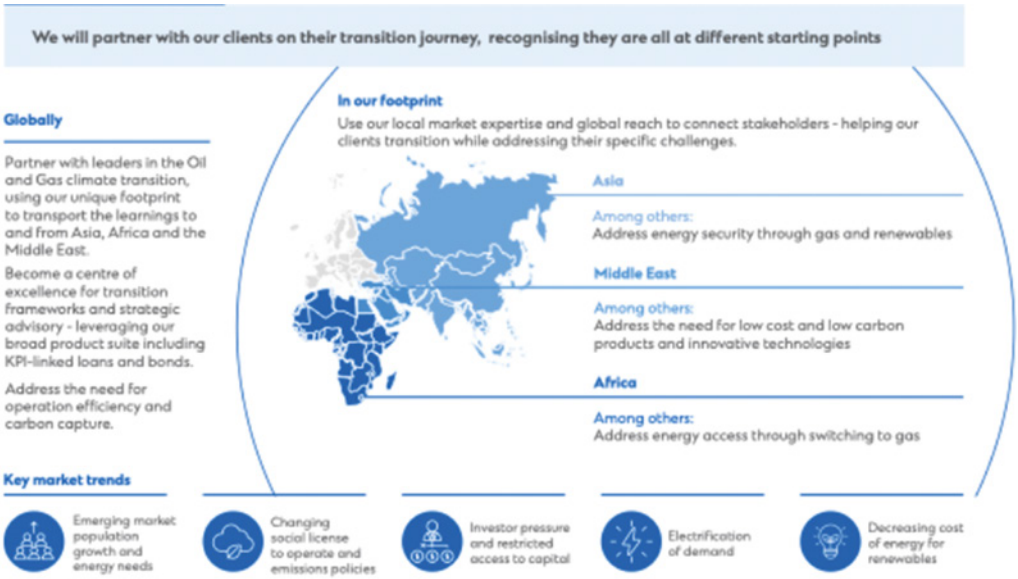
Our business is based on supporting the real economy. But continuing to finance traditional industries and technologies is not good enough. We have made great progress in green financing but must now turn our attention to financing transition activities. To accelerate the change, we continue to support clients in their transition to net zero by providing advice and capital to reduce emissions as fast as possible without slowing economic development. We will deploy our existing product suite (i.e. Sustainability Linked Loans, Bonds and Derivatives, Project Finance & ESG Advisory) and we will continually innovate to meet our collective challenge.

- For clients who share our ambition and are ready to act, we plan to mobilise USD300 billion to support green and transition finance by 2030.
- For clients who are just starting on their journey, we will provide sector-specific guidance on what our clients must do to prepare for a low carbon future, tailored region by region.
- For clients who haven't launched their climate transition effort yet, we are helping to identify the most relevant transition levers – ensuring our clients create climate transition plans aligned to our climate ambitions.

The Oil & Gas sector

Direct emissions (scope 1 and 2) generated by and for the Oil & Gas sector comprises ~10% of global CO_2 emissions. When combined with end uses in other sectors such as power and transport (i.e., scope 3) this is ~3 times as much as direct emissions. ~50% of the emissions from the sector are emitted in our footprint markets of Asia, Africa and, the Middle East.

To reach net zero carbon emissions from our financing by 2050, we are working on our short, medium, and long-term strategy to materially reduce our financed emissions from the O&G sector. We are doing so while acknowledging that the sector remains a critical enabler of economic development and employment.



Globally we partner with leaders in the Oil and Gas climate transition, using our unique footprint to transport the learnings to and from Asia, Africa, and the Middle East. We strive to become a centre of excellence for transition frameworks and strategic advisory - leveraging our broad product suite including KPI-linked loans and bonds.

Every client has a distinctive opportunity to participate in and accelerate the transition

Different markets, regions, and companies will transition at different speeds due to policy, access to technology, and capital.

- **International Oil Companies (IOCs) Publicly owned without government ties (~15% of O&G emissions)**

Experiencing extreme public and policy pressure; many have aggressive transition targets and will move at a significant scale and speed to transition.

- **National Oil Companies (NOCs) with ties to government (~55% of O&G emissions)**

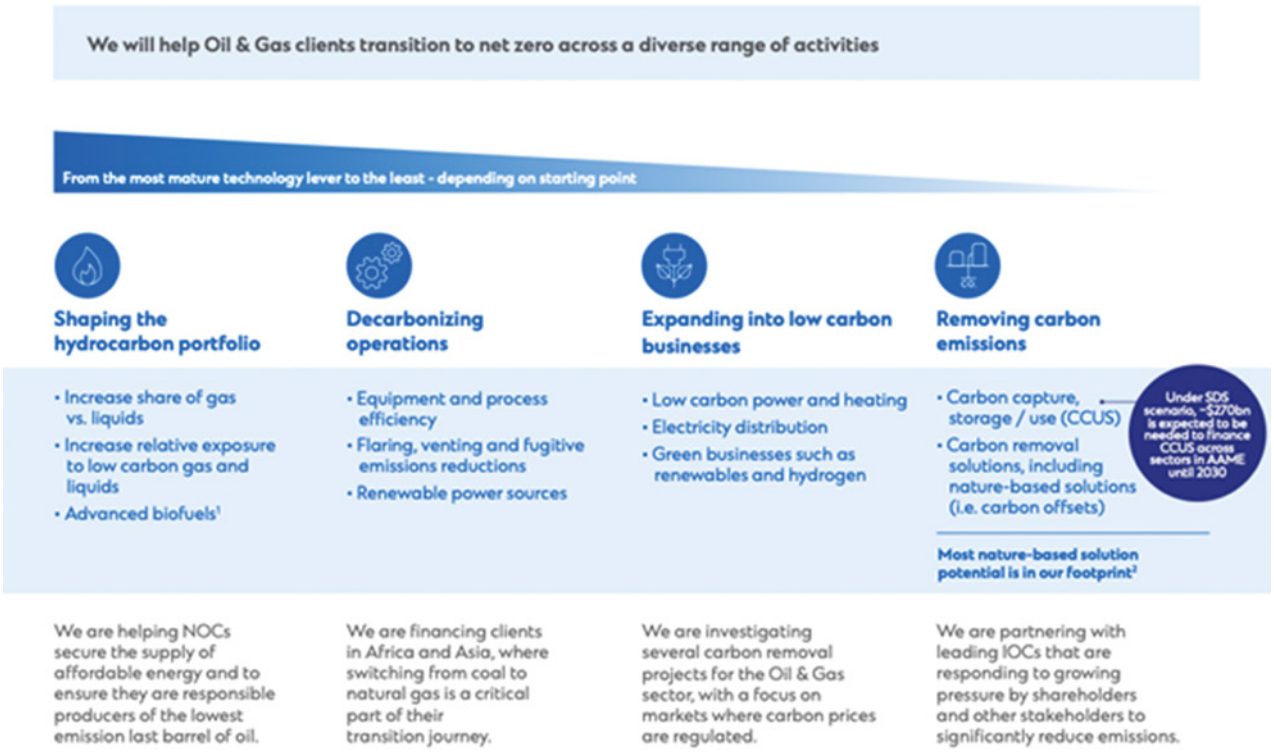
Experiencing medium public and policy pressure but must balance global climate goals in line with national agendas.

- **Small independents and mid-cap firms (~30% of O&G emissions)**

Dispersed along the value chain with varying public and policy pressures, depending on geography. Many are beginning their climate journeys in line with a broader agenda to drive energy access.

Conclusion

At Standard Chartered, we are constantly looking at what we stand for and finding better ways to work towards that. One of the things that is very important to us right now is helping our clients in their journey to net zero. As parents, consumers, and members of society, we all have something at stake. Thus, we are all committed to making the net zero transition successful.



While the world has woken up to net zero being an imperative, sometimes we find that businesses are uncertain about where to begin and what to do. That's where we come in. We can provide the support and advice that clients need to accelerate their net zero journeys.

Standard Chartered is here to support our clients and to enable them as they transition to net zero. However, that is not without conditions. For clients in our highest-emitting sectors, we have made it a condition of our financing that they must have a credible transition plan by the end of 2022. We are confident that those who do not yet have a plan, will because people are starting to realise that the need to decarbonise is a reality. Some companies simply need a roadmap. We're here to help.

Simon Cooper
CEO of Standard Chartered's Corporate, Commercial & Institutional Banking division and CEO of the Group's Europe & Americas region

Author

Simon is CEO of Standard Chartered's Corporate, Commercial & Institutional Banking division and CEO of the Group's Europe & Americas region. Based in Singapore, he is a member of the Group Management Team and Chair of the Group Diversity & Inclusion Council.

CCS Projects Underway at TotalEnergies

Policy, infrastructure

Article highlights

TotalEnergies is playing a leading role in major CO_2 transport and storage projects in Norway, Belgium, Netherlands, UK and Denmark as well as CO_2 capture its own industrial sites. TotalEnergies' CCS projects are designed to safely and permanently store CO_2 from natural gas processing and industrial processes to reduce atmospheric emissions. A key learning from these cutting edge projects is the need to develop projects at scale to significantly reduces the unit cost per tonne of CO_2 stored. There is a clear need for new ways of thinking and deep collaboration between industry, project developers and government to deliver CCS as an affordable solution for decarbonisation.

TotalEnergies' first Carbon Capture and Storage (CCS) projects are focused on Europe, driven by a favourable environment for scaling up CCS to an industrial scale. Business development continues in other parts of the world to prepare for the next wave of projects. TotalEnergies draws on its European experience, with the necessary adaptations to meet local needs. Today, TotalEnergies is leading major CO_2 transport and storage development projects in Europe: Northern Lights in Norway, the world's first commercial CCS chain; Antwerp@C in Belgium, one of the main CO_2 hubs in Europe; the Aramis and Azur projects in the Netherlands, which respectively involve CO_2 storage in depleted gas fields; and blue hydrogen production at our Zeeland refinery; and, finally, Northern Endurance Partnership in the United Kingdom, which aims to store CO_2 in a deep saline aquifer.

On the Norwegian coast, near Bergen, construction of a terminal to receive ships carrying CO_2 has begun. The ships will load their cargo of liquid CO_2 at a temperature of -25 ° C and a pressure of 1.8 MPa near Oslo and other European industrial zones. TotalEnergies, together with its partners Equinor and Shell (one-third each), has built the first commercial CO_2 transport and geological storage facility on this site. This project illustrates Norway's established confidence in CCS which dates back to 1996 when CO_2 was first injected into geological storage on the Norwegian continental shelf to reduce emissions from the Sleipner gas field. Similar technology was reused in 2008 to reduce emissions from the Snøhvit field, with TotalEnergies as a partner. These projects led to the implementation of a rigorous validation process for the selection of CO_2 geological storage sites to ensure sufficient storage capacity, tightness of the reservoir and injectivity of the CO_2 in the rock. The Sleipner and Snøhvit projects and others that have been in operation for many years (GCCSI, 2021) confirm CCS as a proven technology (Loria, 2021).

TotalEnergies has acquired extensive experience in these large-scale CCS projects.

Decarbonizing industrial and energy production sites

TotalEnergies' CCS projects are designed to safely and permanently store CO_2 emissions from natural gas processing and industrial processes. It has been established through the execution of various projects, the effect of scale significantly reduces the unit cost per tonne of CO_2 stored. This finding is illustrated by examining the following projects.

The Aramis project and CO_2

Aramis, a CO_2 logistics project developed in the Netherlands by TotalEnergies, together with Shell, Energy Beheer Nederland (EBN) and Gasunie, will

provide large-scale, flexible CO_2 transport services with open access to offshore CO_2 storage (Figure 1).

TotalEnergies participates in the entire CCS chain related to Aramis. On capture, it will produce blue hydrogen at its Zeeland refinery, a joint venture between TotalEnergies and Lukoil. The Dutch have an ambition to reduce emissions by 59% below 1990 levels by 2030, this will be achieved by setting the cost of CO_2 at 125 euros per tonne in 2030. Sixty percent (60%) of emissions at the Zeeland refinery come from the reforming of methane on H2 production units. An investment of approximately 250 million euros will reduce annual CO_2 emissions by 0.9 million tonnes per year.

Captured CO_2 will be transported by ship to a CO_2 hub located in the Maasvlakte industrial park in the port of Rotterdam from where it will be transported via a new offshore pipeline for injection into former offshore gas fields.

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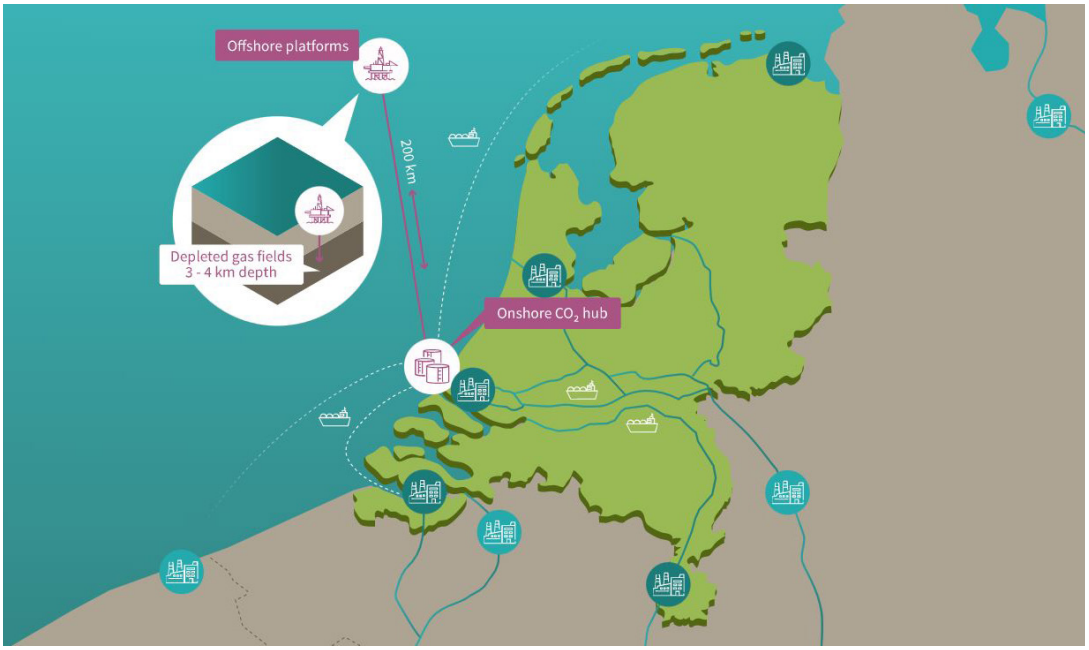

Figure 1: The CCS chain implemented in the Aramis project in the Netherlands (Aramis, 2021).

Captured CO_2 will be transported by ship to a CO_2 hub located in the Maasvlakte industrial park in the port of Rotterdam from where it will be transported via a new offshore pipeline for injection into former offshore gas fields.

The Aramis project aims to store 5 million tonnes per year initially, with the potential to store over 8 million tonnes per year by 2030. The depleted gas fields have an estimated storage capacity of 400 million tonnes of CO_2. The investment decision is expected in 2023, with the first injections starting in 2026 (see Figure 2).

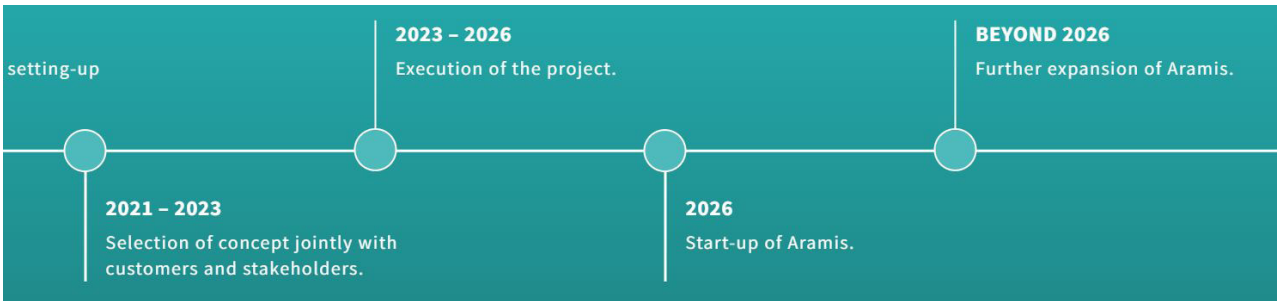

Figure 2: Aramis project implementation schedule (Aramis, 2021).

This project shows how important it is for emitters in the same basin to collaborate. In a similar way, TotalEnergies is studying the possibility of building other CO_2 hubs, in Antwerp (Antwerp@C, 2021) and Normandy (TotalEnergies, 2021). Together with Air Liquide, Borealis, Esso SAF and Yara International ASA for the Seine Axis and Air Liquide, BASF, Borealis, ExxonMobil, INEOS, Fluxys and the Port of Antwerp for Antwerp@C, TotalEnergies has decided to examine the technical and economic feasibility of developing joint CO_2 gathering infrastructures, building a CO_2 liquefaction plant and a site for the temporary storage of CO_2 before it is shipped by sea. These hubs could contribute to a reduction in CO_2 emissions by 2030 of up to 3 million tonnes per year for the Seine Axis and 9 million tonnes per year for Antwerp@C.

The CO_2 captured in these two projects will then be transported to offshore geological storage sites.

Northern Endurance Partnership (NEP)

A good example of our CCS strategy is the Teesside and Humberside region, which was selected (October 19, 2021) by the British authorities as one of the two regions that will be decarbonised by the middle of the 2020s. Although the eligible emitters will not be selected until later in 2022, the gathering and storage project has already been chosen: it is the Northern Endurance Partnership (NEP), which includes BP, Equinor, National Grid, Shell and TotalEnergies. It aims to offer a transport and storage service to emitters in the two industrial clusters of Teesside and Humberside, which are now grouped as the East Coast Cluster (see Figure 3). Two subsea pipelines will connect Humber and Teesside to the storage site, a saline aquifer. The initial development of this offshore project will require five subsea injection wells to be drilled.

In addition to the objective of decarbonising the industries in the East Coast Cluster, there is the possibility of new low carbon electricity generation from gas to compensate for the intermittency of renewable energy. An 860-megawatt (MW) Net Zero Teesside (NZT) power station will be the first commercially developed gas-fired power station in the UK to be equipped with a CO_2 capture system. NZT Power is today a cooperation between Equinor and BP, as operators.

The existing deep-water ports and rail links at both sites offer the potential to receive CO_2 transported by sea or rail in the future. By 2026, 4 million tonnes of CO_2 per year could be collected and stored, with the aim of reaching 10 million tonnes per year by 2030 with the arrival of other industries.

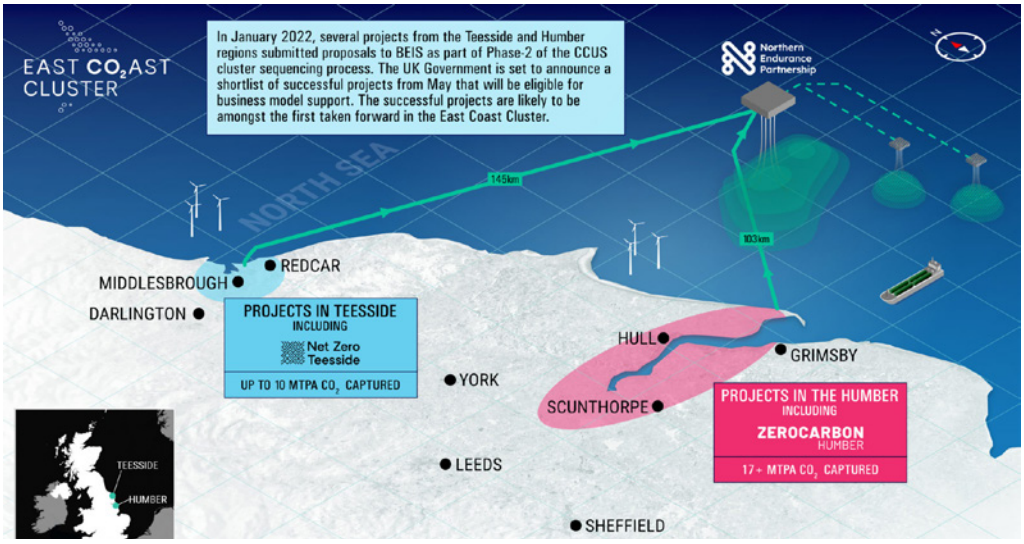

Figure 3: Schematic presentation of the concept behind the East Coast Cluster Net Zero project (Teesside, 2021).

The projects described above are still at the design and engineering stage. This is not the case for the Longship project or more accurately Northern Lights, the maritime transport and storage part, in Norway. This project is already in the construction phase of the installations.

The first commercial CCS chain: the Longship project in Norway

High investment and operational costs make it difficult for private players to invest in CCS without government support. The Longship project is the first commercial CCS project in the world. It owes its existence to strong support from the Norwegian government. Gassnova SF, a Norwegian state-owned CCS development company, coordinated the design studies. The studies recommended the formation of a new player that would offer a CO_2 transport and storage service to CO_2 emitters. This led to the formation of a consortium, and later a 50/50 joint venture, with Equinor, Shell and TotalEnergies. In the end, two Norwegian sites were selected for investments in new CO_2 capture facilities with a total capacity of 800,000 tonnes per year: Norcem's cement plant southwest of Oslo and the City of Oslo's Fortum incinerator (see Figure 4).

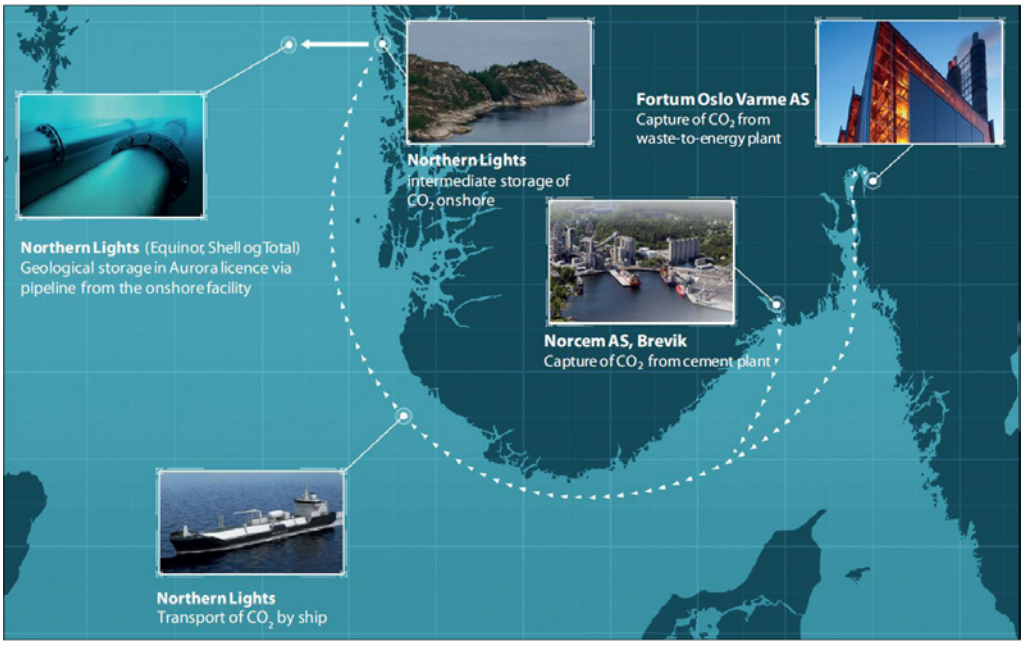

Figure 4: The Longship project in Norway (Norwegian Ministry of Petroleum and Energy, 2019-2020).

Northern Lights (see Figure 5), part of the Longship project, involves transporting CO_2 by ship and storing it. The ships will transport liquid CO_2 from the two terminals at the above-mentioned CO_2 capture sites to an intermediate storage facility (see Figure 6) located at Naturgassparken, about 750 km away on the west coast of Norway. These ships, which are in construction, will have a capacity of 7,500m3, making them the largest CO_2 transport ships in the world.

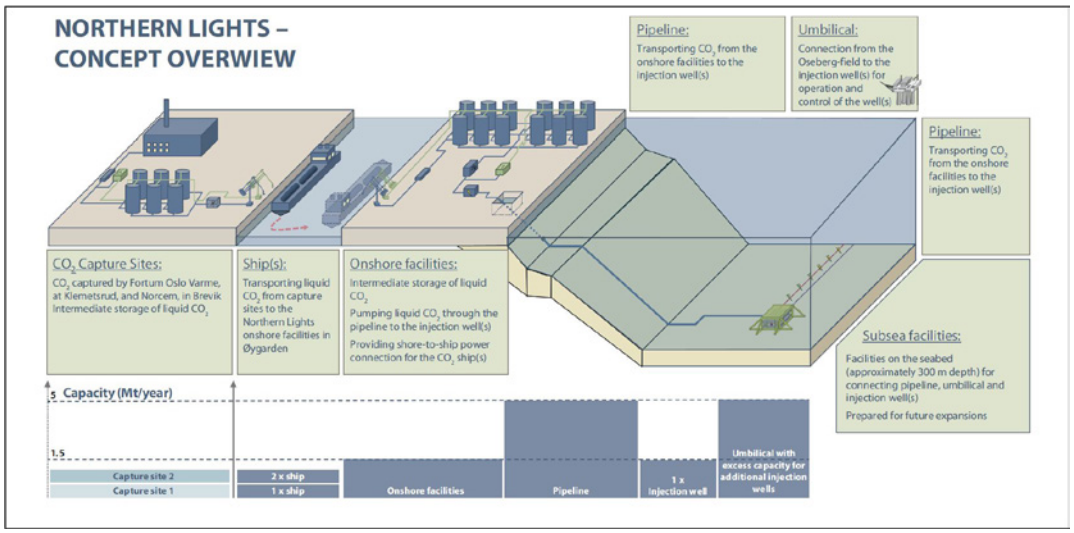

Figure 5: Schematic of the Northern Lights CCS chain (Norwegian Ministry of Petroleum and Energy, 2019-2020).

After arrival at the temporary storage site, CO_2 will be pumped through a 100 km long subsea pipeline before being injected via two subsea wells at a depth of 2800m and directly into the saline aquifer.

With 80% of the funding coming from the Norwegian government, it has the right to storage capacity for the two industrial sites.

Figure 6: Synthesis image of the storage site located on the Naturgassparken coast (Norwegian Ministry of Petroleum and Energy, 2019-2020).

The project is planned in several phases: the first will provide a storage capacity of up to 1.5 million tonnes of CO_2 per year by 2024. A second could increase this capacity to 5 million tonnes of CO_2 per year by 2030. This incremental capacity will require additional investment to expand the vessel fleet, extend onshore storage and drill new injection wells. The subsea pipeline is already oversized making additional injection possible.

Northern Lights is a pioneering project in Europe. Discussions are already well advanced with European emitters who are showing a growing interest in storing their residual CO_2 making storage one of the solutions for deep decarbonisation of industry. The increase in storage volumes will over time reduce the costs and an increase in the added value of low-carbon products may eventually mean that CCS is commercially viable without government support.

Public-private partnerships are emerging in many countries to define the most appropriate ways to launch and sustain the massive investments needed for decarbonisation. Similarly regulators and the CO_2 storage industry are working together to ensure that regulation is in place to achieve permanent storage of CO_2.

Conclusion: where will tomorrow's CCS projects be developed?

To enable faster development, we are building on the treatment of our own residual CO_2 emissions and scaling up our systems by accepting the emissions generated by third parties, particularly in the industrial hinterlands where we operate. This creates decarbonized regions where new industries can be set up, with residual CO_2 captured and transported to permanent geological storage sites. In addition to deep saline aquifers (whose water is unsuitable for consumption), we are converting depleted hydrocarbon fields into storage sites, thus enabling them to be reused within the framework of the decarbonised economy. Of course, these are collective actions which call for partnerships deeply rooted in the industrial territories.

Outside of Europe, TotalEnergies is working with its partners, including a number of National Oil and Gas Companies (NOCs) to develop geological storage capacity. When initiating a project the appetite of the host country for the development of CCS as a means of deep decarbonisation of industry is a key criteria for selection. Size is also a decisive criteria in the choice of our developments, especially outside of Europe and the US, in regions where the mechanics for CO_2 price discovery are yet to be put in place and new ways of thinking are required.

The growing scale and complexity of CCS projects mean that it is necessary to work with many partners: players in the technology sector, maritime transport, pipeline transport, CO_2 emitting industries, port and industrial areas, energy companies, etc.

The first CCS projects developed by TotalEnergies in Europe are a springboard for future CCS developments worldwide. CCS is a deep decarbonisation pathway that is one of the means of implementing the ambitions of governments, territories, industry and many civil society stakeholders to achieve the goal of "net zero emissions".

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David NEVICATO

Net Zero Emissions Regretless Policy of Taipower

Corporate strategy

Facing climate change and the domestic and overseas trend of net zero emissions, the demands of industries and the private sector for zero-carbon electricity are highly driven. Furthermore, in response to the significant growth and grid connection of green energy, the power department not only faces the challenges of its self-transformation but also plays a crucial part in the wave of reformation.

To implement net zero emissions of electricity, Taipower has formulated and actively promoted its net zero strategy comprising three major aspects of supply, power grid, and demand to assume the leading character for net zero measures nationwide in the hope of jointly creating the new prospect of net zero emissions in Taiwan with different sectors.

In recent years, discussions of climate change issues on the international stage have been growing vigorously. Driven by globalization, the effects of frequent industrial production and business trading activities in quantity on climate change shall not be underestimated. According to the report of the United Nations, net zero emissions shall be achieved by 2050 regarding the GHGs emissions during the current century to keep the increase in temperature of the century (2100) within 1.5° C, avoiding causing greater and unreversible destructions to earth.

At the COP26 in 2021, except for feverish discussions of net zero emissions by 2050 as well as discussions and establishment of the short-to-mid-term substantial targets by 2050, nations have also mentioned the decrease of global dioxide emissions by 45% from 2010 to 2030 to at least have a chance to achieve net zero emissions by 2050. The power department has also declared to "phase down" the coal-fired power generation without using CCS technologies to minimize the use of coal. Meanwhile, nations are urged to set a higher carbon dioxide reduction target for 2030 at the end of the year (COP27) and to examine the national determined contribution (NDC) each year instead of once every five years.

Taiwan's geographical environment is an island, and it adopts the independent power grid model. Under the backdrop of climate change, impacts on Taiwan in the future will be more intense; therefore, connecting to the international standards and actively initiating the net zero transition are challenges unavoidable for the government, departments, and Taipower Company. In light of the recent efforts of all departments under the government, NDC announced Taiwan's Pathway to Net-Zero Emissions in 2050 on March 30, 2022. Under the environmental evaluations, planning, and analysis for economic, technological, industrial, people's well-being, and social aspects, the power department will become the key role for net zero achievements in Taiwan. In particular, the core comprises three major planning indexes as follows:

- **1. Growing power demand:**

It is estimated that the power demand will grow at a CAGR of 2%±0.5% to 2050, and the final power consumption will fall approximately between 420 billion kWh to 570 billion kWh; that is, the power consumption will increase over 50% as compared to the present.

- **2. Zero carbon transition of the power structure:**

Renewable energy will account for 60% to 70%; in particular, offshore wind power will account for the major portion; hydrogenic energy, the emerging carbon-free energy, will account for 9% to 12 %; thermal power generating units + CCS

equipment will account for 20% to 27%.

• 3. Electrification of non-power departments:

Through electrification conversion of fossil fuel from the manufacturing department, transportation department, business department, and building department, the emissions will be transferred to the power department, and the power department will support the zero-carbon target of different departments through its net zero transition.

After understanding the role to be assumed by the power department in the future, the subsequent application and introduction of "technologies" by the Taipower Company will be of crucial importance. Based on the strategical structure of "from low-carbon to net-zero" promoted by the Ministry of Economic Affairs and the observation of the domestic and foreign technological development trends, it is generally recognized that 2030 will be the watershed regarding the matured application for net zero forward-looking technologies.

- During the stage from present to 2030, the preparation time we invest in developing forward-looking technology maturity will still focus on continuing to promote green energy, increase power generation by using gases, carbon dioxide reduction, and strengthening the grid connection scale and system tenacity of renewable energy and system tenacity based on the existing foundation of the energy transition; meanwhile, we will make early deployment for the R&D of forward-looking net-zero technologies.
- During the stage from 2030 to 2050, we will enter into the net zero transition stage that faces the maximum capacity for the grid connection of renewable energy, maturity of carbon-free power technologies, and the large-scale commercial introduction of hydrogenic energy, ammonia energy, biomass energy, CCS, geothermal energy, ocean energy, and other emerging technologies. For power grids, smart power grids, long-duration power storage, HVDC, and relevant new power grid technologies shall be introduced with a precondition to solving the intermittency of green power, the abandoning of wind power and solar power, and the insufficient system inertia.

Under the abovementioned development, we concluded that the major challenges of the power department in the future are the method to achieve the "zero carbon" status of power supply, the "application" of forward-looking technologies in the future, the way to guide other departments to reach "electrification" for their energy use, and the "strengthening" of the power grid system to jointly facilitate the adjustment stability, tenacity, and agility of the power system with the mass renewable energy grid connection. In light of the abovementioned challenges, Taipower Company also further organized its power net zero emissions strategical structure focusing on three major aspects of supply, power grid, and demand.

In terms of supply, the power generation structure adjustment through short-to-mid-term energy transition and carbon dioxide emissions reduction for expanding the scale of green energy and replacing gas energy with coal-fired generated energy will be the promotional focus before the maturity of emerging technologies. In the long run, we will introduce forward-looking technologies and promote hydrogen-enrichment combustion, ammonia-coal combustion, biomass energy, and other technological options through fuel replacement; subject to the feasibility of technologies; we will continue to develop combustion and introduction expansion to allow the transition of the traditional thermal power generation to achieve net zero emissions. During the year, we actively executed co-combustion technology MOU with leading global suppliers of technologies to initiate relevant demonstration projects. Our partners include Siemens AG from Germany (MOU executed in April) and Mitsubishi Company from Japan (MOU to be executed in November). Furthermore, for biomass energy, the initiation of the newly established power generation unit project at Taichung Power Plant and the existing coal-fired power generation unit modification project is under evaluation. Regarding the unreplaceable part of renewable energy and carbon-free fuel, we will introduce carbon fixation technologies. At present, we are establishing our carbon-dioxide reduction park at Taichung Power Plant in the hope of commencing various tests and demonstration and verification planning step by step and expanding the introduction of power plants and power generation units to complete the last mile to net zero carbon dioxide emissions.

In terms of power grids, in response to the power grid transition constructions for the mass renewable energy grid connection. First, create a friendly green power grid connection environment with the purpose of decarburization, make power grid resources available for sharing, and improve the grid connection capacity and

system tenacity through continuously reinforcing the power grid construction to realize the target of renewable energy maximization and domestic energy independence step by step. Second, in response to the peak/off-peak features and electrification trend of renewable energy, resource integration on the demand end shall be reinforced for adjustment; therefore, intelligence becomes a material promotion strategy for power grids. In recent years, we have been actively installing smart power grids and a great number of AMI smart meters to strengthen energy management services and improve energy use efficiency through the smart application of data and technologies to relieve the power supply pressure under the nighttime peak loading brought by renewable energy. In addition, for the intermittency issue caused by different solar power generation volumes during daytime and nighttime after the mass renewable energy grid connection, we plan to transfer the power to the peak hours of demand for use by way of energy storage. Except for installing energy storage systems, we will introduce energy storage resources in the private sector through the auxiliary service procurement and power transaction platform model. In the long run, we also plan to build new pump storage units, continue observing the development of renewable energy, introduce hydrogen production technologies in due course to achieve energy storage through hydrogen, and utilize surplus power from renewable energy to produce green hydrogen for the diversification of energy storage methods.

In terms of demand, we will mitigate power consumption demand and balance the changes in loading through demand management measures. For power-saving, we launched multiple power-saving measures ((including energy-saving and power consumption diagnosis, smart digital services, and Taipower APP) and combined more digital innovative tools of intelligence to allow users to control their power consumption management and, in turn, save energy and minimize power demand. Regarding the demand response, apart from the traditional incentive plan, we will observe the power consumption model of the industry and private sectors, re-design the rate for different periods and intervals for users to further adjust their power consumption habits and time (time belt differentiated rate); by doing so, we can adjust the changes in loading by adopting aspects and practices of the demand end to maintain the stable operation of power systems.

To summarize, as a state-owned business, the stable power supply has always been Taipower Company's mission. On the path of sustainable corporate development in the future, we will include power net zero emissions in our core values; meanwhile, in accordance with international trends and the net zero route promoted by the government, we will adopt substantial acts to provide crucial drivers for the net zero transition in Taiwan. We also expect to exert our influence to assume the leading character in the national power department and join hands with the industrial department and partners in social sectors to realize the net zero prospect for Taiwan.

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President Taiwan power Company

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Master of Electrical Engineering, National Cheng Kung University. Previously the Vice President and CEO of Distribution & Service Division of Taipower Company. Wang Yao-Ting has been working in the power system field for over 30 years and possesses extensive, professional, and practical experiences in the power grid department. He is leading Taipower to achieve the company's net zero target.

TCI Reaffirms its Sustainable Investments to Helps its Customers' Net Zero Pathways in 63 Countries

Renewable energy, net zero, corporate strategy

Abstract

On the Earth Day, April 22, 2022, we committed to a more ambitious climate goal: In addition to using 100% renewable energy by 2030, TCI aims to reduce the water intensity by 25% by 2030, achieve zero waste in production, and net zero carbon emissions by 2040.

TCI is an international contract development and manufacturing company (CDMO). The main products include supplements, functional foods and drinks, skin care products, personal products, medical devices, and pet health supplements, etc. Committed to the CDMO business model, TCI designs unique formulas for our brand customers through differentiated product design and R&D technology advantages. TCI has created unconventional products in the market to meet the needs of customers and end consumers and has sold these products to 63 countries worldwide.

"Businesses must live in the future. People shall manage the world's sustainability issues ahead of the major impacts from the accumulated problems." Only companies that live in the future can survive, and the "future" will only co-exist with sustainable development. Renewable energy transformation, increasing the use of recycled materials, and developing an unmanned intelligent factory are unstoppable trends. This is a very important strategy we always reaffirm the policies in the executive meetings.

TCI greatly invests in developing renewable energy as the first company in Taiwan to commit to RE100

In 2018, TCI became Taiwan's first company to join RE100, committing to 100% renewable energy by 2030. Presently, TCI continues to purchase Taiwan Renewable Energy Certificates (T-RECs), sign Renewable Energy Power Purchase Agreements (PPAs) with renewable energy providers, and build solar-powered systems for self-use. In the future, TCI plans to increase its renewable energy use rate by establishing its solar power plant as the main strategy. We are confident of reaching the goal of using 100% renewable energy by 2030.

TCI's Pingtung-based Precise Manufacturing Center has fully integrated the ISO 50001 energy management system since 2017. Solar power generation equipment was installed on the roof with a total capacity of 1,362.24kWh. With the strong sunshine of Southern Taiwan, the roof of TCI's factory can produce more than 1GWh per year. Considering the limitation of the factory roof, TCI also searches for space outside the factory to install renewable energy generation devices and expects to reach 50% of renewable energy usage by 2030. In the future, TCI plans to conserve natural resources close to the self-build power plant to create a natural positive renewable power plant. In the future, the space of the conservation park will be no less than the power plant. TCI

will also help contracted farmers to adopt environment-friendly farming methods to increase soil carbon sinks; thus, the implementation of achieving environmental goals can be assured.

Pledged to achieve zero-carbon emission: zero-carbon factories and zero-carbon products

In addition to RE100, TCI is also taking the lead in responding to international climate initiatives such as EP100 and SBTi by making commitments to energy efficiency and science-based reduction targets respectively.

TCI's carbon emissions target has been approved by SBTi (Science Based Targets initiative) and will follow the strictest 1.5° C pathway. The emissions target in Scope 1 and 2 will be gradually advocated with the use of renewable energy and the improvement of energy efficiency to reduce 51% absolute emissions by 2030. In Scope 3, TCI will reduce emissions from the "purchase of goods and services" through supplier screening and communication. The Scope 3 emissions target is to reduce by 15% by 2030 (2018 as the base year).

The four factories in the Pingtung Agricultural Biotechnology Park, as the benchmark of all other business sectors of TCI, have improved the energy efficiency and related emission reduction programs. In 2021, the S5 functional drink factory, S9 functional food factory, and S12 automated warehouse will carry out comprehensive energy-saving projects, such as automatic scheduling control for air conditioning, factory steam conversion, and cloud APP for process control...etc., The outcome from these implementations saved about 1.2 GWh of electricity in 2021. It is expected to further save nearly 4GWh in 2022.

In addition to achieving a zero-carbon factory, TCI joint hands with customers and the supply chain partners to develop zero-carbon health supplements and facial masks, from raw material procurement, production and manufacturing, production and delivery, consumer use, and waste disposal. Hence the life-cycle carbon footprint of TCI's products can be PAS 2060 carbon neutral certified. Not only does this enhance the beauty and health of the consumers, but also mitigates the impact on the climate.

Elevated Energy Productivity and Responded to EP100 Climate Initiative

To improve energy productivity, TCI joined the EP100 initiative in early 2019. The target is to implement a group-wide energy management system by 2026, and to improve energy productivity and energy use efficiency by 35% by 2040 (with 2016 as the base year).
In this regard, TCI continues to invest in energy efficiency projects and capital expenditures, including upgrading energy-efficient equipment; replacing LED lighting systems; installing smart meters and energy monitoring systems; and integrating cloud-based AI computing to achieve a more comprehensive energy management.
On the Earth Day, April 22, 2022, the Company set a more ambitious climate goal: In addition to using 100% renewable energy by 2030, TCI aims to reduce the water intensity by 25% by 2030; achieve zero waste in production; and net zero carbon emissions by 2040.

Next Step for Sustainability: develop biological carbon sink, optimize the intelligent factory, and purchase more renewable energy

TCI has now implemented automated production lines for many product categories, from filling to packaging, with unmanned production. With the command from the MES production management systems, the automatic warehouse releases and allocates the material onto the automated guided vehicle (AGV). The AGV automatically transports the raw materials and products to designated areas, which not only ensures the cleanliness of the entire area, but also ensures the health and safety of the consumers. With the automated process, we can also schedule production at night, without excluding daytime shipment; thus, which could speed up the production efficiency of drinks and powder sachets. This efficiency improvement shortens the production lead time to 28 days potentially, increasing the value of production and reducing the intensity of electricity consumption.

Since 2019, TCI has been working with Sunny Founder on the public welfare green energy

projects – installing solar panels on the rooftops of long-term care centers and the non-profit organization for people with disabilities. The T-RECs issued by the solar power generated are then bought back from social welfare units under long-term contracts, realizing both renewable energy and social welfare. This long-term green energy contract will generate nearly NT$4 million in revenue to support the operation of social welfare organizations and reduce carbon emissions.

In addition, TCI has also participated in renewable energy trading in Taiwan in 2019. After the amendment of the Renewable Energy Development Act, TCI has publicly signed a renewable energy power purchase agreement with the provider, Mr. Watt, and become one of the first companies in Taiwan to complete a renewable energy purchase. In the future, TCI to search for more partners for public welfare green energy, such as fishery and electricity symbiosis solar power projects, hoping to achieve a win-win situation for both ecology and green energy. TCI believes that sustainability is how a company elevates its position in the market. We will continue to implement diversified sustainability strategies, including factory construction and product design, and encourage our suppliers to commit to sustainability and net zero emissions. We are confident that TCI will continue to receive recognition from international supplement and personal care brands in Europe and the United States, and obtain international orders, proving that sustainability can be the key driver for a corporate's operation and profit.

Yung-Hsiang Lin
The Chairman of TCI CO., LTD.

Author

The Chairman of TCI CO., LTD. Mr. Yung-Hsiang Lin has been dedicated to Biotech innovations for more than 20 years. He invented the world-class exclusive bio-resource data mining system, created high-efficacy health supplements and medical device products that were sold in 63 countries. Mr. Yung-Hsiang Lin leads TCI's Net Zero Pathway by 2040 and shows his strong belief in corporate sustainability bringing both business and blessings.

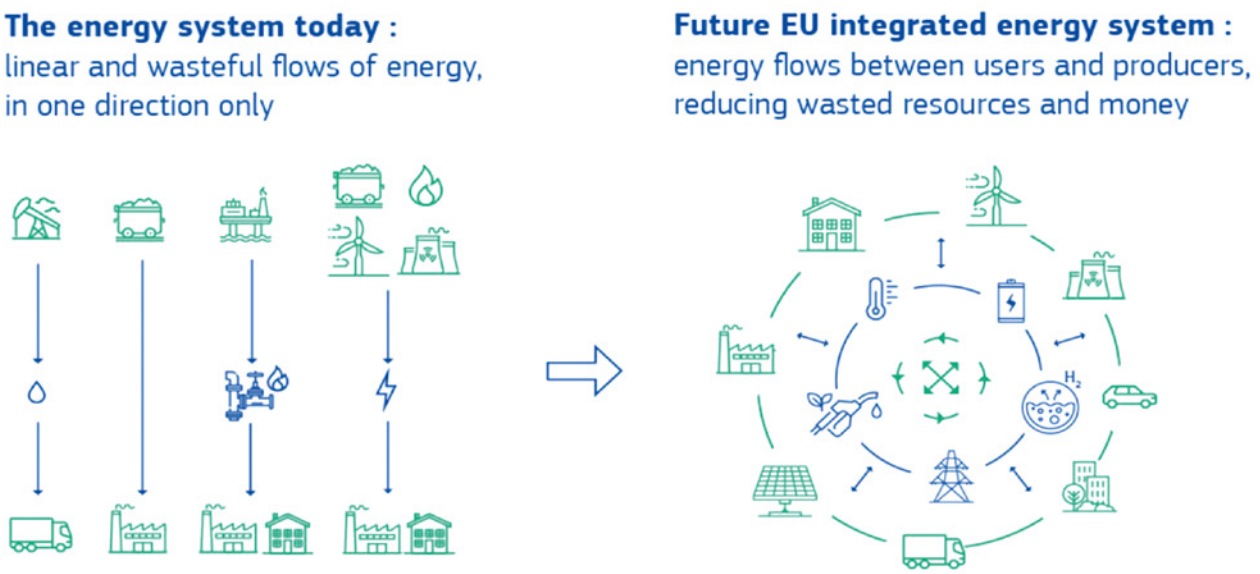
Chapter.3

The High Profile Solution - Hydrogen Energy Applications and Development

Europe's Policy and Current Status in Promoting Hydrogen Energy Development

EU Hydrogen Energy Development Policy

The European Commission announced the European Green Deal at the end of 2019, which incorporates climate change and environmental challenges into its policies and sets out corresponding actions, intending to achieve a 50% to 55% carbon reduction target by 2030 and zero greenhouse gas emissions by 2050. In the EU Energy System Integration Strategy and the EU Hydrogen Strategy, published by the European Commission in July 2020, hydrogen plays an important role in the integration of the EU energy system and the future of the cyclic energy system, as one of the foundations of the future decarbonization of the European energy system. Furthermore, since it can be used as a raw material, fuel or energy carrier and energy storage, and can be used in a wide range of industrial, transport, power and building sectors, hydrogen can be used as a clean energy alternative in areas where electrification is challenging to achieve, among the three main directions mentioned in the New Energy Systems Integration Strategy. In addition to developing policies and guidelines on hydrogen, the EU also supports many hydrogen development projects and initiatives, the key being the European Clean Hydrogen Alliance, which was established in July of the same year. The Alliance was announced in March 2020 as part of the European Industrial Strategy Guidelines and launched on July 8 of the same year in parallel with the EU's Hydrogen Strategy Guidelines to combine resources, expand the investment pipeline for hydrogen production and build the hydrogen industry chain through the Alliance.



Source: EU strategy on energy system integration

In addition, the specially developed Hydrogen Energy Strategy plans to support the decarbonization process in industry, transportation and energy production through renewable hydrogen (also known as green hydrogen) produced from wind and solar energy in an integrated energy systems, which consists of three phases:

(1) Phase 1 (2020 to 2024):

Install at least 6 million kilowatt regenerative hydrogen electrolysis plants and produce up to 1 million tons of regenerative hydrogen in the EU.

(2) Phase 2 (2025 to 2030):

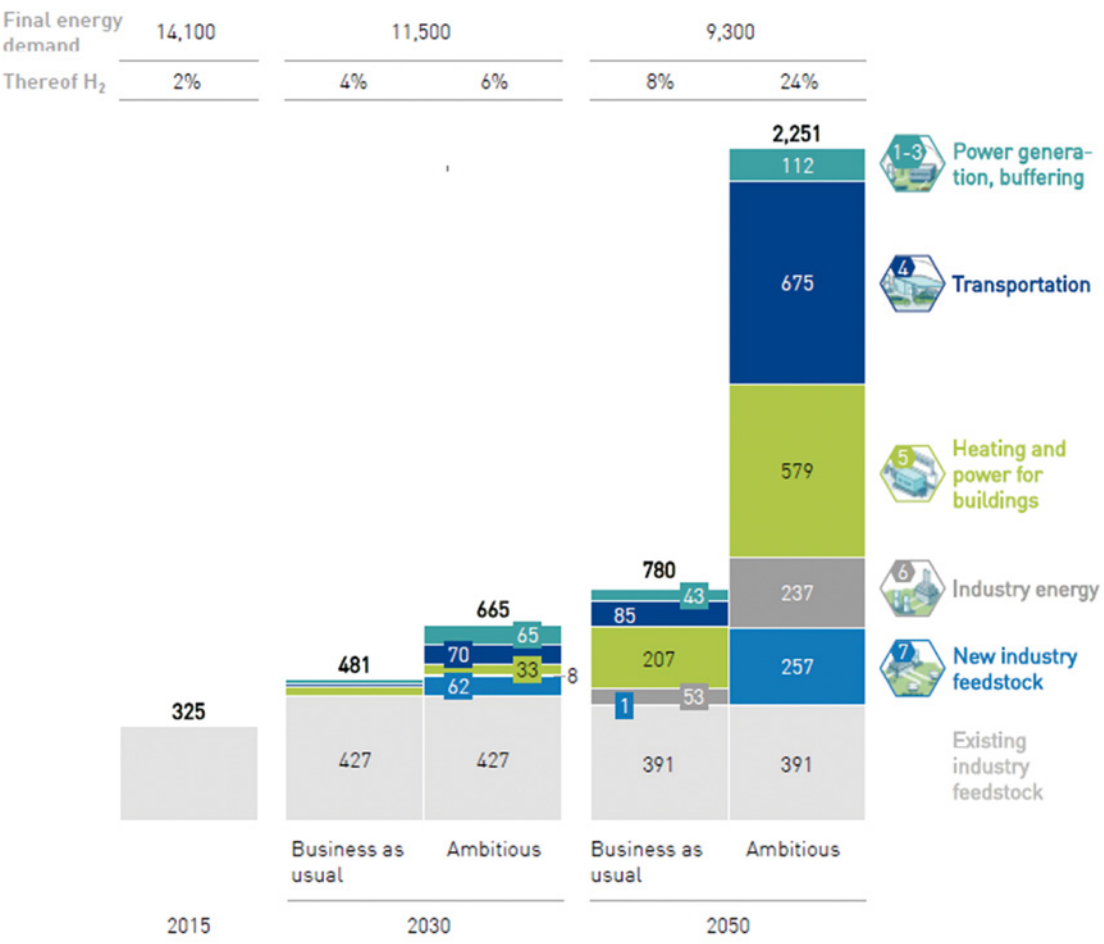
To install 40 megawatt regenerative hydrogen generators and produce up to 10 million tons of regenerative hydrogen in the EU by 2030. In addition, the establishment of regional hydrogen production centers called "Hydrogen Valleys," dedicated hydrogen infrastructures that not only balance hydrogen for industry and transport with electricity, but also provide thermal energy for residential and commercial buildings, and that serve as the framework for the future European regional hydrogen energy network. The goal of the EU at this stage is to create an open and competitive EU hydrogen market, where cross-border transactions are unimpeded and hydrogen supply is efficiently distributed across sectors.

(3) Phase 3 (2030 to 2050):

Renewable hydrogen technologies should be mature and capable of large-scale application in hard-to-decarbonized sectors, from aviation and shipping to hard-to-decarbonize industries and commercial buildings. Renewable hydrogen is expected to meet 24% (or 2,250 TWh) of the total energy demand in the EU by 2050.

EXHIBIT 2: HYDROGEN COULD PROVIDE UP TO 24% OF TOTAL ENERGY DEMAND, OR UP TO ~2,250 TWH OF ENERGY IN THE EU BY 2050

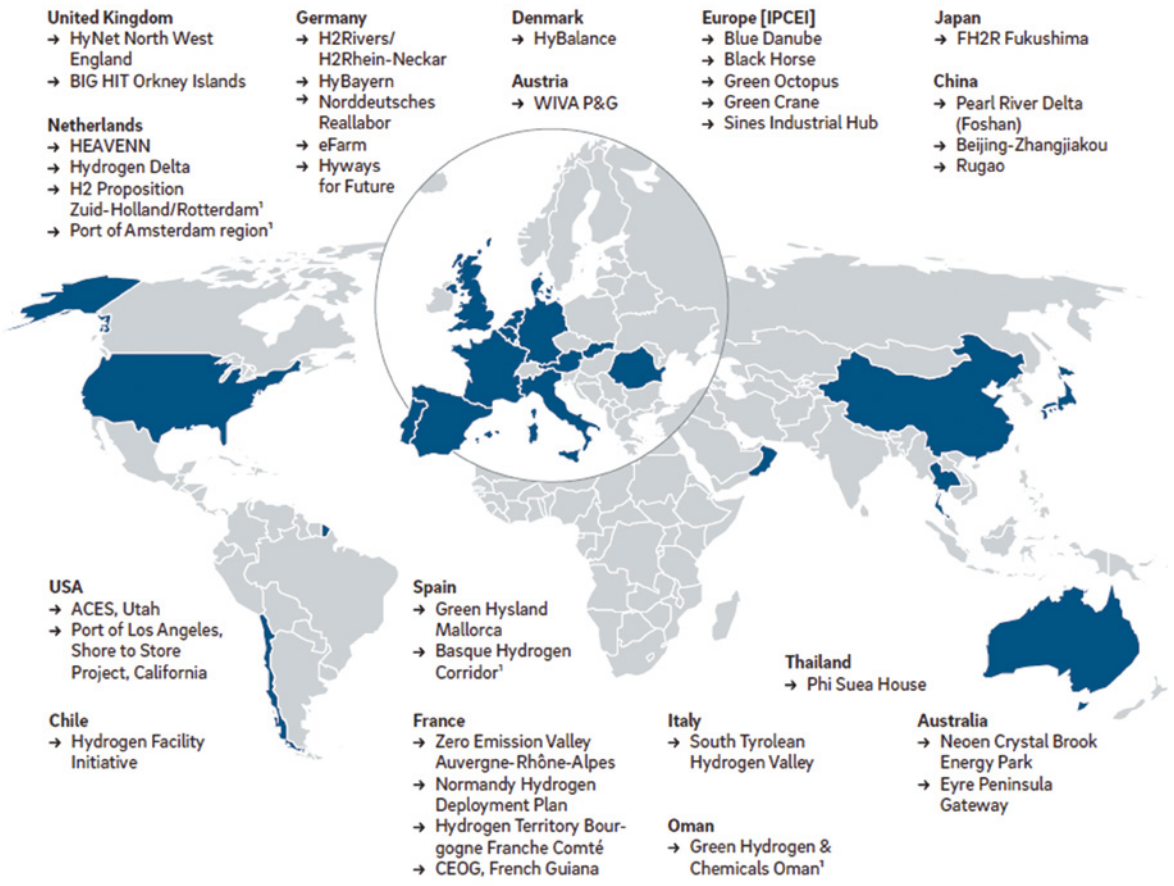
TWh



[1] According to the Hydrogen Energy Strategy, renewable hydrogen refers to hydrogen produced by water electrolysis (in an electrolysis tank, driven by electricity) from renewable energy sources. Renewable hydrogen has near-zero greenhouse gas emissions over its entire life cycle and can also be produced through the conversion of biogas (rather than natural gas) or biomass.

In each of these phases, the Hydrogen Valley is a regional hub for hydrogen production as a critical project for the development of a new hydrogen economy, linking production, transportation and various end-uses. At the same time, the European Union has established the Mission Innovation Hydrogen Valley Platform to promote the development of the Hydrogen Valley by creating a global platform for information flow and cooperation on large-scale hydrogen projects.

C: Hydrogen Valleys on the Mission Innovation Hydrogen Valley Platform (as of May 31, 2021)



Current Developments

While the EU's hydrogen energy strategy presents investment opportunities and development, it also poses significant challenges. In addition to technological breakthroughs, cost is an essential factor in the expansion and spread of hydrogen energy. The International Energy Agency estimates that the current price of green hydrogen is between €3.5 and €5.0 per kilogram, which is much higher than the €1.5 per kilogram of grey hydrogen, and therefore is not competitive in the market today and for some time to come, and will require long-term investment. As a result, it is expected that the EU will need to make long-term, large-scale investments in renewable energy plants to produce hydrogen in order to meet the goals set by the EU.

According to the Hydrogen Council, a business group, and McKinsey & Company, a management consulting firm, more than half of the world's announced hydrogen projects are focused on Europe, and the most significant hydrogen-related investments are expected to occur in Europe over the next decade, including the manufacture of green hydrogen and hydrogen from fossil fuels with carbon capture technology. In addition, according to a report released by the Hydrogen Energy Council, if all plans are realized, global investment in hydrogen energy will exceed $300 billion over the next decade, accounting for about 1.4% of total energy industry investment, with Europe accounting for about 45% of that investment.

The European investment agenda for hydrogen energy is as follows:

Item / Year	2020	2021
Investment Agenda	Through the European Clean Hydrogen Alliance, develop an investment agenda to stimulate the roll out of production and use of hydrogen and build a concrete pipeline of projects (by end of 2020)	Support strategic investments in clean hydrogen in the context of the Commission's recovery plan, in particular through the Strategic European Investment Window of InvestEU (from 2021).

Increasing Demand and Expanding Production	Propose measures to facilitate the use of hydrogen and its derivatives in the transport sector in the Commission's upcoming Sustainable and Smart Mobility Strategy, and in related policy initiatives (2020)	• Work to introduce a common low-carbon threshold/ standard for the promotion of hydrogen production installations based on their full life-cycle GHG performance (by June 2021). • Work to introduce a comprehensive terminology and European-wide criteria for the certification of renewable and low-carbon hydrogen (by June 2021). • Develop a pilot scheme – preferably at the EU level – for a Carbon Contracts for Difference programme, notably to support the production of low carbon, circular steel, and basic chemicals.
Designing a Supporting Framework	n/a	• Start the planning of hydrogen infrastructure, including in the Trans-European Networks for Energy and Transport and the Ten-Year Network Development Plans (TYNDPs) (2021) taking into account also the planning of a network of fuelling stations • Accelerate the deployment of various refuelling infrastructure in the revision of the Alternative Fuels Infrastructure Directive and the revision of the Regulation on the Trans-European Transport Network (2021). • Design enabling market rules to the deployment of hydrogen, including removing barriers for efficient hydrogen infrastructure development and ensure access to liquid markets for hydrogen producers and customers and the integrity of the internal gas market, through the upcoming legislative reviews (2021).
Facilitating Hydrogen Technology Research and Innovation	• Launch a 100 MW electrolyser and a Green Airports and Ports call for proposals as part of the European Green Deal call under Horizon 2020 (Q3 2020) • Steer the development of crucial pilot projects that support Hydrogen value chains, in coordination with the SET Plan (from 2020 onwards). • Facilitate the demonstration of innovative hydrogen-based technologies by launching calls for proposals under the ETS Innovation Fund.	Establish the proposed Clean Hydrogen Partnership, focusing on renewable hydrogen production, storage, transport, distribution and critical components for priority end-uses of clean hydrogen at a competitive price (2021).
International Oriented	• Strengthen EU leadership in international fora for technical standards, regulations and definitions on hydrogen. • Promote cooperation with Southern and Eastern Neighbourhood partners and Energy Community countries, notably Ukraine on renewable electricity and hydrogen. • Set out a cooperative process on renewable hydrogen with the African Union in the Africa-Europe Green Energy Initiative framework. • Develop a benchmark for euro denominated transactions by 2021.	n/a

Global Hydrogen Energy Technology and Market Development

• Hydrogen Energy Related Regulations Inventory

Many countries are already focusing on the development of hydrogen energy, and most advanced developing countries have introduced hydrogen energy policies. The International Energy Agency predicts that global demand for hydrogen will reach 520 million tons by 2070. As an essential measure to address climate change and accelerate energy transformation, more and more economies are placing greater emphasis on developing the hydrogen energy industry. According to a recent report by the International Hydrogen Energy Council, 131 large-scale hydrogen energy development projects have been launched worldwide since February 2021, and global investment in hydrogen energy is expected to reach $500 billion by 2030. The World Energy Council estimates that hydrogen could account for up to 25% of global end-use energy consumption by 2050.

Cross-border hydrogen collaboration among energy, chemical, and manufacturing companies is booming.

As a result, hydrogen fuel cell vehicles have been introduced to the market, and there has been a boom in the development of hydrogen-powered trains, ships, trucks, and other emerging vehicles. For example, Hyundai Motor in Korea has invested approximately 7.6 trillion won ($6.4 billion) in hydrogen-related R&D and facility expansions. In addition, in July 2021, Hyundai Motor announced a partnership with Hyundai Electric Energy Systems to develop hydrogen fuel cell packages for mobile generators and alternative marine power supply solutions.

In 2019, Australia released its National Hydrogen Strategy, which outlines 57 action plans to build hydrogen energy hubs, create industry demand by the 2025 milestone, and become a significant global hydrogen economy by 2030. On the supply side, Australia will focus on enhancing hydrogen production technologies and efficiency, and strengthening hydrogen supply through liquefaction, pure hydrogen pipelines or underground storage technologies, while on the demand side, there are three main categories of consumer products such as hydrogen refueling stations, hydrogen-powered vehicles or synthetic fuels for aviation and marine use, industrial products such as retrofitting equipment with hydrogen input holes, and infrastructure such as strengthening hydrogen power grids in remote areas. The Australian government is committed to investing in developing hydrogen power stations, hydrogen-powered vehicles and synthetic fuels for aviation and shipping. In terms of funding, the Australian Government is investing $300 million in the Hydrogen Jumpstart Fund, which will be used specifically to finance hydrogen energy projects, and the Australian Renewable Energy Agency is administering a $70 million Renewable Hydrogen Energy Construction Fundraising Program for alternative energy solutions of 10MW or more. In July 2020, the European Union released the EU Hydrogen Energy Strategy, which plans to increase the share of hydrogen in the energy mix to 12-14% by 2050. It outlines a comprehensive investment plan that includes the entire industrial chain of hydrogen production, storage and transport, as well as investment in existing natural gas infrastructure, carbon capture and storage technologies, and proposes to strengthen further R&D and technological innovation (mainly to develop hydrogen produced from solar and wind energy) and promote international cooperation in hydrogen energy. According to France's National Hydrogen Energy Strategy, the country will build and install hydroelectric devices on a large scale, develop the electrolysis industry, and promote the use of hydrogen fuel cells in transportation, among others. The country plans to have 6.5GW of electrolysis tank capacity by 2030, producing 600,000 tons of green hydrogen and reducing CO_2 emissions by 6 million tons. In June 2021, the US announced its "Hydrogen Energy Earth Initiative," which proposes to reduce the cost of green hydrogen by 80% from the current $5 per kilogram to $1 per kilogram within 10 years, and the US Department of Energy announced $52.5 million in funding for 31 hydrogen-related projects. Korea has enacted the world's first Hydrogen Economy and Hydrogen Safety Management Act in recent years, laying the legal foundation for the government's commitment to hydrogen energy and the implementation of facility safety standards, providing a more transparent mechanism for Korea's hydrogen pricing system. Japan has also formulated policies focusing on hydrogen energy applications, hydrogen transportation and hydrogen production, as well as measures to achieve its goals; Singapore announced a $36 million low-carbon energy research grant program in 2020 to support research and development of hydrogen energy and other low-carbon technologies; Chile released its national green hydrogen strategy in November 2020, intending to produce the world's cheapest green hydrogen by 2030 and become one of the world's top three hydrogen exporters by 2040. In July 2021, the Egyptian government issued a statement urging the development of a comprehensive national hydrogen development strategy to empower Egypt's hydrogen production and utilization capabilities and integrate green hydrogen into the country's integrated energy system.

According to the International Energy Agency (IEA), as the costs of renewable energy sources such as solar and wind energy decreases and economies of scale emerge from electrolytic tanks, green hydrogen from renewable energy sources will become more competitive in terms of cost by 2030, and market recognition is expected to increase further. However, the hydrogen industry is still in its infancy and faces many challenges, including the lack of scale in infrastructure, the high cost of low-carbon hydrogen, the immaturity of the application industry clusters, and the lack of perfect policies and regulations. The current state of development of the hydrogen industry shows that the production and use of low-carbon hydrogen needs to be stimulated by countries through various means, together with strategic investment and financial incentives. An increasing number of economies have set targets for hydrogen refueling stations. As of February 2021, Europe has 200 hydrogen refueling stations in commercial

operation. Germany has already built about 100 of them, and plans to build 400 by 2023. France is aiming for 400 to 1,000 hydrogen refueling stations by 2028.

Many economies are strengthening their bilateral partnerships to ensure stable supply partnerships and promote the formation of a global hydrogen supply chain. The European Commission is committed to strengthening innovative cooperation between European and African partners in sustainable development, including the hydrogen-focused Euro-African Green Energy Initiative (EAGEI), which signed a framework agreement with the Port of Rotterdam in the Netherlands to export green hydrogen to the Netherlands and Europe as a whole. Masdar City Government in UAE, Siemens Energy, Marubeni Corporation and other companies have reached an agreement to establish a demonstration plant for hydrogen production in the city. In addition, Germany and Saudi Arabia will cooperate closely in the production, processing, application and transportation of green hydrogen.

The United Nations Industrial Development Organization has also launched a Global Partnership for Industrial Hydrogen Applications to promote hydrogen solutions worldwide in recent years. The partnership aims to promote strategic dialogue and enhance the exchange and cooperation on policies, technologies and standards.

- **Hydrogen Energy Regulatory Restrictions and Advancements**

On the domestic front, although the Taiwan government has not yet enacted regulations or explicit policies on hydrogen energy, it has been actively working towards this project. The Taiwan Institute of Economic Research (TIER) and the Taiwan Hydrogen and Fuel Cell Coalition (THFCP) have actively cooperated with many countries that are more advanced in developing hydrogen energy to hold forums and even sign memoranda or agreements. The following table shows the countries and initiatives THFCP has taken in recent years to promote hydrogen energy in Taiwan.

Partner Countries	Actions
Germany	On May 28, 2021, the THFCP promoted and discussed Taiwan's products and technologies to the State of North Rhine in Germany and 30 German industry and economic promotion units at the Taiwan-Germany Hydrogen Energy Exchange Video Conference on issues related to hydrogen energy and fuel cells in Taiwan. Furthermore, on August 10, 2021, the Energy Bureau of the Ministry of Economic Affairs and the German Institute Taipei jointly organized the 2021 Taiwan-Germany Energy Transition Forum, which not only focused on the exchange of experiences related to energy transition between the two sides, but also discussed issues related to hydrogen energy.
UK	At the Taiwan-UK Hydrogen Forum held on October 21, 2021, the Taiwan Hydrogen and Fuel Cell Alliance and the Scottish Hydrogen and Fuel Cell Association signed a Memorandum of Understanding to deepen the exchange between Taiwan and the UK on hydrogen technology and applications, and to discuss how the hydrogen and fuel cell industries in Taiwan and the UK can work together in depth on a bilateral scale, as well as to explore opportunities for cooperation in third countries such as India and Malaysia.
Canada	The Canada-Taiwan Low Carbon Emissions - Hydrogen and Fuel Cells (HFC) Forum, held on January 18, 2022, brought together Canadian and Taiwanese leaders in the hydrogen fuel cell industry to discuss bilateral cooperation to achieve the goal of net zero carbon emissions by 2050. In addition, Taiwan and Canada signed a memorandum of understanding at the forum, aiming to establish an exchange and cooperation platform between industry, government, academia and research, and to promote cooperation and development in the hydrogen energy and fuel cell technology field between Taiwan and Canada.

In addition, the Ministry of Science and Technology (MOST) has recently launched the "National Net Zero Technology Action Plan," which focuses on the layout of emerging technologies required for energy saving and carbon reduction after 2030. To achieve this goal, we expect to invest approximately $41.5 billion in low-carbon and carbon-negative technologies through 2030, with significant investments in hydrogen energy, energy storage devices and smart grids.

The following table shows the status of hydrogen energy promotion in other regions.

Region	Country	Actions
Europe	EU	The European Clean Hydrogen Alliance plans to establish at least 40GW of renewable hydroelectric plants by 2030, with hydrogen production from renewable electricity (e.g. wind and solar) and low-carbon hydrogen from fossil fuels as a supplement to create a complete hydrogen value chain in Europe. As a result, clean hydrogen is expected to meet 24% of global energy demand by 2050, with annual sales estimated at nearly €630 billion and 1 million jobs in the European hydrogen value chain.
	UK	The UK's National Hydrogen Strategy proposes that by 2030, the UK is expected to have 5GW of hydrogen production capacity to replace natural gas and power 3 million UK homes, making it a global leader in hydrogen energy; by 2050, between 20% and 35% of the UK's energy consumption will come from hydrogen, which is expected to be well above the global average of 10%.
Asia	South Korea	In August 2018, the Korean government designated the hydrogen energy industry as one of the three strategic investment areas for innovation and growth. In January 2019, the Korean government released the "Roadmap for the Development of the Hydrogen Energy Economy," which focuses on hydrogen fuel cell vehicles and fuel cells, hydrogen fuel cell vehicles, hydrogen refueling stations, hydrogen power generation, hydrogen gas production, storage and transportation, and safety regulation, and is expected to create 43 trillion won in annual added value and 420,000 jobs by 2040, and to make Korea the world's leading country in hydrogen energy economy with the highest international market share of hydrogen fuel cell vehicles and fuel cells.
	Japan	As Japan has almost no energy resources, it attaches great importance to the use of hydrogen energy. Therefore, it expects to occupy the top of the hydrogen energy industry chain and become an exporter of hydrogen energy in the future, and proposes to be the first to realize a "hydrogen society" in the world, offering a "Basic Strategy for Hydrogen Energy" and a "Hydrogen Energy Utilization Progress Chart" in 2017 and 2019 respectively, with the following two main goals: to reduce the price of hydrogen fuel cell vehicles to the same level as hybrid vehicles by 2025; to build 900 hydrogen refueling stations by 2030 to commercialize hydrogen power generation, and to continuously reduce the cost of hydrogen supply so that it can compete with conventional energy prices.
North America	US	In November 2019, the Fuel Cell and Hydrogen Energy Association (FCHEA) released "A Roadmap for the US Hydrogen Economy - Reducing Emissions and Driving Hydrogen Growth Across the US," which outlines a roadmap for "building cross-market and application partnerships for long-term global energy technology leadership" from an industry perspective. The US Department of Energy plans to spend $8 billion to establish regional hydrogen energy centers to expand the use of hydrogen in industry, and another $1 billion to reduce the cost of producing hydrogen from renewable energy sources, and $500 million to support the production of hydrogen energy equipment and create a domestic supply chain. By 2050, hydrogen demand is expected to reach 63 million tons, contributing $750 billion in annual revenue, providing 3.4 million jobs, and meeting 14% of US end-use energy demand. Externally, it expects to export technology to regions such as Europe, China, Japan, Korea, and Australia that are looking to develop hydrogen energy infrastructure to maintain the US position as a global energy leader.

Hydrogen Energy Technology Investment

As hydrogen technology is still in its infancy, there is less investment in hydrogen technology than in other familiar renewable energy sources globally. Only the European public sector has invested more money in hydrogen technology to promote hydrogen development and stimulate private investment in hydrogen technology. In general, investment in hydrogen technology can be based on investment in renewable energy. Therefore, in this section, we will start with the general financing practices for renewable energy to illustrate the financing options available for hydrogen technologies, and then introduce the current status of investment in hydrogen technologies.

- **Introduction to Related Financial Support Programs**

Funding

Financing for renewable energy projects comes from a combination of indirect financing (debt) and direct financing (equity), just as it does for general corporate finance. Indirect financing can take the form of loans or bonds; direct financing can take the form of pure equity or quasi-equity (e.g., secondary bonds, mezzanine financing, among others). The following are some of the most common types of direct financing and indirect financing.

Direct financing is a way to raise funds by selling or leasing property or providing services.
1. Private Placement
2. Public offerings of stock
3. Asset securitization
4. Yield Companies (Yield Co.)
5. Crowd fundraising

Indirect financing refers to the supply and demand of funds through financial intermediaries such as banks to reach financing transactions.
1. Bank financing
2. Leasing

Introduction to Green Bonds

In addition, renewable energy projects can be financed in a different way than ordinary businesses, such as by issuing green bonds. A "Green Bond" is a bond whose purpose is to finance a low-carbon environmental or green economy investment project, where the issuer commits to use the funds raised for the purpose of financing a green economy investment project, and is labelled as "green" by the issuer. The difference between the bonds and ordinary bonds is that the funds must be used for "green" investment projects with positive environmental benefits.

1.Principles of Green Bond Issuance

Green bonds are voluntary commitments by bond issuers to use bond funds; therefore, there are currently no mandatory standards or legal requirements governing them. The most widely recognized standard is the International Capital Market Association (ICMA), which, in cooperation with major international financial institutions, introduced the Green Bond Principles (GBP) in 2014. The funds raised are divided into 10 uses.

i. Renewable Energy
ii. Energy Upgrading
iii. Pollution Prevention and Control
iv. Environmental Sustainability Management of Biological and Land Resources
v. Land and Water Biodiversity Conservation
vi. Clean Transportation
vii. Sustainable Water Resources and Wastewater Management
viii. Climate Change Adaptation
ix. Eco-efficient and circular economy products, production technologies and processes
x. Green Buildings

2. Overview of Green Bond Issuance in Taiwan

The initial issuance of Taiwan's green bonds began on April 21, 2017, when the Securities and Exchange Commission (SEC) released the "Green Bond Guidelines" and on May 19, 2017, the first batch of Taiwan's green bonds were successfully listed and issued by four banks, including KGI Bank, SinoPac Bank, Chinatrust Bank, and Yushan Bank, with a total issuance amount of NT$5.17 billion. CPC issued the first green corporate bond in Taiwan. After evaluation, CPC selected two projects, including the "Taichung Plant Phase II Investment Plan of the Natural Gas Division" and the "Third Liquefied Natural Gas Receiving Station Investment Plan," and issued a 10-year green bond of NT$2.8 billion on September 20, 2017 under the green project category of "greenhouse gas reduction," making it the first green bond issued by a production company in Taiwan.

In order to establish a more complete over-the-counter trading system for sustainable development bonds, on April 29, 2021, the OTC announced and implemented the "Sustainable Development Bond Practice Guidelines," which consolidates the "Green Bond Practice Guidelines" and "Sustainable Development Bond Practice Guidelines," and adds new socially responsible bond qualifications and related regulations. According to the "Sustainable Development Bond Practice Guidelines," the scope of sustainable development bonds includes green bonds, social responsibility bonds and sustainable development bonds that the OTC approves.

Since the issuance of green bonds in Taiwan in 2017, Taiwan Power has issued green bonds every year, and as of May 9, 2022, it has issued a total of $43.85 billion in green bonds, and the total amount of green bonds expected to be issued in mid-June is $47.05 billion, making it the largest issuer of green bonds in Taiwan.

• Current Status of Hydrogen Energy Technology Investment

Hydrogen Energy Industry Market Investment

Currently, there are relatively few investments related to the hydrogen industry and hydrogen technology. Most existing financing is either government funding or joint public and private investment. Most of these funds are used for the development of the hydrogen industry and hydrogen technology, and the following is an overview of hydrogen financing in each country.

1. US

In November 2021, the US passed a $1.2 trillion bipartisan infrastructure bill that will see the Department of Energy spend $8 billion to establish regional hydrogen energy centers to expand the use of hydrogen in industry, another $1 billion to reduce the cost of producing hydrogen from renewable sources, and $500 million to support hydrogen equipment production and build the US domestic supply chain.

2. Canada

Canada's hydrogen energy strategy builds

on existing policies, such as the Healthy Environment and Healthy Economy strategy, which proposes a $1.5 billion Low and Zero Emission Fuel Fund and nearly $300 million in incentives for the purchase of zero-emission vehicles, to build an entire green economy and clean energy environment and to promote the development of the hydrogen industry. In addition, on June 9, 2021, the federal government, the Province of Alberta and Canadian company Air Products announced a $1.3 billion investment in a world-class liquid hydrogen manufacturing plant that is expected to be operational by 2024. In addition, the federal government and Alberta announced in June 2021 that they will invest $9.2 million in the "Electrification of Alberta's Zero Emission Trucks" to develop hydrogen and electric hybrid trucks and $2.3 million in hydrogen refueling stations to transform the low-carbon economy.

3. UK

In February 2020, the UK's Department for Business, Energy and Industrial Strategy (BEIS) announced a comprehensive £90 million programme, of which £28 million is dedicated to the development of hydrogen energy projects, including the construction of two of the largest low-carbon hydrogen power plants ever built in Europe. One of these is HyNet, a project coordinated by Progressive Energy Limited, in partnership with Johnson Matthey, SNC Lavalin and Essar Oil, to develop a hydrogen production facility in the UK's first net-zero industrial estate using carbon capture and storage technology. From 2025, the HyNet project will build new infrastructure while upgrading and reusing infrastructure currently engaged in the production of fossil fuels to produce, store and distribute hydrogen energy in the northwest of England and North Wales by using the most advanced technologies. The hydrogen produced at the plant will be used at the nearby Unilever site and at the Greengate glass plant in Pilkington - which will be the first time hydrogen has been used in a global glass manufacturing plant. In addition, in October 2021, the Chancellor of the Exchequer confirmed in his 2021 Budget and Spending Review that the UK Government plans to spend £240 million between 2022 and 2025 on the Net Zero Hydrogen Fund (NZHF) to support the commercial deployment of new low carbon hydrogen projects, with a target of 5GW of hydrogen energy production by 2030.

4. Germany

There is already a precedent for public funding of hydrogen technology in Germany. In the area of industrial hydrogen energy, the German Federal Ministry of Education and Research has provided more than 60 million euros in funding for the "Carbon2Chem" project, which will investigate how to use industrial gases generated in the production of steel to make primary products that can be used for fuel, plastics or fertilizers. The German steel industry is expected to emit 20 million tons of CO_2 per year in the future, which means that 10% of the annual CO_2 emissions from German manufacturing and industry can be used. The project is expected to receive more than 100 million euros in funding by 2025.

5. Czech

There is no specific investment mechanism for hydrogen technology in the Czech Republic, but there are already some examples of cooperation to support such projects. For example, in 2019, the regional governments of Usti and Labem as well as UNPETROL, a.s. (a PKN Orlen Group company) brought together 17 public and private institutions to sign a memorandum of cooperation on the development and use of hydrogen energy, an initiative aimed at supporting the use of hydrogen energy in local industry.

6. Italy

SNAM S.p.A. (SNAM) launched the SNAMTEC program in 2019 with the aim of improving energy efficiency, reducing pollutant gas emissions and fostering technological innovation in the energy sector. The SNAMTEC project consists of a one-month trial in Campania, which introduced a 5% hydrogen quota into the energy mix and demonstrated that even a tiny amount of hydrogen in the energy mix can significantly reduce CO_2 emissions.

Hydrogen Vehicle Market Investment

Organizations and companies around the world are currently working to find funding for hydrogen technology for the automotive industry. Two EU-funded research projects (H2ME1 and H2ME2) are known to be aimed at increasing the number of hydrogen fueling stations in the EU by 49 and over 1,400 cars, trucks and trucks by 2022. With budgets of €70 million and €100 million respectively, the EU Vision 2020 program has invested a total of €67 million in these two projects, which will run until May 2020 and June 2022 respectively. These research projects include more than 40 partners from nine countries and the transport, hydrogen and energy sectors, including Audi, BMW, Engie, H2 MOBILITY, Hyundai, Michelin, OMV and Renault.

Air Liquide and TotalEnergies Partner to Develop Low-Carbon Hydrogen Production in the Normandy Industrial Basin

#Hydrogen, #Energy Transition, #CCS, #Low Carbon Aviation
#Low Carbon Transportation#Net Zero, #Carbon Neutrality

Hydrogen is at the heart of the energy transition and clean transport revolution. As a precursor of hydrogen transition, Air Liquide has been using its existing industrial facilities, technologies and expertise, collaborating with visionary partners to develop low carbon hydrogen production and applications worldwide, in particular for the transportation sector. This article showcases pioneering projects on carbon capture and storage (CCS) and several practical hydrogen applications on aviation, helping to prepare airports for the coming hydrogen era.

Air Liquide and TotalEnergies partner to decarbonize hydrogen production at TotalEnergies' Normandy platform in France. This project will enable in time the supply to TotalEnergies by Air Liquide of low-carbon hydrogen by relying on Air Liquide's hydrogen network in Normandy and the implementation of a large-scale CO_2 capture and storage solution (CCS). In line with the objective of both companies to reach carbon neutrality by 2050, this ambitious project is part of a sustainable development approach which will help develop a low-carbon hydrogen ecosystem in the "Axe Seine/Normandy", progressively supported by technologies such as CCS and electrolysis.

Reducing Carbon Emissions

Under a long-term contract agreement, Air Liquide will take over and operate the 255 tons-per-day hydrogen production unit at the TotalEnergies platform in Normandy. Connecting the unit to Air Liquide's hydrogen network will enable it to optimize its performance and, ultimately, develop the world's first low-carbon hydrogen network. The network already includes a hydrogen production facility in Port-Jérôme equipped with Air Liquide's CryocapTM carbon capture solution since 2015. Air Liquide is considering adding a large-scale unit to produce renewable hydrogen via electrolysis.

In addition, the companies will launch development studies to deploy a carbon capture and storage (CCS) project to decarbonize the hydrogen produced in this unit at the Normandy platform. Air Liquide would install its Cryocap™ process to capture CO_2, while TotalEnergies would handle transportation and storage of the captured CO_2, notably through the Northern Lights (Norway) and Aramis (Netherlands) CCS projects being developed in the North Sea.
In the long term, the implementation of these projects would reduce the carbon emissions from the unit's hydrogen production by approximately 650,000 tons of CO_2 per year by 2030.Hydrogen, a New Era for Aviation

Aviation is responsible for 2% of CO_2 emissions and is at the heart of ecological issues. For aircraft as well as for airports, hydrogen could help cut emissions by 50% by 2050. Present across the entire hydrogen value chain, Air Liquide is using its technical and industrial expertise in hydrogen to help decarbonize aviation from the ground to the air.

Hydrogen can be used for many applications in and around the airport

Low-carbon hydrogen is produced in gaseous form, particularly by using renewable energies for water electrolysis, as is already the case at Air Liquide's Bécancour site in Quebec. The numerous pipelines deployed by Air Liquide will soon mean that it can be transported in large quantities to a liquefier located near each airport. Thanks to its expertise spanning more than 50 years in the aerospace industry and extreme cryogenics, Air Liquide can use its experience in liquid hydrogen to serve airport ecosystems. Once liquefied, it is transferred to storage containers. Trucks can then fill up their tanks and carry out logistics, such as refueling on the tarmac.

The airport ecosystem

Once available at the airport, liquefied hydrogen is used for many purposes, including ground logistics: baggage tractors, forklifts, pods, super tugs, shuttle buses, etc. For example, at Seoul-Incheon International Airport, Air Liquide provides recharging stations for airport vehicle fleets with filling times of under 5 minutes. The environmental impact of all these vehicles is considerably reduced by using hydrogen to power them. Finally, thanks to high-performance trucks capable of storing up to 300 liters of liquid hydrogen, refueling can be done directly on the tarmac in a few minutes. One of the Group's projects is the winner of the AMI "H2 Hub Airport" to develop an airport hydrogen industry.

Aboard the aircraft

Aboard the aircraft, hydrogen can be used to power all the flight and communication systems in the cockpit, while ensuring passenger comfort by powering lighting, heating and all on-board services, including catering and refrigeration. In the future, it could be used for propulsion – either by direct combustion or by powering a fuel cell. When used in fuel cells, hydrogen combines with oxygen from the air to produce electricity with only water as a byproduct. The first hydrogen-powered commercial aircraft has been announced by Airbus for 2035. To best prepare for its arrival and contribute to the emergence of an innovative and strategic French sector, Air Liquide has partnered with Airbus and the ADP Group in June 2021.

With an already well-established presence in many business areas, Air Liquide is ideally positioned to develop synergies between mobility applications. This is in large part thanks to infrastructure that serves the entire airport infrastructure: taxi stands, bus terminals and train stations for local or long-distance transportation. This complementarity of infrastructure uses is a major lever for making low-carbon hydrogen accessible.

Air Liquide, Airbus and Groupe ADP partner to prepare Paris airports for the hydrogen era

Air Liquide, Airbus and Groupe ADP have partners to prepare for the arrival of hydrogen in airports by 2035 as part of the development of hydrogen-powered commercial aircraft. The partners will leverage their respective expertise to support the decarbonization of the aviation industry and to define the concrete needs and opportunities that hydrogen can bring to the aeronautics sector. This partnership reflects the 3 partners' shared ambition to contribute to the emergence of an innovative and strategic French sector dedicated to achieving climate-neutral aviation worldwide.

To prepare for the arrival of the first hydrogen-powered commercial aircraft by 2035, airports will need to be adapted, in particular, to include the specificity of liquid hydrogen supply. The partnership announcement focuses on carrying out feasibility studies aimed at developing this infrastructure.

As a first step, a study involving a representative panel of around 30 airports worldwide will be launched to assess potential configurations for liquid hydrogen production, supply and distribution. Detailed scenarios and plans will then be drawn up for the two main Paris airports: Paris-Charles de Gaulle and Paris-Orly. These scenarios will be essential in defining the required infrastructure, including scope and location, and in identifying and integrating the constraints relative to both industrial and aviation safety standards.

This partnership brings together complementary expertise with the ambition to support the transformation of airports and pave the way for a new era of sustainable air travel.

Case Study: Hydrogen for Incheon International Airport

Incheon Airport T2 Hydrogen Refueling Station, jointly invested by Air Liquide, Hyundai Motor Company, and Hydrogen Energy Network (also known as'HyNet'), equipped with Air Liquide technology was completed in 2021. This was a key milestone as it commemorated the commissioning of the 100th hydrogen refueling station across 68 sites in Korea.

For the Airport T2 Hydrogen refueling station, Air Liquide supplied the high-capacity hydrogen refueling station equipment. The Group will also be the hydrogen molecule supplier under a long-term contract. Hyundai Motor will provide new hydrogen buses along with after-sales services. HyNet will operate the station which will primarily serve hydrogen buses but will also be used for fuel cell passenger cars, in line with the government plan to considerably densify the network of hydrogen stations in the country.

With a capacity of delivering 1 tonne of hydrogen per day, this station is at least 4 times larger than the existing hydrogen stations on the Korean market today. On average, it is able to serve 40 buses or 180 passenger cars per day. Leveraging on Air Liquide's most recent technology, it will allow two buses to fill simultaneously as well as passenger cars consecutively with limited waiting time for efficient peak time management.

The introduction of the hydrogen station is in line with the strategy of Incheon International Airport Corporation, which strives to become the Northeast Asia air logistics hub, and promotes itself as an eco-friendly international airport. As such, Incheon International Airport Corporation will also gradually upgrade its current fleet of shuttle buses with hydrogen buses.

Case Study: Air Liquide, Airbus, Incheon Airport and Korean Air Partner to Prepare the Use of Hydrogen in the Decarbonization of the Aviation Sector in Korea

Air Liquide, Airbus, Korean Air and Incheon International Airport Corporation partners to explore the use of hydrogen at Incheon International Airport. More globally, the collaboration will also study the development of Korean airport infrastructure to support the deployment of hydrogen-powered commercial aircrafts. This partnership reflects a shared ambition to drive the emergence of an innovative aviation sector dedicated to supporting the Korean government's goal of carbon neutrality by 2050.

The four partners will prepare a roadmap to first develop hydrogen usage at and around Incheon Airport, and build scenarios to support the

deployment of hydrogen ecosystems connected to other Korean airports. As a second step, the partnership focuses on carrying out studies aimed at defining and developing the required liquid infrastructure at Incheon Airport to prepare for the arrival of the first hydrogen-powered aircraft.

Each partner will leverage their complementary expertise to help define the potential opportunities that hydrogen offers, and support the decarbonization of the aviation industry. Air Liquide will bring its extensive expertise in mastering the entire hydrogen value chain (production, liquefaction, storage and distribution), in particular liquid hydrogen supply. Airbus will provide characteristics of hydrogen-powered aircraft ground operations as well as aircraft characteristics and fleet energy usage, while Korean Air will provide expertise on ground aircraft operations and aviation management and operations. Finally, Incheon International Airport Corporation will provide an airport development plan outlook, along with air traffic characteristics and distribution among terminals, starting with Incheon International Airport, one of the largest and busiest airports in the world.

Through this partnership, Air Liquide will leverage its strong local footprint to accelerate the deployment of hydrogen solutions in South Korea.

Author

Air Liquide is a world leader in gases, technologies and services for Industry and Health. It is present in 75 countries with approximately 66,400 employees and serves more than 3.8 million customers and patients. Air Liquide has been rooted in Taiwan since 1987 with more than 40 production facilities and service locations islandwide to support its customers in diverse industries through innovative and unique blend of products, equipment and services.

Bosch Aspires to Be a Beacon of Sustainability

Technology

BOSCH
Invented for life

Bosch sees it as its strategic imperative to find technological responses to societal and ecological challenges. As early as 2020, Bosch became the first industrial enterprise to be carbon neutral at its locations worldwide. Currently, the company is striving to reduce carbon emissions along the value chain. With this attitude, Bosch characterizes its product portfolio towards sustainability, from shaping the hydrogen economy, driving mobility transformation, to making industrial technology more efficient.

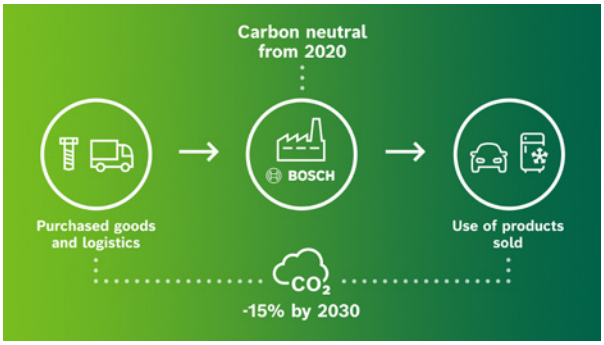
Bosch aspires to be a beacon of sustainability

For the Bosch Group, sustainable, ecological, and socially responsible action is the foundation for our success in business. This attitude characterizes the entire company and is reflected in our actions at all levels: Bosch aspires to be a pioneer in climate action and has anchored this aspiration in its sustainability vision. As a technology company, Bosch sees it as our strategic imperative to find technological responses to societal and ecological challenges. This is what we mean by "Invented for life," and we are driving the development and application of a broad range of technologies to help us deliver on this claim.

Bosch: a climate action pioneer

Climate change is one of the biggest challenges facing humanity: stopping it is a task for society as a whole. At Bosch, we started our climate actions early on and have marked significant milestones. Bosch has become carbon neutral (Scope 1 and 2) since February 2020, with more than 400 locations worldwide, Taiwan included. The achievement has made Bosch the first globally operating industrial enterprise to reach such a lofty goal. Such accomplishments in climate action have won recognition outside the company as well: the non-profit Carbon Disclosure Project (CDP) has added Bosch to its prestigious A List in 2021.

To Bosch, achieving carbon neutrality is the result of strategic planning and systematic approaches. In the course of reducing carbon emissions, four levers have been applied at Bosch: increasing energy efficiency, expanding renewable energy supply, procuring green electricity, and offsetting unavoidable carbon emissions. However, we believe that the first two levers will be key to improving the quality of carbon neutrality in the long term as the share of electricity consumption and carbon offsets reduce overtime. In line with the global strategy, Bosch Taiwan replaced conventional light bulbs with energy-efficient LED light bulbs to reduce emissions while offsetting inevitable carbon footprints.



Picture 1: Bosch is striving to reduce emissions along the value chains by 15 percent by 2030

The next milestone: climate action across the entire value chain

As proud as we are to achieve carbon neutrality at our locations worldwide, we do not see it as the end of the road for our climate action efforts. While we continue to improve existing measures, we are now going beyond our immediate sphere of influence and actively tackling our Scope 3 emissions: we are working to reduce emissions generated along our value chains, upstream and downstream, and during the entire life cycle of our products, by 15 percent before the end of this decade. This is, in fact, an ambitious goal: in terms of volume, it amounts to 67 million metric tons. The target was certified by the Science Based Target initiative (SBTi) in 2020. That makes Bosch the world's first automotive supplier to reach "Targets set" status in the SBTi. To accomplish this goal, we have identified three activities that generate by far the most Scope 3 emissions: purchased goods and services, upstream and downstream transport and logistics, and product use.

To further reduce carbon emissions from purchased goods and services, we seek to engage in close dialogue with our global supplier network. In 2020, we identified the supplier groups with the largest purchasing volumes and the largest carbon emissions. Later, we contacted suppliers directly to obtain real data on their carbon emissions. For this purpose, we used the platform provided by the Carbon Disclosure Project (CDP) as well as our own queries. Furthermore, we set up the new "Sustainability" category for our "Global Supplier Award" in 2021 to encourage activities mitigating climate impact. When awarding procurement contracts, CO emissions are to be taken into account as one of the criteria.

As logistics connect nods along the value chain, in the field of logistics, Bosch emphasizes transportation, with a focus on procurement optimization in the product creation process and large-scale production, as well as avoiding air transportation. We also focus on the consistent application of the total cost of ownership (TCO) approach, which factors in key cost components such as freight costs or customs duties. The proximity of potential suppliers to our sites is therefore an important selection criterion. In this way, we are optimizing the number of transports and their capacity utilization and keeping carbon emissions as low as possible.

Bosch products are already designed to be energy efficient that can help mitigate global warming during their use. In 2020, we recognized additional potential areas for further reducing carbon emissions during the use of products. We are working in three directions that go hand-in-hand with one another: transforming the energy, shaping the product portfolio, and further increasing energy efficiency.

Picture 2: Bosch is pushing to establish a hydrogen economy and has made heavy upfront investment in its development

Transforming the energy sector: pioneering in hydrogen economy

On the path to a climate-neutral future, Bosch is devoted to making it possible for energy- intensive industries to shift to renewables. Therefore, Bosch is pushing to establish a hydrogen economy and has made a heavy upfront investment in its development. Today, Bosch offers the technology needed for hydrogen use in various sectors, from fuel cells for mobile and stationary applications, hydrogen filling stations with compressors, to hydrogen produced in our own plants. In May 2022, Bosch further announced to enter the electrolyzer components business. Bosch is getting hydrogen-based technologies out of the

laboratory and into industrial practice onto the roads and into factories.

Bosch is the market leader in powertrain technology, and fuel cells further broaden Bosch's footprint. Fuel cells have attained the technological maturity required for broad use. They are the favored option for heavier loads and longer distances. Powered by green hydrogen, hydrogen produced with renewable energy, a fuel-cell powertrain generates zero local emissions and is climate-neutral. Bosch is working to prepare the fuel-cell stack and fuel-cell system for volume production. Between 2021 and 2024, Bosch will have invested one billion euros in the mobile fuel cell. A joint venture with the Chinese premium commercial-vehicle manufacturer Qingling for fuel-cell systems in China was launched in April 2021. In addition, a major order for electric air compressors with integrated power electronics (EACs) from cellcentric, the joint venture between Daimler Truck and Volvo; Bosch air compressors to be used in cellcentric fuel-cell systems from the middle of the decade.

Picture 3: Bosch has put a micro power plant based on solid-oxide fuel cells (SOFC) into operation at Bamberg's central bus station since 2021

With an overall efficiency of more than 85 percent, stationary fuel cells based on solid-oxide fuel cell (SOFC) technology have a major role to play in the transition to alternative energy. They can be used flexibly at the point of electricity consumption to precisely meet demand. One use that Bosch has planned for solid-oxide fuel cells is as distributed, connected power plants, which can then be used in cities, factories, trade, commerce, data centers, and marine applications. Bosch estimates that the market for decentralized power generation will reach a volume of 20 billion euros by 2030. By the start of large-scale production, which is planned for 2024, Bosch will have invested over 500 million euros in the development and pre-commercialization of stationary fuel- cell systems. Pilot plants are already in operation at several Bosch sites in Germany. In fact, Bosch's first commercial plant-developed together with the municipal utility Stadtwerke Bamberg - has been in operation since 2021 at the city's central bus station.

Green hydrogen will play an essential part in meeting climate targets. In light of energy diversification, the move away from fossil fuels, and the need to reduce carbon emissions, demand for green hydrogen is growing rapidly-not only in energy-intensive industries such as steel, chemicals, and heavy-duty freightbut also in private real estate. This is why Bosch is planning not only to use hydrogen but also to participate in its production. We are branching out into the development of components for electrolyzers, which use electrolysis to split water into hydrogen and oxygen. Bosch is collaborating with a number of partners to develop a way of combining the electrolyzer stack with a control unit, power electronics, and various sensors to create a "smart module". These compact modules are combinable and can be easily integrated for use in small units with a capacity of up to ten megawatts and in gigawatt-rated plants in either onshore or offshore settings.

Picture 4: Bosch has a broad product portfolio of electromobility

Shaping the product portfolio: contribution to the mobility transformation

We firmly believe that the mobility of the future should have no negative repercussions in terms of global warming, and it should remain affordable for most people. With our product range, we are making an important contribution in this respect while pursuing a holistic approach at the same time. Bosch currently invests over 800 million euros a year in electrification, resulting in growth in electromobility at a rate twice as high as the market and in 2021 and sales revenue of more than one billion euros. A five-fold increase is expected in sales revenue here by 2025. This business success will also increase the contribution we make to saving resources and climate action - while we move a step closer to our ambitious carbon reduction targets.

Bosch is second to none in the range of electromobility it offers: from eBike systems to construction machines, from silicon carbide chips to the pre-integrated eAxle module. As a systems supplier for highly efficient drive systems, it plays a key role in advancing the development of electric drives with products such as the eAxle or improved thermal management for hybrid systems and electrical powertrains. Since the end of 2021, Bosch has been manufacturing power semiconductors made of silicon carbide (SiC), which can extend the range of electric vehicles by up to 6 percent.

To facilitate charging electric vehicles in everyday life, Bosch has developed a new flexible charging cable with integrated control and safety technology as well as adapters for type 2 and household plugs. Even when charging at a 230-volt socket, it eliminates the typical in-cable control box-and, as a result, weighs a good 40 percent less than conventional charging cables. For charging on the go, Bosch's Internet-based charging service offers access to over 200,000 charging points in Europe-thereby contributing to the expansion of the charging infrastructure for electric vehicles.

Picture 5: Bosch believes that industry will become a driver of ecological transformation and is supporting the transition into Industry 4.0

Increasing energy efficiency: efficient industry

The industrial sector accounts for around one-fifth of global CO_2 emissions, and approximately half of the greenhouse gas emissions in Taiwan. Therefore, Bosch believes that industry will become a driver of ecological transformation, and we are contributing our technological know-how and manufacturing expertise to support the transition into Industry 4.0. While industry 4.0 connects people, machines, and data, it represents paramount possibilities for efficient industrial manufacturing. According to Germany's digital association Bitkom, an accelerated digitalization scenario for industrial manufacturing in Germany could save up to 61 megatons of CO_2 by 2030.

Connecting machinery and processes intelligently enables information and communications technology and creates the basis for energy-efficient production. In this vein, we are increasingly relocating functions from hardware to software. Take digital twins for example. The augmented virtual copies of physical assets in the real factory allow us to simulate and optimize workflows and processes-and this without interrupting operations. In the factory of the future, it will be possible to adjust many things at the touch of a button and the only static elements of such a factory will be the floor, ceiling, and walls. Everything else will be dynamic and variable, with machines constantly rearranging their constellations and changing their configuration, depending on the job in hand.

As a result, plant and equipment will last longer, and the number of raw materials used in the production of new hardware will decrease. As a result, the efficiency of industrial operations increases while helping to conserve valuable resources.

Another example is ctrlX Automation, an open platform that provides all the building blocks for complete automation without being bounded by the conventional architecture of controllers. The platform allows the volume of all automation components to be reduced by up to 50 percent on average. What's more, the drives weigh up to one-third less. The lighter the hardware, the less drive power and energy are required. Bosch is even rethinking hydraulics and unlocking its potential: machine tools, injection molding machinery, and presses often use smart hydraulic power units such as Bosch Rexroth's CytroBox. The integrated variable-speed pump drive reduces energy consumption and electricity costs by up to 80 percent compared to conventional drives. CytroBox's load-dependent control means that it is always in the optimum operating mode. It switches to standby mode when not in use.

Moving forward: Bosch to be a beacon of sustainability

To Bosch, sustainability is not only the foundation of our success in business but also an impetus for technological innovation. We take pride in our pioneering climate action, and we are looking to contribute more with our broad portfolio and profound expertise in mobility, industry, and hydrogen technology. This is not an easy path, and we still have a long way to go. Nevertheless, we are excited to be part of the solution and are committed to making our company a beacon of sustainability.

Andreas Schmidt
Managing Director of
Bosch Taiwan

Author

Andreas Schmidt has been managing director of Bosch in Taiwan since December 1, 2021. He represents the Bosch Group in Taiwan and oversees Bosch operations in the region. Mr. Schmidt is contributing his rich experience to the future development of Bosch in Taiwan.

Germany is to Become Climate-Neutral by 2045

Deutsches Institut Taipei
德國在台協會

In 2019, the "Climate Cabinet" was established under the leadership of Chancellor Angela Merkel with Federal Ministers for the environment, transport, energy, construction and, finance. Later the same year, the Cabinet passed the "Climate Action Programme 2030" to set up the sectoral measurements, supervise, evaluate, and adjust the projects, reduce the financial burden of the consumers, and lower the levy embedded in the electricity price. The most important component of this programme is the introduction of a national emission trading system in Germany, especially for the sectors of transport and building.

On 31st August 2021, the amendment of the Federal Climate Change Act" came into force. Since then, the Federal Government has tightened the climate protection requirements and anchored the goal of greenhouse gas neutrality by 2045. By 2030, the emissions are to be reduced by 65 % and 88 % by 2040 compared to 1990. The various sectoral targets were adjusted to meet the ambitious CO_2 reduction targets.

The climate targets are regularly monitored. Starting in 2022, the Expert Council for Climate Issues will present a progress report every two years. If the budgets are not adhered to, the Federal Government takes immediate action.

In order to achieve the climate protection goals and to become independent of fossil energy imports, the Federal Government has set the goal to increase the share of renewable energies in gross electricity consumption to 80 % by 2030, and almost 100 % by 2035. To achieve this ambitious goal, the Federal Government is taking measures called "Easter Package ("Osterpaket)" to accelerate the expansion of wind and solar energy, exit from fossil fuels, and increase more energy efficiency.

For a lasting success of the energy transition and climate protection, using alternatives to fossil fuels is necessary. Hydrogen will play a key role as a versatile energy carrier. Therefore, in 2020, the Federal Government announced the "National Hydrogen Strategy." Hydrogen produced in a climate-friendly manner makes it possible to significantly reduce CO_2 emissions, especially in industry and transport, where energy efficiency and the direct use of electricity from renewable energies are not sufficient.

From fossil fuels to renewable energy

The data of BDEW (Bundesverband der Energie- und Wasserwirtschaft e. V.) shows that the gross power production from renewable energy in Germany in 2021 has reached 40.9%, in which wind energy (20.1%) and solar (8.8%) are still the two important sources, followed by Biomass (7.5%), Hydropower (3.4%) and others (1.0%).

Phasing out nuclear power has been a consensus of all political parties in Germany since 2011. Now the Federal Government is sticking to it: Germany will phase out nuclear energy by the end of 2022.

Among other factors, disposal and safety questions are still unsolved. "Because of this danger, Germany has decided to phase out the use of nuclear power," said Federal Chancellor Olaf Scholz on January 12th , 2022 in the Bundestag.

In July 2020, the" Coal Phase-Out Act" was adopted by the Bundestag and Bundesrat. It aims to gradually reduce and eventually phase-out coal power plants in Germany by 2038, to provide the public with a cost-effective, efficient, and climate-compatible energy supply. The end of power generation by burning coal will significantly reduce Germany's share of CO_2 emissions.

To accelerate the expansion of renewable energy by the "Easter Package"

To achieve the climate protection goals and to become independent of fossil energy imports, the share of renewables in gross power consumption should increase to at least 80 % by 2030 and to almost 100 % by 2035, while the share in 2021 was just 42.4%. In other words, the gross power consumption should achieve double growth within less than ten years. In addition, to meet the climate targets set by the amended "Climate Change Act", Germany must nearly triple the present rate at which the emissions are reduced to reach the goal of 80% CO_2 reduction by 2030, compared to 1990. On 6th April 2022, the Federal Government passed the "Easter Package (Osterpaket)" to accelerate the expansion of wind and solar energy, exit from fossil fuels, and increase energy efficiency. The "Easter Package" includes various aspects: the comprehensive amendment to the Renewable Energy Sources Act 2023 ("EEG 2023"), changes to the Energy Industry Act, Federal Requirements Plan Act, Grid Expansion Acceleration Act, the Offshore Wind Energy Act, and other energy regulations. For the wind energy sector, the Federal Government aims to use 2% of the land area to boost the development of the onshore wind energy sector.

The Federal Government has been funding the expansion of renewable energies since June 2022 from the Energy and Climate Fund (EKF) (in the future: Climate Transformation Fund). The EKF is financed by the charges from European emissions trading and part of the national CO_2 pricing for heating and transport. Until now, the EEG levy for electricity consumers has been financing the energy transition as well. On 1st July 2022, the EEG levy was abolished, which resulted in approx. 6.6 billion Euros less income for the EKF in the future.

To increase energy efficiency

According to figures from the Working Group on Energy Balances (AGEB), primary energy consumption fell by 11% in 2019 compared to 2008.

Those acting in an energy-efficient manner do emit fewer CO_2 emissions and save money. This goes for private households, companies, and municipalities. The return on investments in energy efficiency is currently higher than on secure investments in the capital market.

Greater energy efficiency also renders the German economy more competitive in the international market. After all, if you use fewer resources and emit fewer emissions, you have a cost advantage. Using energy sparingly also promotes new business models as well as innovative technologies and services with which German companies can score in international markets.

The "Energy Efficiency Strategy 2050" has set an interim target for reducing primary energy consumption by 2030 for the first time and bundles appropriate measures and initiates a broad-based stakeholder process for the further development of energy efficiency policy. The Federal Government aims to make the German economy the most energy-efficient economy in the world and to reduce primary energy consumption by 2050 drastically. In order to achieve this goal, the Federal Government passed the Energy Efficiency Strategy 2050 (EffSTRA) on 18th December 2019. The strategy sets the course for more energy efficiency in Germany and makes an important contribution to the implementation of energy and climate policy goals at the national and European levels. The Energy Efficiency Strategy 2050 is based on three elements:

- **1. A national energy efficiency target for 2030**

By 2030, primary energy consumption should fall by 30 % (compared to 2008). This corresponds to a reduction in consumption of around 1,200 terawatt hours (TWh). With this goal, Germany is also making an ambitious contribution to achieving the EU efficiency target for 2030.

- **2. A new National Action Plan on Energy Efficiency (NAPE 2.0)**

The "National Action Plan on Energy Efficiency (NAPE)" of 2014 is a comprehensive package of actions to make better use of the possibilities of energy efficiency in Germany. The action plan focuses on expanding the available information and guidance in the energy sector, the financial support of innovative energy solutions for new plants and new buildings, and the obligation of

large companies to carry out regular energy audits.

However, the reductions in consumption achieved to date must be amplified to meet the energy efficiency targets set for 2030 and 2050. For this reason, the Energy Efficiency Strategy 2050 bundles a large number of effective efficiency measures for 2021 until 2030 in the new National Action Plan on Energy Efficiency (NAPE 2.0). NAPE 2.0 and the 2030 climate protection program are closely linked. After all, the vast majority of measures to reduce energy consumption also lead to a reduction in greenhouse gas emissions.

The NAPE 2.0 looks at the demand side of the energy system and expands the previous efficiency policy. The tax incentives for energy-efficient structural renovations from the beginning of 2020 lead to more energy efficiency in residential buildings. In addition, the existing building subsidies programs have been bundled, enhanced, and simplified with the Federal Subsidy for Efficient Buildings (BEG) in January 2021. The Federal Ministry for Economics and Climate Protection is providing around 6 billion euros p.a. for energy efficiency projects for the next four years. Since the beginning of 2021, there is a levy on the usage of fossil heating and fuels with the aim to reduce consumption and greenhouse gas emissions in the future. The implementation of NAPE 2.0 is monitored annually to check success.

• 3. A roadmap energy efficiency 2050

The Federal Ministry of Economics and Climate Protection is also initiating a stakeholder process called "Roadmap Energy Efficiency 2050". Business, civil society, the Federal States, and representatives of science, discuss ways to reduce primary energy consumption by 2050.
During the kick-off event for the Energy Efficiency Roadmap 2050 on 26th May 2020, six working groups were set up for the sectors of industry, buildings, transport, qualification/skilled workers, digitization, and system-related issues. They meet twice a year and present their results on the energy efficiency platform. The dialogue process is scheduled to last 2.5 years and should be completed in October 2022.

Hydrogen: key element for the energy transition

German companies are already well established in the hydrogen sector, e.g. with fuel cells and electrolysis for green hydrogen production. With the aim to assert the global pioneering role in hydrogen technologies, the Federal Government has drawn up a "National Hydrogen Strategy" including an action plan which is continually developed. The Federal Cabinet adopted the "National Hydrogen Strategy" on 10th June 2020 and established a National Hydrogen Council, which first met on 9th July 2020.

The strategy pursues the following major goals:

- Hydrogen produced in a climate-friendly manner, especially from renewable energies, and its derivatives as key elements of the energy transition.
- To create a regulatory framework for domestic markets for the production and use of hydrogen. The focus is on areas that show potential profitability or that cannot be decarbonized in any other way, such as certain industrial and transport sectors (air, shipping, long-distance transport).
- To reduce the implementing costs of hydrogen technologies in order to open global markets.
- To strengthen German companies' competitiveness by promoting research and development and the export of these new technologies based on hydrogen.
- To generate and secure the future national supply of hydrogen from renewable energy sources. Next to the promotion of the national generation potential, reliable international partners - with a focus on the EU – need to be identified for the production/transport of hydrogen, or the establishment of adequate cooperation and import structures. There is also an opportunity to expand the EU's internal energy market, and to create hydrogen partnerships with developing countries with good renewable energy sources. As long as clean hydrogen is only available in limited quantities and at a high cost, a European market for low-carbon blue and turquoise hydrogen can play a transitional role in ramping up the hydrogen economy in the European market.

Updates to Hydrogen Policy and Funding in Australia

K&L GATES

This article provides a high-level consolidated overview of a number of policy and funding developments in the hydrogen energy industry in Australia. These developments have come at both Commonwealth and State level and highlight the current governmental appetite to foster the emerging Australian hydrogen industry and to position Australia as a global hydrogen leader. This article supplements the Australian chapter of The H2 Handbook of K&L Gates, which can be accessed here.

Australian Policy Updates

• New South Wales

NSW Net Zero Industry and Innovation Program

In March 2021, the New South Wales (NSW) Government published the NSW Net Zero Industry and Innovation Program (Program) as part of the NSW Net Zero Plan Stage 1: 2020-2030, which aims to achieve a 35 percent reduction in emissions compared to 2005 levels. AU$750 million will be invested under the Program by 2030 to help realise that aim. The Program has three areas of focus Clean Technology Innovation, New Low Carbon Industry Foundations and High Emitting Industries: While the Program is technology neutral, it facilitates the development of the hydrogen industry as the funding offered could apply to hydrogen projects.

As part of the Program's aim, the NSW Government committed AU$70 million in funding to support the establishment of hydrogen hubs in the Hunter and Illawarra regions. The hydrogen hubs have also received a potential AU$4 billion in industry investment.

NSW Hydrogen Strategy

In October 2021, the NSW Government also published its NSW Hydrogen Strategy (NSW Strategy) with a focus on green hydrogen. The NSW Strategy is built upon three strategic pillars- enabling industry development, laying the industry foundations and then rapidly driving the scale of hydrogen produced. Through these three pillars, the NSW Strategy's key aims are to:

- deliver on the stretch targets of 110,000 tonnes of green hydrogen production per annum and 700MW of electrolyser capacity by 2030;
- reduce the cost of green hydrogen by AU$5.80 per kg in the next decade to under AU$2.80 per kilogram in 2030; and
- drive decarbonisation for transport, industrial and energy sectors to help reach net zero emissions by 2050.

The NSW Strategy provides up to AU$3 billion of incentives to commercialise hydrogen supply chains, which includes:

- providing a 90 percent exemption to network use of system charges for electrolysers that connect to parts of the electricity network with spare capacity by 2030 for 12 years, subject to certain conditions;
- waiving contributions to environmental and electricity schemes for hydrogen producers for 12 years and may be extended for new capacity installed after 2031 (subject to review);
- expanding the NSW Energy Security Safeguard to support hydrogen with a market-based scheme that provides financial incentives for green hydrogen production; and
- creating a hydrogen refueling station network for heavy vehicles along strategic freight corridors.

• Northern Territory

Renewable Hydrogen Strategy

In late 2020, the Northern Territory (NT) Government published its Renewable Hydrogen Strategy (NT Strategy). The NT has a target of net-zero emissions by 2050 and it is anticipated that hydrogen could play a critical role in achieving

this aim. The NT Strategy outlines a five-point plan, which underpins the transition to renewable hydrogen:

In late 2020, the Northern Territory (NT) Government published its Renewable Hydrogen Strategy (NT Strategy). The NT has a target of net-zero emissions by 2050 and it is anticipated that hydrogen could play a critical role in achieving this aim. The NT Strategy outlines a five-point plan, which underpins the transition to renewable hydrogen:

1. Local industry development to facilitate the adoption of a hydrogen based industry.
2. Resource management to optimise the Territory's resources and infrastructure to facilitate the development of a hydrogen industry.
3. Grow and harness demand for hydrogen to maximise domestic use and international export opportunities.
4. Support innovation and emerging renewable hydrogen technologies.
5. Implement responsive laws and regulations.

Renewable Hydrogen Master Plan

In October 2021, the NT Government released the Renewable Hydrogen Masterplan (Masterplan) which builds on the NT Strategy to help create its hydrogen industry and forecasted a growth of AU$3.7 billion. It focuses on foundation activities to enable private sector investment and establish a local and export industry. The Masterplan is to be delivered in two parallel parts:

1. Laying the foundations – the identification of areas that require further development to enhance both government and private sector investment and accelerate the development of a renewable hydrogen industry.
2. Scaling to export – comprehensive assessment of the international hydrogen market and supply chains to scale to export.

On 21 June 2022, the NT Government announced that it will invest AU$5 million over four years in support of its Masterplan.

• Victoria

In February 2021, the Victorian Government published its Renewable Hydrogen Industry Development Plan (Plan). The Plan sets out how Victoria will develop its renewable hydrogen sector.

The Plan identifies 18 outcomes across three focus areas to develop the Victorian hydrogen sector in various ways, from research and development to export. The key focus areas and some of the respective outcomes for these areas include:

Foundation for renewable hydrogen

- Accelerating innovation through research and development of hydrogen technologies.
- Continuing the development of clear regulations, standards and codes to ensure that hydrogen is fit for purpose.

Connecting the economy

- Using existing gas networks as a potential distribution pathway for renewable hydrogen.
- Advancing the integration of hydrogen within the transport sector to support decarbonisation.

Leading the way

- Enabling hydrogen pilots, projects and demonstrations through government support.
- The Victorian Government will work with companies to promote Victoria as a global trade and investment destination.

• Western Australia

Renewable Hydrogen Roadmap

In November 2020, Western Australia (WA) launched its Renewable Hydrogen Roadmap (Roadmap). The Roadmap identifies 26 initiatives that the WA Government is implementing to achieve its 2019 Hydrogen Strategy. These include developing a renewable hydrogen supply chain model, undertaking a legal framework review, developing the Oakajee Strategic Industrial Area and conducting modelling for the hydrogen storage potential of depleted gas and oil fields.

Hydrogen Strategy Update

The WA Government updated its Hydrogen Strategy (WA Strategy) in January 2021. The main update was to bring forward its goals originally set for 2040 to 2030. These goals include:

- WA's global hydrogen export market share to be similar to its share in LNG today.
- WA's gas pipelines and networks to contain up to 10 percent renewable hydrogen blend.
- Widely using renewable hydrogen in mining haulage vehicles.

- Using renewable hydrogen as a significant fuel source for regional transportation.

Commonwealth Government

In September 2020, the First Low Emissions Technology Statement (Technology Statement) was announced as the first major milestone of the Technology Investment Roadmap.

The Technology Statement sets out how emerging low emissions technologies can become economically competitive with and replace current high emission practices.
Clean hydrogen and carbon capture storage (CCS) are identified as some of the priority low emission technologies.

For clean hydrogen, the key goal is to reduce its price to AU$2 per kilogram, so that it becomes competitive in applications such as producing ammonia, as a fuel for transport and for firming electricity.

The Technology Statement anticipates that CCS will be critical to the development of new low emissions industries such as blue hydrogen. As such, the priority is to have CO compression, hub transport and storage for CCS priced at less than AU$20 per tonne. The Commonwealth Government considers that this would allow CCS to be competitive over the long term with other forms of emissions reduction.

Australian Legislative Updates

• New South Wales

On 29 November 2021, the Energy Legislation Amendment Act 2021 (NSW) came into force to facilitate the development of hydrogen industry as set out in the NSW Strategy. Amendments include:

- permitting the Minister to grant exemptions from the Energy Savings Scheme under the Electricity Supply Act 1995 (NSW) for electricity used to produce green hydrogen;
- exempting electricity loads producing green hydrogen from contributing to the Climate Change Fund; and
- permitting the introduction of regulation to prevent network service providers from recovering distribution and transmission charges from someone purchasing electricity to produce green hydrogen.

• South Australia

In February 2021, hydrogen was declared as a "regulated substance" and therefore regulated by the Petroleum and Geothermal Energy Act 2000 (SA) (PGE Act).

On 25 August 2021, the Petroleum and Geothermal Energy (Energy Resources) Amendment Bill 2021 was introduced which proposes to expand the scope of the PGE Act to include the generation of hydrogen from means not already permissible under the PGE Act, including electrolysis of water. It is intended to provide all hydrogen generation sectors the same one-window to government regime as is currently provided to petroleum, by introducing Hydrogen Energy Licences into the PGE Act. Existing environmental approval, compliance and reporting obligations under the PGE Act will be extended to hydrogen projects licenced under the PGE Act. The Bill has not yet been passed.

• Victoria

On 14 September 2021, the Energy Amendment Bill 2021 (Vic) came into force. The main purpose of the Act is to allow Victorian laws around energy and gas to be aligned with national energy laws. The Act amends the National Gas (Victoria) Act 2008 to enable the Minister to declare a mixture of natural gas as a gas. This would allow hydrogen to be blended with natural gas.

• Western Australia

The WA government has acknowledged that reforms to the National Gas Law, National Gas Rules and other legislation are necessary in carrying out the planned hydrogen developments to meet its target emission goals. One such required amendment is to broaden the definition of gas to include hydrogen. However, no clear timeline for these proposed amendments has been provided.

On 18 November 2021, the WA proposed a new form of tenure under the Land Administration Act 1997, called 'diversification leases'. These allow pastoral lease areas and vacant Crown land to be used to develop hydrogen and renewable projects. They are set for introduction to Parliament in the second half of 2022.

• Commonwealth Government

National Gas Reform

In August 2021, Energy Ministers tasked the Australian Energy Market Commission (AEMC) with a review of the National Gas Rules and National Energy Retail Rules to develop initial rules that will extend the regulatory frameworks to include low-level hydrogen blends and renewable gases. A draft legislative report will be ready by mid-2022.

Certification Scheme

In June 2021, the Australian Government published its Discussion Paper on the Hydrogen Guarantee of Origin scheme for Australia. The paper outlines methodologies for guaranteeing the origin of clean hydrogen from electrolysis, coal gasification with CCS and steam methane reforming with CCS. It has been proposed that The Clean Energy Regulator will be responsible for running the scheme.

Trials began in late 2021 to test the accuracy, administrative burden and verification mechanisms associated with relevant emissions accounting methodologies outlined in the paper. However, the trials will not cover certificate creation and surrender as legislation is needed for these components.

Other – Private Sector Certification Scheme

In December 2020, the Smart Energy Council established a hydrogen certification scheme- the Zero Carbon Certification. The industry-led scheme assesses the embedded carbon in produced hydrogen. On 4 February 2022, it announced that ActewAGL's hydrogen fuelling station in Canberra 'has been certified with renewable hydrogen produced from 100 percent renewable energy and with zero carbon emissions.'

Australian Funding Updates

• Australian Capital Territory

The Australian Capital Territory is investing AU$12 million in its Renewable Energy Innovation Fund, which may support hydrogen-related research and development.

• New South Wales

In addition to the funding details released as part of the NSW Net Zero Industry and Innovation Program, the Energy and Utilities Administration Act 1987 (NSW) was amended in late 2020 to specify that AU$50 million from the Climate Change Fund established under that Act is to be spent to develop the green hydrogen sector between 2021 and 2030. This will include the production of hydrogen energy using renewable energy and the supply, use and export of green hydrogen.

As part of the NSW 2022-23 Budget, the government is investing:

- AU$300 million over 10 years to support clean manufacturing, using new, clean technologies including green hydrogen;
- AU$3.1 million (AU$6.1 million recurrent expenses over four years) to the Renewable Fuel Scheme as a part of the NSW Strategy; and
- AU$465.7 million from the Climate Change Fund.

• Northern Territory

In the 2022-2023 NT Budget, the NT Government has committed AU$1.413 million to a new Accelerate hydrogen industry development initiative and AU$2.128 million on the Renewable Remote Power Program, which includes hydrogen trials.

• Queensland

In December 2020, the Queensland (QLD) Government committed a further AU$10 million over the next four years to its Hydrogen Industry Development Fund (HIDF), which was established as part of the Queensland Hydrogen Industry Strategy. Since the Strategy was first announced, the Queensland Government has committed a total of AU$35 million for the HIDF.

In June 2021, the QLD Government committed an extra AU$1.5 billion to the Queensland and Renewable Energy Jobs Fund (QREJF), to a total of AU$2 billion. The QREJF will allow government-owned corporations to purchase or work on commercial and private renewable energy and hydrogen projects that will contribute to Queensland renewable energy targets, have commercial value and create new and ongoing employment.

• South Australia

In April 2021, the Federal and South Australian

Governments signed an AU$1.08 billion State Energy and Emissions Reduction Deal (Deal) to deliver reliable and affordable energy to and help reduce emissions. Under the Deal, the Federal Government will contribute AU$660 million and South Australian (SA) Government will provide AU$422 million. While the Deal focuses on gas, AU$400 million of the Federal funding is to be used for investment priority areas, including CCS, electric vehicles, hydrogen and other emission reduction projects.

As part of the of the 2022-23 South Australian Budget, the SA Government announced a Hydrogen Jobs Plan which includes:

- AU$593 million over four years to build a new hydrogen facility including electrolysers;
- hybrid power station and hydrogen storage capacity in the Whyalla region;
- AU$8.3 million over four years to support implementation of the hydrogen plan; and
- AU$30 million towards a clean hydrogen hub at Port Bonython.

• Tasmania

In March 2022, the Tasmanian Government made available AU$12.3 million for the trial of green hydrogen buses and investigation for green hydrogen for trucking and marine vessels.

Accelerating Victoria's Hydrogen Industry Program

As part of the Plan, the Victorian Government announced a further AU$10 million to Accelerating Victoria's Hydrogen Industry Program for policy, research and industry developments. The key funding discussed in the Plan includes:

- AU$6.6 million to support 6 projects in hydrogen pilots, trials and demonstrations.
- AU$1 million to support industrial users to support business cases, grants and education.
- AU$0.5 million for the Australian Hydrogen Centre's gas blending feasibility studies.

Victorian Hydrogen Hub

In February 2021, the Victorian Government granted Swinburne University of Technology AU$10 million to develop the Victorian Hydrogen Hub (VH2) in partnership with Australia's Commonwealth Scientific and Industrial Research Organisation.

• Western Australia

Renewable Hydrogen Fund 2.0

The Renewable Hydrogen Fund, aims to support the development of the state's renewable hydrogen industry in accordance with the WA Renewable Hydrogen Strategy. The first round of funding was in 2019 with AU$10 million available and the second round of funding was in 2022 with AU$5 million available.

Western Australia (WA) Budget

In the WA 2021-22 Budget, the WA Government committed to:

- AU$50 million fund to support renewable hydrogen industry development, including a AU$10 million for the Hydrogen Fueled Transport Program to advance the uptake of hydrogen fueled transport. Funding will be provided to projects that procure and operate hydrogen or green ammonia fueled transport and the installation of one or more refueling stations;
- AU$7.5 million for development of the Oakajee Strategic Industrial Area as a renewable hydrogen hub; and
- AU$4 million to bolster the Renewable Hydrogen Unit.

The WA 2022-23 Budget includes:

- AU$117.5 million for two hydrogen hubs in the Pilbara and Mid West; and
- AU$300,000 for a high-level feasibility study into the potential to power trains on WA's regional network with green hydrogen.

• Commonwealth Government

2021-2022 Federal Budget

In April 2021, the Commonwealth Government announced new investments in clean hydrogen and carbon capture technologies as part of its 2021 – 2022 Budget (Budget). The Budget will invest AU$539.2 million in new clean hydrogen, carbon capture, use and storage (CCS/CCUS) projects including:

- AU$275.5 million over five years for the development of four new clean hydrogen hubs in regional Australia and implement a clean hydrogen certification scheme.
- AU$263.7 million over 10 years for the development of CCS/CCUS projects and hubs.

2022-2023 Federal Budget

The newly elected Albanese Government will propose its 2022-2023 budget in October this year.

Carbon Capture, Use and Storage Development Fund

The AU$50 million Carbon Capture, Use and Storage Development Fund (CCUS) Fund provides businesses and government agencies with grants from AU$500,000 up to AU$25 million for pilot or pre-commercial projects engaged in carbon capture, use and storage technologies.

While the CCUS Fund is not specific to hydrogen, the objectives of the CCUS Fund include:

- Reducing emissions across energy generation, natural gas or hydrogen production and heavy industries.
- Fostering existing, pilot or pre-commercial carbon capture, use and storage facilities that could form part of a regional hub of such facilities in the future.

ARENA Renewable Hydrogen Deployment Funding Round

In May 2021, ARENA announced it will provide a total of AU$103.3 million in funding to three large-scale hydrogen projects under the Renewable Hydrogen Development Funding Round. The three projects (Engie Renewables, ATCO Australia and Australian Gas Networks) chosen are well-developed and propose to produce hydrogen at large scale (10MW+ of electrolyser capacity) for a variety of end uses and will take place across Western Australia and Victoria.

Hydrogen Hubs

The Australian Government is also investing over AU$464 million through Clean Hydrogen Industrial Hubs grant program, as it sees regional hubs as the best way for the industry to create centers of demand and centralise hydrogen infrastructure.

• Other

In February 2021, National Energy Resources Australia announced a network of 13 regional hydrogen technology clusters with a total investment of AU$1.85 million. The regional clusters have been established around key hydrogen projects and technology supply chains, including four clusters in Victoria, three in Western Australia and one cluster in each other State and Territory.

About K&L Gates and Its Taipei Office

K&L Gates is one of the largest fully integrated law firms in the world, with nearly 2,000 lawyers including over 100 dedicated energy and renewable energy lawyers practicing seamlessly in our 46 offices across five continents. Our broad global platform allows us to guide clients through the legal challenges inherent in the ever-changing international landscape. Our offices are fully integrated with one another, providing a seamless execution of transactions and direct points of contact for any issues that may arise on cross-border transactions. We serve clients in virtually all renewable energy and clean technology sectors in developed and developing nations alike. Our clients operate in solar, wind, biomass, hydropower, geothermal, and complementary sectors, including energy storage, smart grid, and transmission. In addition, our global regulatory and public policy practice helps clients overcome regulatory hurdles and influence legislative and policy development in the renewable energy area. Our Taipei office is a full service law firm widely considered to have one of the leading practices in Taiwan, providing access to the crucial Taiwan market as well as considerable cross-border opportunities in the region and beyond, and regularly advising multinational companies doing business in Taiwan on major infrastructure, energy, renewable energy and power plant projects, project finance, as well as corporate/M&A, joint ventures, investments, capital markets, private equities, disputes and commercial litigations/arbitrations. K&L Gates is ranked by Law 360's as one of the "World's 20 Leading Law Firms" and is awarded by US News Best Law Firms with "Law Firm of the Year" in Corporate Law and as among top 10 firms for most "First Tier" recognitions. K&L Gates Taiwan is ranked by The Legal 500 as a "Tier 1" law firm in Corporate and M&A and a "Tier 2" law firm in Capital Markets and Dispute Resolution.

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Kelly Davies focuses on the development, acquisition and financing of energy projects and energy procurement and sustainability strategies for large businesses. She works closely with clients on all energy aspects of their business and advises on energy transactions both internationally and domestically across the energy sector.
She has advised clients across all levels of the power sector including generators, producers, transmission and distribution network operators, retailers, regulators and consumers and is increasingly advising clients on project development, energy-transition, transportation, usage and accreditation and trading frameworks in the hydrogen space both in Australia and globally. She has extensive experience in the energy market having worked across a number of jurisdictions globally including the UK, Africa, Europe, the Middle East, Asia and Australia. Her recent experience includes advising on a number of renewables projects in Australia.
Kelly regularly presents on developments around hydrogen including the K&L Gates podcast series Hydrogen Rising (www.klgates.com/Hydrogen-Rising) and a recent H2 Handbook (www.klgates.com/epubs/h2-handbook).

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Clive Cachia is a corporate partner and member of K&L Gates' global hydrogen team. He is increasingly advising clients on their energy transition strategies as they move into hydrogen. Clive's recent energy experience includes corporate structuring matters and he also regularly advises major project stakeholders in respect of energy and resources projects, including complex vertical integration and risk sharing JV arrangements. Clive prepared the Australia chapter of K&L Gates' The H2 Handbook.

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Jessie Sun is a lawyer in K&L Gates' Energy, Infrastructure, and Resources practice and advises on project delivery and infrastructure transactions. She has experience in renewable energy projects and PPPs, including advising on transaction structuring, risk allocation, construction and operations, and management. Jessie is also an active contributor to the firm's thought leadership and regularly co-authors legal insights in renewable energy.

Steps To Achieve Taiwan's Net Zero Ambitions

Renewable energy, infrastructure

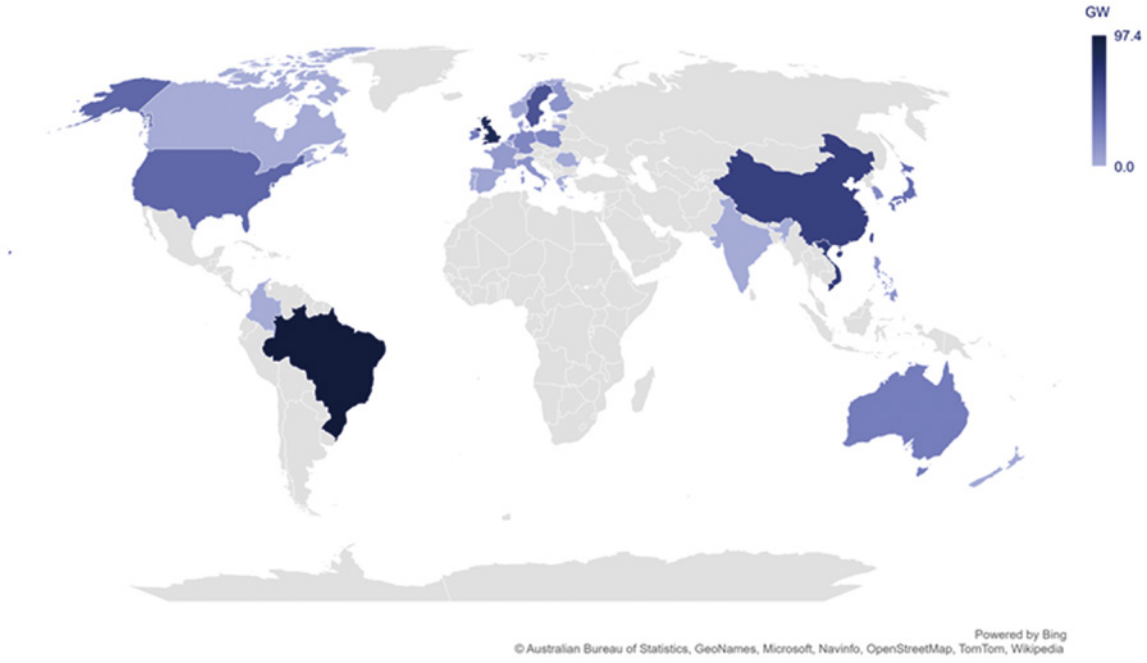
Renewables Consulting Group
an ERM Group company

Article highlight

Taiwan has great potential for multiple renewable energy, the government, industries, and financial sector should work together for diverse development as well as the upgrade of grid infrastructure. Net-zero pathway can not be achieved by a single measure, the energy transition needs the transition of energy infrastructure, society, and financing philosophy.

Taiwan society is making clear pressure on the low-carbon energy transition whilst the deregulation of the energy market. It is apparently the transformation of the whole energy infrastructure and society, and there is no single and simple measure to achieve the targets. RCG's latest Global Offshore Wind Annual Report reveals that Taiwan is one of the top 5 offshore wind markets and shows great interest in floating offshore wind. The government needs to smartly make good advantage of the state-own utility, Taiwan Power Company (TPC), and cooperate with the industries in this special economy to accelerate all the necessaries for Net Zero Emission (NZE). The current NZE roadmap announced by National Development Council (NDC) is a great demonstration. The industries can expect Taiwan fitting to a green-energy-based energy system in the long term, but there are many factors that need more planning and participation from all industries in the great transition.

Exhibit 1 Global overview of offshore wind development

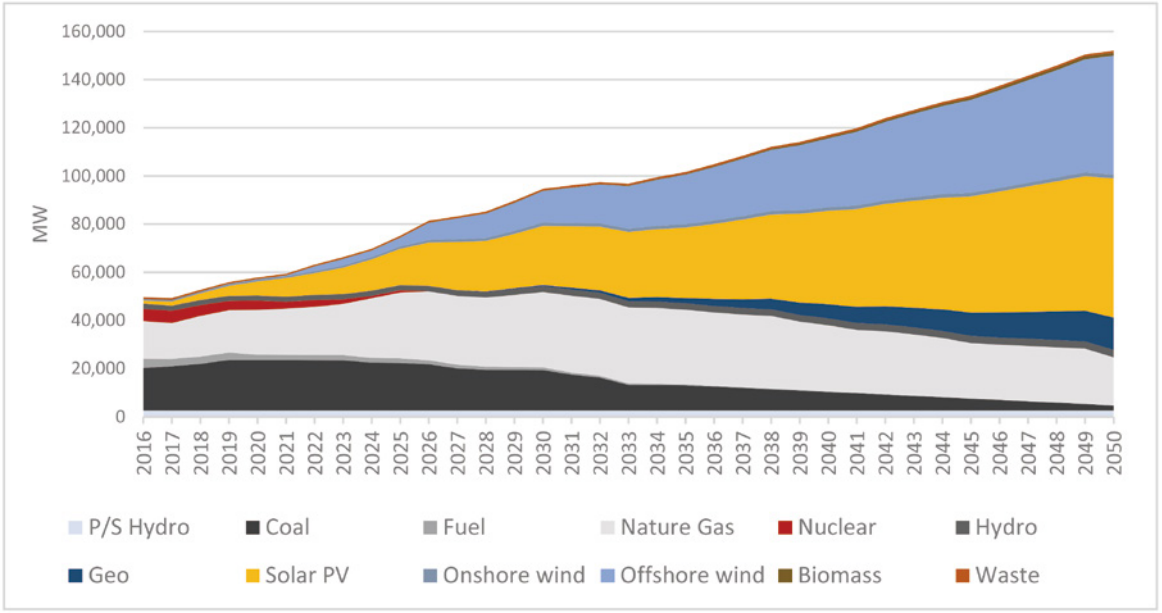


GRID Global Offshore Wind Annual Report 2021

The opportunity of multiple renewables

The top challenge for NZE is to reduce the GHGs emission from energy use. The priority is to significantly develop renewable energy sources, such as offshore wind, onshore wind, solar, geothermal, energy storage, etc. Despite being blessed with abundant renewable resources, Taiwan is an island nation that cannot connect to the grids of neighbouring countries. Various studies assess the natural potential and constrain for renewable capacity in Taiwan, and most of them show the great value that can support the NZE energy transition. Following the policy, The Renewables Consulting Group (RCG) makes the scenario of renewable energy development in Taiwan (Exhibit 2), the NZE target is achievable. However, there must be drastic changes in the shifting, timing and framing of fossil fuels to renewables.

Exhibit 2 Energy capacity development scenarios (RCG)



Source: RCG forecasting

The feasibility of development is the key apart from natural potential. RCG collects the market intelligence and public information of offshore wind farm in its Global Renewable Infrastrucuture Projects Database (GRIP), and supports the development and due diligence of onshore wind and solar project in various markets. To achieve the renewable energy target needs to consider the feasibilities including technology, policy and regulation, finance and market readiness. The factors are interdependent on each other, the feasible technology may not have financial feasibility, or local regulation may limit the feasibility of certain technology. The government needs to reduce the constraints and support with the right policy and regulations to lower the obstacles in this race. The developer should keep R&D to create the room for different technologies and cooperate with the stakeholders and industrial communities to improve all the capabilities to seek the best business opportunity to make positive impacts on climate action.

Taiwan government set the tone for a "wind and solar dual engine" approach for energy transition, and eyes on geothermal, small hydro and ocean energy. Due to the fact that different types of technologies have varying characteristics, it is recommended to exert the best potential of renewables to make a stable and balanced energy system. No single type of renewable source can be the superhero for future power supply (or the concept of baseload in conventional power supply). However, the government should consider all the potential of different technologies to contribute to a zero-emission energy system, Over-relying on certain technology may lead to unstable systems and over-pressure on the related environment. The combination of all the potential renewable energy can lay out the steady transition and sustainable development.

Exhibit 2 Comparison of different renewables

Source: RCG

Technology	Advantage	Generation pattern
Solar	• Can develop in small to large scale • Generation peak matches with load peak in the noon time • Less NIMBY effect	Regular daily generation having great power in 10 am to 2 pm
Offshore wind	• Economies of scale for development • Good capacity factor for whole day	Clear seasonal pattern and have very good generation in winter
Onshore wind	• Lower CAPEX than offshore wind • Easier to have MW scale capacity	Similar to offshore wind but affected by site condition
Geothermal	• Stable generation • Less NIMBY effect comparing with thermal power plant • Can combine generation with other combustion sources	Whole time stable generation
Small hydro	• Relatively lower CAPEX • Controllable generation which can combine with small scale water storage facility	May limited by seasonal water resources, but should have stable generation in summer
Ocean energy	• Relative stable generation • Less NIMBY effect	May have seasonal patterns depending on the site and technology

Ancillary service and supporting infrastructure

Energy transition not only represents the change of the energy sources we use, but also the system and practice we adopt. When solar and wind energy have high penetration rates, it means the management of supply/demand and the power dispatching should be very different from today. As mentioned, renewable energy generation patterns are different from coal and natural gas units, it need fundamental changes of TPC, industries, and society. The energy transition is not only the responsibility of the developer and the TPC, it will also need many related new services and infrastructure from the wider business.

People are keen to have 100% renewable energy, but this cannot achieve without the ancillary service and energy storage facility. NDC plan to have 40-80 GW solar and 50 GW offshore wind capacity, but the grid system needs to digest the peak generation from solar. For example, the generation factor at 40% of 60 GW solar and 50% of 50 GW can bring 49 GW power supply, but the peak-load in 2021 happened in July at about 38.6 GW. The renewable generation may be more than the load at certain period. Although we may expect the future load to grow as well, the high generation of renewable energy can lead to curtailment risk for renewable sources. On the other hand, the sudden decrease of solar energy in the evening is a tough issue for reliable power supply. Also, RCG modelling shows the likelihood of offshore wind curtailment risk on a windy Sunday in winter and spring due to low load. For example, with 60% of 50 GW offshore wind generation, will exceed the weekend load. At that time, the TPC dispatching center needs to curtail some of the renewable generations, leading to the loss of the asset owner and wasting the generation -not a positive sign for developers.

The entire energy system must be smarter and more flexible. The demand-respond scheme is important but not the only measure. TPC has established the energy trading platform, and the need for ancillary services is huge and urgent. The demand response capacity should match with certain ratio with the total solar and wind capacity. Also, Taiwan needs a large energy storage capacity to absorb the noon time solar peak and offset the second peak load in the evening. With more energy storage and ancillary service capacity, TPC can be more confidently to keep coal power plants cool.

The national grid system also needs to upgrade to embrace more renewable capacity of distributed generation. It is expected to have a large amount of solar need to connect to the grid in distributed sites, and wind energy needs proper connection points close to the coast. The industry must improve the resilience to avoid the threats from wild animals and natural hazards, but also be nimbler with better assessment and planning. TPC has announced to invest more than 100 billion NTD for the grid upgradation, after several national power outages in recent years. However, the upgrade should not be only the new cable and substation, but the smarter and more flexible system.

The integrated measure will be helpful with the innovative management. For example, the popular swap

battery scooter system has great potential to provide energy storage capacity for the grid, but swapping station peak demand happened in the evening as the users tend to change the battery on their way home. This pattern may worsen the evening peak-load supply. There is a huge opportunity for the industries to come out with innovative solutions for ancillary services and the different sources of energy storage including swapping batteries, EVs, hydro dams, and hydrogen facilities. The transformation of the energy infrastructure and landscape is expected. Without better ancillary service and supporting facilities, the offshore wind farm may not have the best contribution to the system.

Financing the transition

All the project development cannot complete without the support of the financial sector. Green finance, responsible investment, and ESG investment are the burning topics today, and more and more institutional investors pouring capital into renewable energy and related development. However, the financial sector and investors also need to learn to identify the risk and opportunities for green projects. Various technologies can have completely varied results, depending on conditions and markets. Although some projects may look promising at first glance, the detail will tell a different story. Also, the fast-changing market and new technologies bring challenges for investors. We witnessed the offshore wind turbine size developing rapidly, Taiwan erected the first 4 MW turbine in 2017 and will have 14 MW turbines installed in 2025. We expect the capital is the driving force for technology R&D and project development, but the finance needs due diligence and market intelligence to invest in a sustainable future.

There is no risk-free investment, the balance between the risk and return is the key financial sector to participate in this green transition. Following the de-regulation of the Taiwan energy market, the government also expects the corporate power purchase agreement (CPPA) to replace the Feed-in-Tariff (FiT) to be the main source of return for renewable energy projects. However, it is still not easy for the financial sector to take CPPA as the guarantee of future returns. We need to believe in a paradigm shift in the energy market. All the commercial terms and conditions will be carefully discussed and reviewed. We already found the CPPA discussion to become white-hot in Taiwan in past two years after TSMC signed the first CPPA with Orsted. Regarding the NZE target, it cannot be achieved without a large amount of CPPAs, whilst the financial sector and investors have to accept the new paradigm for renewable energy project finance.

Conclusion: leave no one behind, and include all potential factors

We need to borrow the old slogan for sustainable development for the NZE transition: leave no one behind. It is a challenging mission., Therefore, stakeholders need to take comprehensive measures and efforts to approach the goal. Leave no one behind for green energy transition representing the need to consider all the small factors and emerging technologies, and no one should be ignored. Combating climate change is a landscape change in infrastructure and people's behaviour. The policymaker, developers, supply chain, lenders, and investors should contribute from multiple perspectives. The business opportunity is huge whilst the action is urgent; the strategy and the comprehensive planning are the keys to making the best in the transition.

Author

Wen is the Associate Director of RCG Taiwan with several years of consulting experience in sustainable development and renewable project development. RCG supports market intelligence, technical advisory, and project development, engineering advisory for renewable industries.

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Advise on Taiwan CPC Net-Zero Development Strategy Based on European Oil and Gas Industrial Experience

Based on the European "Green Deal" policy and the experience of Net-Zero development in the oil and gas industry, this paper explores and provides recommendations to Taiwan CPC Net-Zero development strategy. It includes systematic Net-Zero roadmap and decarbonlization strategy, developing hydrogen energy value chain and carbon capture technology, promoting blending and transmitting hydrogen with natural gas using pipeline networks, encouraging oil and gas enterprises transforming from gasoline stations to hydrogen refueling stations, and finally establishing a reliable carbon tracking and early warning management mechanism to achieve the sustainable goals of low carbon by 2025 and Net-Zero

Net-Zero roadmap and decarbonlization strategies of oil and gas enterprises

Under the EU 2021 "Green Deal" policy and 2050 carbon neutral goals, oil and gas groups such as Shell, BP, E.ON, Total, and ENI are actively launching Net-Zero goals and development roadmaps. Similarly, following the announcement of the Net-Zero roadmap and strategy by Taiwan government on March 30, 2022, Taiwan CPC is also actively planning its response, including medium-term goals for carbon reductions by 2025 and 2030, and long-term goals by 2050. Based on the strategies and experiences of European oil and gas enterprises, it is suggested that the three major roadmaps of "Energy Saving and Carbon Reduction", "Development and Use of Renewable Energy" and "Promotion of CCUS" can be the foundations of Taiwan CPC, to systematically fuse the three main pillars of "Excellent Oil, Carbon Reduction and Clean Energy", integrate a more specific roadmap strategy, and gradually realize Net-Zero goals through the phased approach of carbon reduction, decarbonization and carbon neutral.

Recently, European Union has announced that it will no longer sell oil-fuel vehicles in 2035, which means a significant reduction in vehicle oil fuel production. It is worthwhile for Taiwan to ponder over the determination of "decarbonization". Therefore, CPC can follow the example of fossil fuel reduction strategy proposed by International Energy Agency (IEA) based on the trend of global total energy supply, and the low-carbon fuel concept "Hydrogen and Decarbonized Gas Program" by European Clean Hydrogen Alliance, to set yearly goals for "fossil fuel deduction" and "of Excellent Oil and Clean Energy" of Taiwan CPC. The Net-Zero development strategies of European and American oil and gas groups such as Total, Shell, BP, Chevron, and ExxonMobil, all include the promotion of large-scale green energy development or investment projects in the near future. Therefore, Taiwan CPC is encouraged to demonstrate its CPC (Clean Power Company) commitment to clean energy by making concrete plans or investments in offshore wind power, other green energy and electrolyser systems and etc., in order to have the opportunity applying the German Power-to-X concept of using surplus green power to produce green hydrogen, which can then be converted into low-carbon fuels or recycled chemicals using advanced catalyst and decarbonization technologies. Then the above will align with government policy and measures of carbon circular economy to achieve the goal of carbon neutrality of Taiwan CPC.

Development of Hydrogen Value Chain and CCUS Technology

In Net-Zero development strategy, hydrogen value chain and CCUS (Carbon Capture, Storage and Utilization) play an important role of decarbonization. Since Taiwan CPC's business covers almost the entire hydrogen value chain (as shown in Figure 1), CPC can further develop the advantages and business transformation opportunities through hydrogen production, storage, transportation, transmission, and hydrogen usage on application end.

In terms of hydrogen production and storage, hydrogen production is a key challenge for the development of hydrogen energy. The traditional grey hydrogen model will no longer be accepted. Therefore, in the transition period, hydrogen production must be fused with carbon capture to form blue hydrogen. One example is the co-production project of tempering co-operation between CPC and China Steel Corporation. A typical steel mill CCS process captures the CO/CO_2 produced by blast furnace gas (BFG) and Linz-Donawitz converter gas (LDG), and then uses the water gas shift reaction process to convert steam and carbon monoxide into carbon dioxide and hydrogen, and introduce selective adsorption of acid substances for carbon capture. In Europe, there is an advanced process which is combining the two steps of carbon capture and hydrogen production in one process. The process will achieve adsorption of carbon dioxide and generation of hydrogen at the same time. As a result, the reverse reaction rate of the water-gas shift can be reduced, thereby reducing the steam consumption. Compared with the traditional carbon capture process, the steam consumption of this new technology can be reduced by two-thirds, and the cost has been reduced by 25% in a successful case on a Swedish steel mill.

Carbon capture technologies for industrial processes include pre-combustion capture, oxyfuel combustion capture, and post-combustion capture (as described in ISO/TR 27912). Many new technologies and patented products in Europe under developing that can save equipment space, construction time and cost, and increase carbon capture efficiency, reliability and safety. Therefore, it is recommended that Taiwan CPC can exchange and cooperate with European high-end manufacturers with mature technology through the platform of the international chamber of commerce to introduce the most optimal solutions.

Third party certification plays a key role in the CCUS and hydrogen value chain. For CCUS, performance tests can be verified according to ISO 27919-1 and ISO 27919-2, and the carbon reduction of CCUS can be certified according to ISO 27915. In terms of the carbon footprint of the hydrogen value chain, the TÜV Rheinland H2.21 standard for green hydrogen and blue hydrogen certification and safety verification can ensure the effectiveness and safety in terms of carbon neutral. These successful EU certification experiences are worthy of emulation by Taiwan CPC.

Blending and transmitting hydrogen with natural gas using pipeline networks

In the area of hydrogen pipeline transmission, the seven heavy industry companies in the GET H2 program in Europe are working together to establish a cross-border pipeline network for green hydrogen, which generated from RWE's electrolyser plant in Lingen, Germany. The gas is transferred to Netherlands where uses existing natural gas pipeline network and then to BP's refinery in Gelsenkirchen, Germany. It is estimated that by 2030, the pipeline transportation of green hydrogen from refineries, steel mills and other plants in this program will reduce 16 million tons of CO_2. In addition, Germany's natural gas cities have increased their hydrogen blending ratio to 20%. Therefore, it is recommended that Taiwan CPC Can adapt and develop moderately to achieve the effectiveness of carbon reduction under the feasibility of blending hydrogen transmission and pipeline safety fitness verification.

Transformation of oil and gas enterprises from gas stations to hydrogen refueling stations

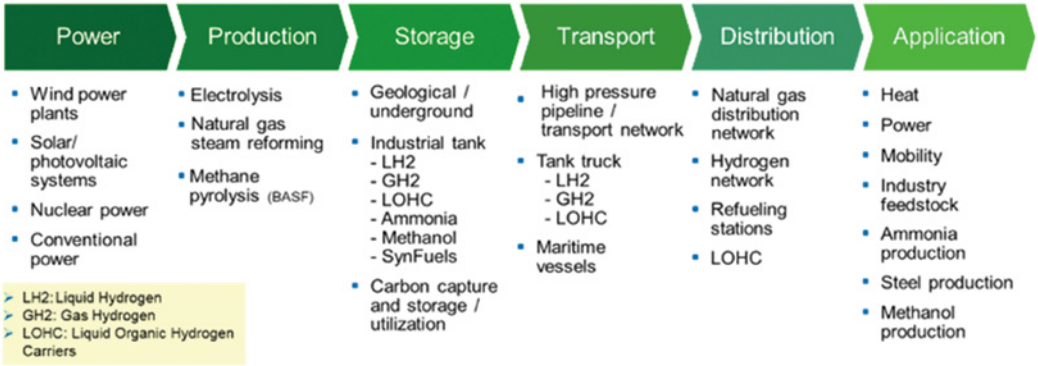
In order to promote the commercialization of hydrogen refueling stations in Taiwan, reference can be made to the "hydrogen partnership" approach of Germany's hydrogen strategy. Taiwan CPC is encouraged to build up strategic alliances with upstream hydrogen producers and downstream fuel cell vehicle operators to

accelerate the popularization of hydrogen refueling stations.

Due to the stringent public safety requirements for hydrogen refueling stations in Europe, America and Japan, strict third-party verification must be carried out in accordance with international standards such as ISO 19880 serise, SAE J2601 and etc., from safety risk assessment during the design phase of hydrogen refueling stations, manufacturing and inspection of major equipment and components of hydrogen refueling stations, on-site equipment installation verification and performance testing, hydrogen quality testing, and hydrogen refueling protocol testing of hydrogen refueling machines and fuel cell vehicles. Safety implemation is the first principle during development of hydrogen refueling stations

Carbon tracking and early warning management

Due to COVID-19 epidemic globally since 2020 and the chaotic energy market caused by Russia-Ukraine war in 2022, many countries, multinational organizations and industrial enterprises have realized that Net-Zero development has deviated from the plan. German government started to tighten its carbon management strategy since April 2022. And corporate organizations have been adopting dynamic carbon management measures and adapting third-party certified carbon tracking platforms to carry out intelligential ESG management. Therefore, it is recommended that Taiwan CPC can set more specific key performance indicators for carbon reduction and carbon footprint alert mechanism, to shorten review interval, to consider establishing a command center of carbon tracking management to implement dynamic management and prediction through big data analysis. These will verify the effectiveness of ESG management system and the ability of achieving goals, so as to gradually realize the low carbon goal by 2025 and Net-Zero by 2050.



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Achieve Net-Zero and Energy Independence with Offshore Wind and Renewable Hydrogen

P2X, offshore wind, renewable hydrogen

Russia's invasion of Ukraine and sequential energy crisis have led us to reflect further on our energy dependency. With Russia using liquified natural gas as a lever to fulfill its military and geopolitics ambitions, Europe realised now that it must end the long-term energy dependency on Russia. In addition, the transition cannot be only shifting sourcing fossil fuel from alternative export countries, otherwise, the EU will continue to entrench itself in the risk of high energy dependency.

Similar thinking may apply to Taiwan as its imports more than 98% of energy supply and largely relies on LNG as the bridging fuel in systematic energy transition before fully replacing coal with renewable energy. As Taiwan is at the start line toward the net-zero goal, we have to enhance our energy system resilience for the long-term pursuit of an autonomous energy system.

In Ørsted's latest white paper, "Need for Speed", we propose applying offshore wind power as the major source of renewable energy and a Power to X (P2X) model combining renewable hydrogen and e-fuels, which may pave a path to Net Zero meanwhile strengthen energy system resilience and autonomy along the way. A 4A approach underlines the 4 essential elements of the pathway- "Accelerate deployment", "Allocate the space", "Activate the industry" and "Appoint a clear role for renewable hydrogen and e-fuels". Bearing this in mind, I would like to take this opportunity to provide our approach as an example for the Taiwanese stakeholders to follow and stimulate more ideas.

Firstly, we welcome the government to collaborate with the industry to deploy even larger-scale renewable energy projects than the current status. Besides speeding up the ongoing renewable energy tenders, policymakers need to make it a priority for launching large scale energy complex projects. For example, the Danish government initiated the Energy Island Project, which could host up to 10 GW of offshore wind, combined with energy storage and hydrogen electrolysers. In Taiwan, we should also primarily focus on offshore wind farm development with installation capacity at a scale around 750MW to 1GW, in order to satisfy the massive market demand for affordable green electricity and enable offshore wind projects to integrate with renewable hydrogen and P2X facilities.

At the same time, offshore wind developers must continue to promote standardized and consistent design specifications for wind farm projects and components to further improve supply chain efficiency. Moreover, developers should also take responsibility to show market signals to the supply chain with long-term procurement demands as much as possible, and share extra risks with suppliers to mitigate market uncertainties. In the 900 MW Greater Changhua 1 & 2a wind farm project, Ørsted has demonstrated leadership by reaching an agreement with Siemens Gamesa to set up its offshore wind turbine nacelle assembly facility in Taiwan, best showcasing of moving ahead of the government to establish offshore wind energy ecosystem prior to policy timeframe.

Secondly, in terms of space allocation, we believe that maritime spatial planning should accommodate more offshore wind development to accelerate the energy transition. In the pathway to net zero, the Taiwanese Government proposes

lifting restrictions on offshore wind farms that were only allowed to be located within territorial waters. This is a significant first step as the most efficient approach would be consenting the developers to select wind farms at the completion of preliminary site screening and bear associated risks. Meanwhile, the authorities should avoid site duplication and wind farm boundaries overlapping so that those wind farm developers will not unnecessarily repeat the efforts at the same sea area, thus improving economic efficiency. When the market works in an efficient way, we have a greater chance to figure out the best business model for Taiwan marine spatial planning and utilize wind resources. As for the land, we should incorporate the grid network and PX2 infrastructure into long-term territorial spatial planning.

We acknowledge the need to continuously reduce environmental footprint and social costs when adding more renewable energy installations --- this is exactly the reason that Ørsted sets the ambition to deliver net-positive biodiversity impact in all renewable energy projects it commissions from 2030. On the other hand, we must conduct fair dialogues to enable mutual understanding and avoid misinterpretation to unnecessarily hold back renewable energy development. It largely relies on responsible and science-based environmental planning, environmental impact assessment, review and monitoring processes, as well as a more transparent and justice stakeholder communication mechanism. In doing so, we are able to build a solid foundation based on trust and evidence to realize a carbon-neutral future.

Thirdly, we anticipate further evolution of the entire offshore wind industry which offers affordable electricity at a fair cost and at the same time creates social value. As facing global copper and steel commodity price surge and cost increase in the supply chain, Taiwan authorities remain the upper limit of project capacity installation at 500 to 600 MW may lead to a poor scale economy of the offshore wind industry. We are deeply concerned that other than the historical cost decrease induced by technology innovations, is the industry moving towards a future with a vicious circle of unhealthy cost-cutting thus weakening the offshore wind industry from making a significant contribution to society? Acknowledge the problem, offshore wind auction bidding mechanism must seek improving project scale to ensure installation capacity is economically viable. Furthermore, (the mechanism should) encourage business models that create social value while discouraging those that embrace price war by undermining project quality. In appraising an offshore wind project, one should adopt indicators including: Completing the project on time and quality meanwhile achieving national carbon reduction targets, conserving and managing biodiversity, pursuing sustainability through collaborating with local communities, and using the best way to integrate the diversified energy portfolio and resilient grid network.

Apart from the auction bidding mechanism, the authorities may also consider having the constant growing market forces to drive offshore wind development. In other words, developers are granted autonomy for capital investment in offshore wind projects or facilities integration such as marrying green electricity to renewable energy as a response to diversified customer demands.

Fourthly, we should come up with a clear stance on renewable hydrogen and e-fuels. Renewable hydrogen and P2X have the potential as the solution to the industrial sectors difficult to phase out coal and synthetic fuel, at the "last mile" hindrance from achieving net-zero. Renewable hydrogen and P2X solutions can be the last mile to Net-zero target. A policy framework favoring P2X infrastructure is required for scaling up deployment. Other markets in the Asia Pacific (Korea, Japan, Australia) are already defining roles for renewable hydrogen in a variety of sectors from industrial usage to transport and power generation.

In the short term, we can use pilot projects to bring different stakeholders together, including developers, users, and governments, to shape the policy framework and road map. We could also consider gaining support from government grants or public budgeting before the market of P2X and investment and financing mechanisms becomes mature.

In the long term, we need to create an effective market for the production, sale, and application of renewable hydrogen and e-fuels, and this market needs to be driven by clear demand. Green power alone is not enough to achieve decarbonization in sectors such as heavy industry, aviation, and heavy transport. Apart from encouraging different sectors to invest in green hydrogen and e-fuel procurement planning through policy, it is

also vital to increase the scale and efficiency of renewable hydrogen applications, which will need to be pursued over the next decade or so, across production and consumption, across business and academics, and across government and private sectors.

At the same time, we suggest that P2X infrastructure and a hydrogen transmission backbone should be incorporated into the national infrastructure thinking and planning. The government could consider prioritizing the renovation or upgrading of existing gas supply networks in industrial or heavy transport clusters, and turn them into new hydrogen transmission backbones to support the acquisition and application of renewable hydrogen.

We believe that the denser and more large-scale the local P2X system is, the more resilient Taiwan's energy system will become. This resilience comes from two directions. Firstly, in the future, renewable hydrogen will be an internationally sought -after resource. Relying on the import of hydrogen from one or a few countries will replicate the over-reliance on fossil fuels of previous generations. Therefore, we need to ensure that we have the capacity of producing renewable hydrogen domestically. Secondly, the conversion of green power to renewable hydrogen or e-fuels can be seen as a form of energy storage, providing a complementary and stabilizing effect to renewable energy with intermittent characteristics.

Is Taiwan really capable of supplying renewable hydrogen on its own? Our answer is yes. It's an interlocking issue with offshore wind. By accelerating deployment, allocating the space, and activating the industry, Taiwan will have more affordable green power which creates the basis for the development of domestic renewable hydrogen production and applications. As we move towards a net-zero transition by 2050, and in the pursuit of energy independence over the past few generations to date, we foresee offshore wind and renewable hydrogen as key to our ambitions. Ørsted will continue to provide feasible, affordable, and sustainable solutions for Taiwan and the global community to realize our vision of a net-zero transition and energy independence. We will continue to focus on working with partners from different countries and communities to create a world that runs entirely on green energy.

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Author

Christy Wang is the General Manager of Ørsted Taiwan. She has overall end-to-end responsibilities for Ørsted activities in Taiwan. Wang manages and develops the Taiwan country organization and key functions in the Taipei office to ensure a well-functional business platform, which supports offshore wind farm projects and other business activities not only in Taiwan but also other markets in APAC.

CPC's Approach to Net Zero Transition—Pathways to Net Zero

台灣中油股份有限公司
CPC Corporation, Taiwan

CPC's strategies in response to the goal of net zero emissions by 2050

At the COP26 Summit, the target of "net zero emissions by 2050" was included in the Glasgow Climate Pact and carbon neutrality and net zero emissions became issues of much attention across the corporate world. The National Development Council in Taiwan also proposed its own pathways and strategies for net zero on March 30, 2022, also noting that more technology and research regarding net zero emissions and new energy technologies will be adopted after 2030. To facilitate these strategies, CPC founded the Climate Change Response Team in 2021 (Figure 1). Convened by the Chairman of the Board, the Team consists of Low Carbon Development Center and Manufacturing Energy Conservation Center, which are composed of people from different divisions and departments. The Team is focused on eight areas, namely transition strategies, hydrogen power, carbon capture, utilization and storage, low-carbon/zero-carbon energy development, offshore wind power, low-carbon/zero-carbon product supply, refinement transition, and carbon reduction in manufacturing. Through these efforts, it is hoped that a new CPC, a Clean Power Company, can be born, providing diverse power systems through materials innovation, carbon reduction, and green power development.

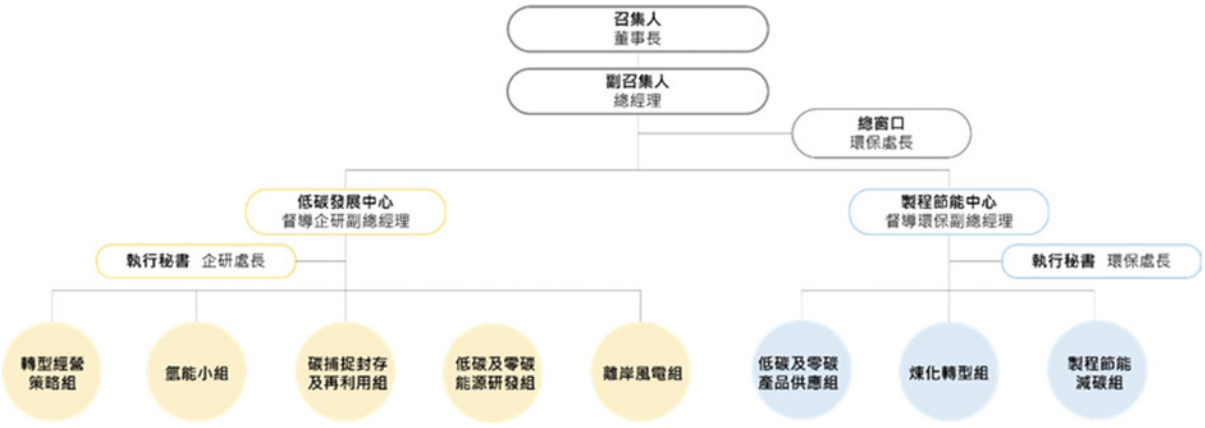

Figure 1 Organization of the CPC Climate Change Response Team

CPC GHG Reduction Performance Results

A state-owned company, CPC has one foot each in the power and petrochemical industries. Over the years, CPC has thoroughly implemented the government's carbon reduction policies and reduced GHGs. Since 2005, company-wide GHG emissions inventories and plant power saving measures have been adopted, and the Company has also carried out voluntary GHG reduction efforts per the Ministry of Economic Affairs. To strengthen carbon reduction, in April 2019, CPC established the Power Conservation & Carbon Reduction Group, with outside experts invited to the plants to provide guidance and suggestions on power

conservation and carbon reduction. After third-party verification, CPC reports 'a reduction in GHG emissions from 11.58 million tonnes in 2005 to 7.11 million tonnes in 2020, a 38.6% decrease, exceeding the amount required by regulation.

● 1. CPC's Goals and Pathways for GHG Emissions

In response to the global trend of net zero emissions, the Greenhouse Gas Reduction and Management Act was amended in 2021. The long-term goal was revised from a 50% reduction from 2005 levels by 2050 to net zero by 2050. To reach this goal, CPC has set mid-term goals of a 40.6% reduction in emissions from 2005 levels by 2025 and a 49.5% reduction by 2030 (Figure 2). Measures will be adjusted agilely and carbon-negative technologies such as renewable energy, hydrogen power, and carbon capture, storage, and utilization will be incorporated so as to enable reaching the long-term goal by 2050. The strategies are stated as follows:

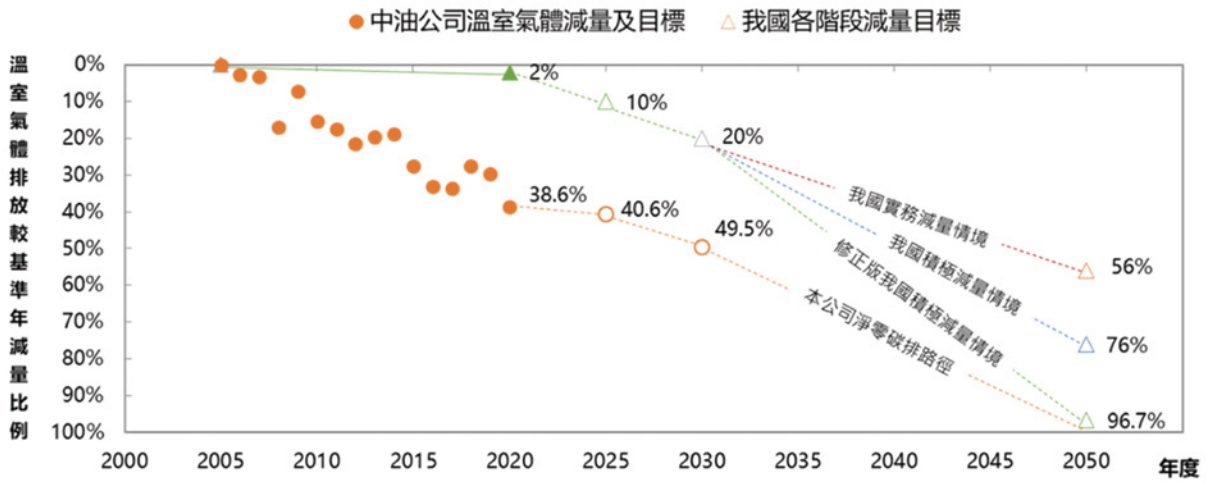

Figure 2 CPC's GHG Emissions Reduction Goals and Percentages on Base Year Over Time

(1) Continue to implement power conservation and carbon reduction plans; Set the goal of enhancing the power efficiency of refineries by 1.7%

- **Boost power efficiency:** Upgrade manufacturing process, expand productivity, and adopt advanced technologies; Set power consumption regulations and reinforce inspection and maintenance; Improve and update manufacturing process and systems.

- **Strengthen power management:** Integrate power management in manufacturing and heaters; Recycle and reuse oil gas, crude hydrogen, and mid and low-pressure steam to enhance power efficiency.

- **Complement and integrate of regional power:** Dalin Refinery uses CSC's waste heat and cold energy to decrease power usage.

- **Utilize low-carbon fuels:** Utilize low-carbon fuels like natural gas and cold energy.

(2) Develop renewable energy

- **Solar power system:** In response to developments in green power and the Renewable Energy Development Act, CPC is planning for the use of solar power systems as an integrated part of the management of the Company's diverse locations, along with carrying out related analysis. It is planned that by 2036, solar power generation capacity will reach 26MW and by 2045, 35MW.

- **Develop geothermal energy in Taiwan:** CPC is conducting geothermal drilling and productivity testing in Yilan for the establishment of geothermal energy plants. To expand the scale of geothermal energy, CPC is also analyzing deep geothermal energy in eastern Taiwan, the Datun Mountains, and elsewhere around the country. CPC has set as its goal reaching 4MW of geothermal energy capacity by 2023, 23.6MW by 2030, and 127MW by 2050.

(3) Carbon capture, utilization, and storage (CCUS)

- CPC is building an experimental carbon capture and transforming system to assess the technical feasibility and optimize the operation parameters, and also evaluating the introduction of the commercial CCU process for the following scale-up. It is planned that carbon capture capacity will reach 1,000,000 tonnes per year by 2030, of which carbon utilization capacity will account for 250,000 tonnes; in 2040, carbon capture capacity will reach 2,000,000 tonnes; and by 2050, 3,000,000 tonnes.

- CPC is evaluating the potential carbon storage sites and conducting the essential studies for a geological storage project. When a suitable site is chosen, several works will be carried out for the pilot test, such as monitoring, well drilling, surface facility engineering, and public outreach. It is planned that storage capacity will reach 100,000 tonnes by 2025, 750,000 tonnes by 2030, 500,000 tonnes by 2040, and 10 million tonnes by 2050.

A state-owned company, CPC is a leading energy supplier which continuously supplies oil and gas domestically. While remaining committed to both product and service quality and to the upholding of our corporate social responsibility, CPC will also follow the 2050 net zero emissions pathways proposed by the government and carry out transformation along three axes: oil optimization, carbon reduction, and clean energy. CPC will also collaborate with companies from home and abroad to develop relevant technologies, hoping to create new momentum that will drive sustainable development in Taiwan and help Taiwan reach its net zero goal faster.

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CPC's Approach to Net Zero Transition— Main Strategies and Action Plans

台灣中油股份有限公司
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To mitigate the impact of reducing GHG emissions and domestic oil product demand on the Company's business, CPC's strategy is focused on oil optimization, carbon reduction, and clean energy, driving corporate transformation through research and development to create relevant technologies and products. The Company's action plans are as follows:

Carbon reduction strategies

• 1. Reduce carbon and save power in the production process

CPC hopes to boost power efficiency by 1.7% in refineries. CPC will continue to encourage carbon reduction and power saving plans, carry out facility renewal, and strengthen regional resource integration to increase overall power efficiency.

• 2. Supply carbon-neutral products

CPC procured third-party-verified carbon-neutral crude oil and natural gas from global energy companies to supply domestic clients, strengthening green sustainability.

• 3. Carbon footprint inventory

CPC conducts GHG inventories which receive third-party verification to realize low-carbon sustainability. Internal carbon pricing (ICP) is also carried out.

• 4. Develop carbon-negative technologies

(1) Carbon capture and storage (CCS)

CPC has proposed a CO2 technology development plan, carrying out site surveys and vibration tests for carbon storage in areas neighboring CPC's refineries. The Company will evaluate their appropriateness, potential, and security so as to increase CCS capacity.

(2) Carbon capture and utilization (CCU)

In the early stage, CPC plans to build a carbon capture facility that can produce methanol at the Dalin Refinery. CPC will also develop a hydrogenation catalyst system which converts the captured CO_2 to petrochemical derivatives, building a complete circular economy supply chain. Additionally, CPC is working with CSC on a steel chemical co-production plan, transforming the converter gas into methanol and methane.

• 5. Develop biofuel and biodegradable plastics

CPC will adopt biofuel development to produce fatty acid methyl esters, polylactide (PLA), and hydroxymethylfurfural (HMF) to partially replace fossil fuels and reduce carbon emissions.

Oil optimization strategies

• 1. Develop COTC (Crude-Oil-to-Chemicals) technologies

By changing crude oil types, adjusting operating modes, and investing in key equipment, CPC will gradually boost the petrochemical product transition rate to reduce fuel, increase petrochemical products, and create new materials.

• 2. Develop high-value petrochemical materials and carbon circular applications

CPC is collaborating with industry, academia, and researchers to create green materials. Key items include:

(1) Dicyclopentadiene (DCPD)

To raise the added value of self-owned materials, Pygas can be used to produce high-purity DCPD through a C5 purification facility. This can be used in 5G high-frequency substrates, wind turbine blades, optical lenses, and as a key material in supporting the domestic semiconductor industry.

(2) Energy storage materials for batteries

In compliance with the government's green energy policy, CPC uses cheap heavy oil to produce soft carbon battery materials that have a long lifespan, high discharge, and high capacity. CPC is also developing lithium-titanium-oxide (LTO) batteries that are highly

safe, extremely durable, and have a long lifespan, making them suitable for use large power storage like batteries for e-buses.

(3) Bio-based hierarchical carbon

CPC is developing bio-based hierarchical carbon with energy storage material to enhance battery density. It can be used in capacitive deionization and supercapacitors.

(4) Steel co-production

CPC is collaborating with CSC to build a demonstration product line, taking the carbon monoxide and dioxide produced in the steelmaking process and synthesizing them through chemical engineering processes and hydrogenation catalysts into chemical products.

(5) High-modular carbon fiber

Through asphalt refining, CSC develops composite materials like high-modular carbon fiber and carbon fiber with wide applications. Lightweight, resilient, and low deformation, they can be used in areas that require high-strength materials, such as rail vehicles, wind turbines, and aeronautical facilities.

(6) Polymer processing technology and ethylene

CPC is developing ethylene and polymer processing technologies to produce linear low-density polyethylene (LLDPE), polyolefin elastomer (POE), ultrahigh-molecular-weight polyethylene (UHMWPE), and linear alpha olefin (LAO).

3. Develop smart green gas stations

In response to future market trends, CPC continues to build smart green gas stations that can generate and store energy. Solar power systems, natural gas batteries, and small wind-power facilities will be used as composite energy sources to create smart, net-zero, and diverse (oil/electric/hydrogen) energy supply stations.

4. Build charging facilities for e-vehicles/ e-scooters:

According to the Smart Energy Charging Facilities for E-Scooters Program approved by the Executive Yuan and budgeted for by the Industrial Development Bureau, 1,000 charging stations for e-scooters will be built by the end of 2022. Gas stations in suitable locations will also be chosen to have charging facilities for e-vehicles set up.

Clean energy strategies

1. Build solar power systems

Since 2010, CPC has been building solar power systems on the rooftops of gas stations. According to the Regulations for the Management of Setting Up Renewable Energy Power Generation Equipment of Power Users above a Certain Contract Capacity (also known as Major Electricity User Clauses), CPC is also seeking out other suitable sites for the deployment of solar power systems to expand capacity.

2. Develop domestic geothermal energy

CPC has carried out drilling tests in Renze and Tuchang, Yilan, and a demonstration plant is planned for construction in Tuchang. CPC will continue to assess deep geothermal options in eastern Taiwan, the Datun Mountains, and elsewhere around the country.

3. Enter the hydrogen energy field

Internationally, hydrogen energy technology is still being refined. CPC will launch a trial operation first and build mobile hydrogen stations for demonstration purposes. In the future, the Company will also organize and establish hydrogen facilities in line with the regulatory requirements and industrial demand.

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Currently, Mr. Tang is the Director of the Department of Planning at CPC, and has been in charge of strategic planning, performance management, investment planning, research and development, and sustainability planning for more than 5 years.

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CPC's Approach to Net Zero Transition—Carbon Capture, Utilization, and Storage (CCUS)

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CPC Corporation, Taiwan

Carbon capture, utilization, and storage (CCUS) is a process that captures and purifies (capture) the emitted CO_2 from power plants, steelworks, refineries, petrochemical plants, and cement plants. The CO_2 can be made into products, such as chemicals, building materials, and food additives (utilization). It can also be permanently stored underground, at least 800m deep, at high pressure (storage). CCUS is one of the best carbon-reduction technologies, and the International Energy Agency (IEA) regards it as an indispensable key technology for making net zero a reality.

In response to the growing push toward net zero, Taiwan's National Development Council, Executive Yuan proposed "Taiwan's Pathway to Net-Zero Emissions in 2050"on March 30, 2022, with carbon-negative CCUS technology among the 12 strategies for transition to net zero. On April 21, 2022, the Executive Yuan also passed the amendments to the Greenhouse Gas Reduction and Management Act, which will be sent to the Legislative Yuan for approval. The name of the Act will be changed to the Climate Change Countermeasures Act, and it will include a carbon fee and CCUS regulations.

To facilitate CCUS, CPC is taking the following approaches to drive research progress:

Establish a dedicated team

At the beginning of 2021, the CCUS Team was established, bringing together the resources of the Refining, Petrochemical and Exploration Departments to move forward with CCUS business and technology development. The Refining and Manufacturing Research Institute, Refining Business Division, and Petrochemical Business Division are responsible for carbon capture and utilization, while the Exploration and Development Research Institute and Exploration and Production Business Divisionare responsible for carbon storage.

Integrate domestic resources and localize technologies

CCUS can be divided into capture, utilization, transportation, and storage. CPC is developing critical technology and establishing trial sites. Using its partners' respective strengths of its partners, such as the steel chemical co-production with CSC and a monitoring technology collaboration with the Industrial Technology Research Institute (ITRI), such actions can be pursued at maximum R&D efficiency.

Learn from global commercial CCUS projects' best practices and adopt the necessary technologies

There are currently 27 commercial CCUS projects in operation worldwide. The sources of carbon captured include power plants, cement mills, steelwork, hydrogen plants, petrochemical plants, fertilizer plants, and natural gas treatment plants. Storage types can be divided into saline aquifers and enhanced oil recovery (EOR). In Taiwan, only saline aquifers are used as there are no appropriate oil fields for EOR.

To learn from the global cases and facilitate the launch of projects in Taiwan, CPC is now negotiating with project leaders and service companies regarding possible collaborations. For instance, CPC held meetings and negotiations with ExxonMobil, INPEX, TotalEnergies, and Schlumberger to secure business partnerships for adopting of necessary technologies and keeping track of technological development, shortening the R&D process.

Engage in public advocacy and communication

Looking at carbon storage projects around the globe, public acceptance is one of the decisive factors behind whether or not a project is successful. Protests and resistance were also why CPC's own carbon storage project was suspended. As such, it is necessary to gain insight into the public's understanding of and questions about this technology. CPC has collaborated with local governments, academic institutes, research institutes, and environmental protection groups to conduct public surveys to understand what the people think about CCUS, their level of acceptance, and their concerns about it. The survey will be a reference when making proposals, strategies, and promotional materials that communicate correct knowledge about carbon storage.

Participate actively in inter-agency CCS pilot test project to improve regulations

Since there are no regulations related to carbon storage in Taiwan for companies to abide by, no matter how much they want to, the government plans to build a local CCS trial site through an inter-agency CCS pilot test project, eliminating regulatory limitations and verifying storage security. CPC will comply with government planning in participation in this pilot test project, using this as an opportunity to develop crucial CCS technology and gather useful information to help the government in the establish sound regulations. The monitoring data collected will serve as a valuable reference for future amendments to the Climate Change Countermeasures Act.

Schedule

- **1. Carbon capture and utilization**

CPC plans to establish its carbon capture and transforming trial system by 2025. The Company will also conduct technology verification, catalyst development, process optimization research, and CCUS commercialization process assessment. In the early stage, CPC will build carbon capture sites by 2030 that could capture 1,000,000 tonnes of carbon per year, utilize 250,000 tonnes of carbon per year, and store 750,000 tonnes of carbon per year (see note).

- **2. Carbon storage**

Besides participating in the inter-agency CCS pilot test project, CPC plans to finish its carbon storage site survey in western Taiwan by 2024. The trial site design, planning, and construction will start based on the survey result. Initially, sites are planned to store 750,000 tonnes of carbon per year by 2030 (see note), with storage gradually increasing to match the Company's carbon reduction needs and storage technologies.

Note: Carbon utilization and storage goals are subject to adjustment based on actual conditions.

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Chih-Wen Wang and Allen Huang are the principal investigators of the "Carbon Dioxide Storage Technology Research" project at the Exploration and Development Research Institute of CPC, and they have coordinated the operations of the CCUS Task Force under the Climate Change Response Team of the company to promote CCUS as one of the net zero technologies towards 2050.

Taiwan CPC Hydrogen Energy Promotion Plan and Results

台灣中油股份有限公司
CPC Corporation, Taiwan

In the International Conference on Hydrogen Energy in March 2016, President Tsai Ing-wen publicly stated that hydrogen energy has been identified as one of the strategic options for Taiwan's future energy transformation, the establishment of a sustainable energy system, and the realization of a non-nuclear home. The government's "Taiwan 2050 Net Zero Emissions Pathways and Strategies," which was officially announced on March 30, 2022, mentions that in the preliminary 2050 Net Zero Emissions Roadmap, renewable energy will account for 60-70% of the total electricity distribution, with 9-12% of the electricity generated by hydrogen, and at the same time, hydrogen energy transmission and storage infrastructure (receiving stations, storage tanks, and pipelines) are to be planned and constructed in accordance with the domestic hydrogen energy supply and demand profile (sources and application areas), and develop domestic regulations and standards to improve the hydrogen energy management system.

Before that, in 2021, the Ministry of Economic Affairs had already proposed that "CPC should transform into a hydrogen energy supplier, initially focusing on the use of gray hydrogen, but gradually moving towards blue or even green hydrogen when the technology is mature, the laws and regulations are perfected, and the market is established." Therefore, CPC takes assuming the role of a domestic hydrogen energy supplier as well as providing safe and reliable hydrogen as its mission. In addition, CPC plans to further develop hydrogen energy applications and to integrate the research and development capabilities of domestic hydrogen energy manufacturers to build a technologically autonomous hydrogen energy industry chain in Taiwan.

With reference to international technology development and Taiwan's policy, CPC has planned a three-stage hydrogen energy development strategy: the first stage is "Establishing Technology, Demonstrating in Advance," in which a demonstration project of hydrogen refueling stations will be conducted to establish the feasibility of hydrogen energy market development. In the second stage, CPC aims to develop a hydrogen source that combines carbon sequestration, storage, and reuse technologies to recover carbon dioxide generated from hydrogen production and supply low-carbon "blue hydrogen" fuel, and to gradually increase its hydrogen supply capacity and establish a business model to meet market demand. In the third phase, "Hydrogen Reception, Clean Home," CPC aims to invest in the feasibility assessment and construction of liquid hydrogen reception stations and the import of green hydrogen fuel from countries with abundant renewable energy resources to help Taiwan move towards a "clean home" for hydrogen.

The first phase of Taiwan CPC's hydrogen energy promotion plan and results, including the construction of hydrogen refueling stations and decentralized fuel cell power generation systems, are described below.

Hydrogen refueling station construction

The "Taiwan 2050 Net Zero Emissions Roadmap and Strategy Summary" mentions the potential of hydrogen in carbon-free transportation because hydrogen fuel cell vehicles do not emit carbon dioxide while driving and have a significant advantage over gas and diesel vehicles in terms of refueling speed. However, a prerequisite for the full penetration of hydrogen fuel cell vehicles is the widespread establishment of hydrogen refueling stations, which are an important infrastructure for the commercialization of hydrogen fuel cell vehicles. As a state-owned company, Taiwan CPC is committed to the demonstration of hydrogen refueling stations in

line with the national policy, which is an important direction for the business transformation of Taiwan CPC.

The hydrogen station construction plan (see Figure 1) will be divided into three stages: evaluation of hydrogen station construction, procurement and construction of hydrogen station equipment, and implementation of the demonstration project and evaluation of benefits. The H35/H70 mobile hydrogen refueling station technology is planned for use in hydrogen buses (350 bar) and light vehicles (700 bar).

Initially, we will evaluate the location of hydrogen refueling stations and collect data on international hydrogen refueling stations. We will introduce hydrogen refueling station equipment that meets international standards through international standards and hydrogen refueling agreements. CPC will also make use of its existing gas station access points to gradually transform gas stations into energy supply stations that can supply hydrogen at the same time, providing consumers with a safe and reliable hydrogen supply environment.

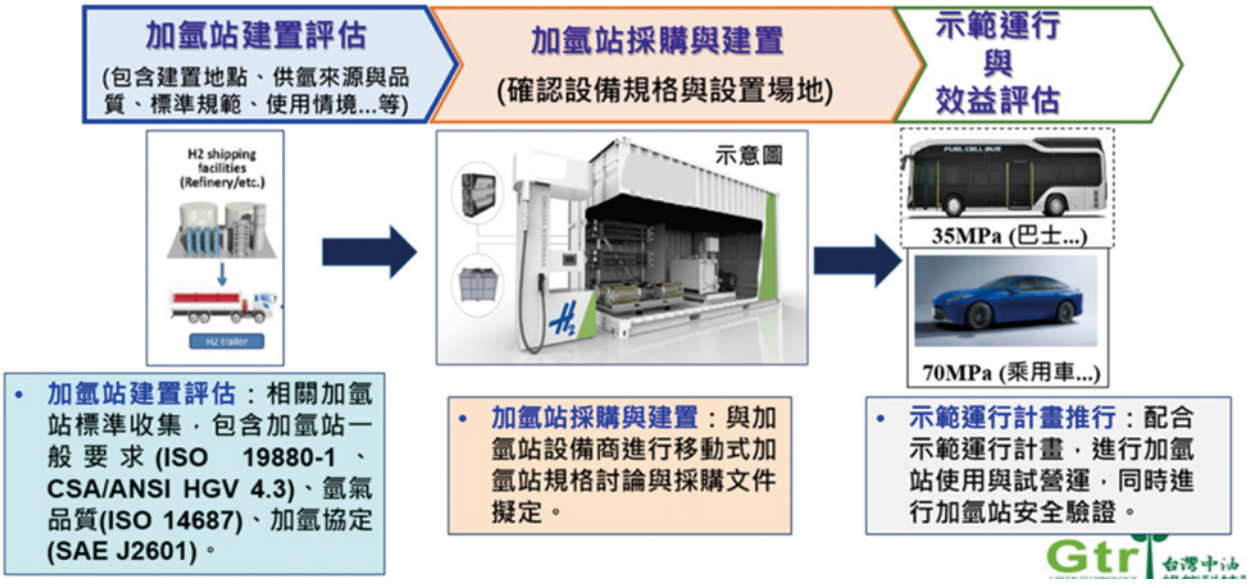

Figure 1 Hydrogenation Station Construction Plan

Decentralized fuel cell power generation system

Since 2016, CPC has been researching on decentralized fuel cell power generation system (Figure 2). Based on its past achievements and experience in developing key components of natural gas recombinant, CPC has developed natural gas recombinant for 5 kW class solid oxide fuel cell through catalyst screening, reactor design, optimization and control of reaction parameters, and thermal management of the system, etc. CPC has also cooperated with domestic research institutions to develop and establish natural gas pipeline gas and sulfur analysis and testing technologies for long-term operation and testing of the power generation system.

From 2019, we have introduced a fuel cell power generation system demonstration project, including the installation of two Japanese Panasonic low-temperature fuel cell systems (0.7 kW) at a smart green energy gas station on Qianfeng Road in Tainan, and integrating with its energy management system (EMS) for application verification. Furthermore, we are cooperating with domestic research institutions to conduct a demonstration project of 5 kW~25 kW solid oxide fuel cell (SOFC) power generation system. In the near future, we will invest in the construction of a fuel cell monitoring and warning system and a large data database. In the medium and long term, we aim to develop a SOFC commercial prototype with our partners or vendors, introduce remote monitoring, large data database, and AI analysis technologies, and establish a

SOFC system maintenance model to drive the development of the domestic decentralized hydrogen energy generation industry.

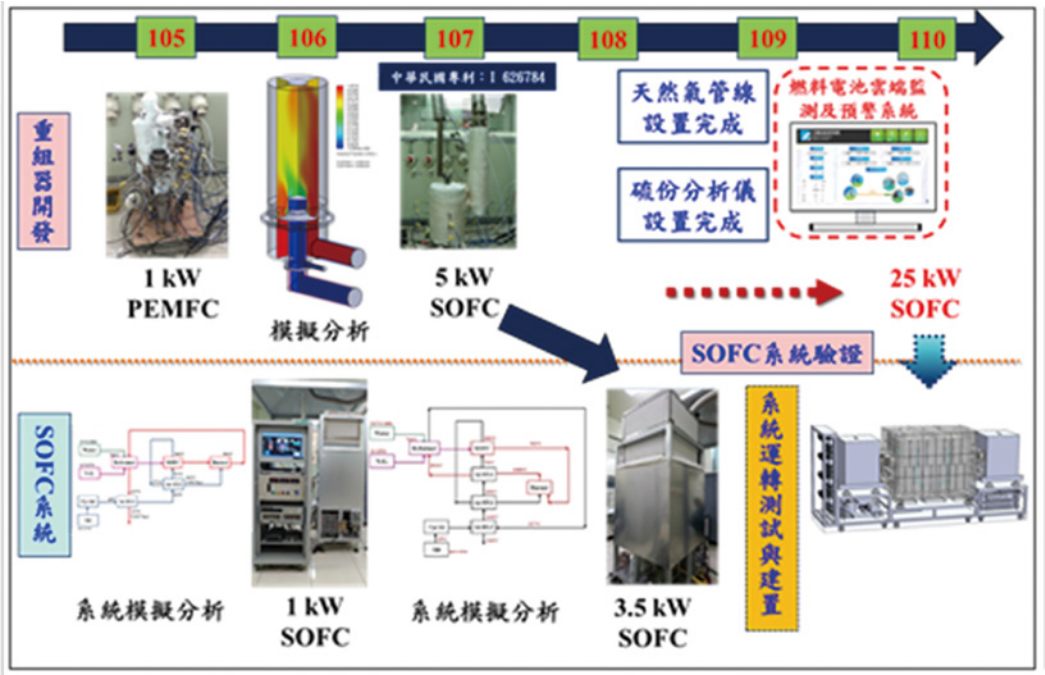

Figure 2 R&D history of CPC fuel cell power generation system in Taiwan

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Evolution of Hydrogen Energy Technology Development

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If the proportion of renewable energy can be further increased globally, it will contribute to net zero emissions. The most common way to use renewable energy is to convert recyclable natural energy (e.g., sunlight, wind, etc.) into electricity through power generation facilities, and after the conversion of renewable energy into electricity, most of the electricity produced is used in a ready-to-use manner because of the instability of renewable energy and the difficulty of storing electricity.

Currently, about 55% of the world's hydrogen is used in ammonia production, 25% in crude oil refining, and 10% in methanol production, all of which are used in oil refining and other industrial applications. Hydrogen can be used as an energy carrier for renewable energy residuals and can be effectively converted into electrical and kinetic energy, and is gradually being used in transportation, industrial and other applications. Hydrogen energy can be used as a fuel source for fuel cells, as well as directly in the industrial sector or as a fuel for transportation equipment, and the introduction of hydrogen fuel cell vehicles can reduce the environmental impact of conventional vehicles and is one of the options for developing hydrogen energy applications in Taiwan.

Hydrogen energy and fuel cell applications have gradually entered the early market, but there are still problems in production, storage, conversion, safety and cost to be overcome and improved. The key issues related to the development of hydrogen energy technologies are described below.

Hydrogen production technology

Currently, more than 95% of hydrogen is produced from coal, natural gas or oil, with natural gas vapor recombination accounting for more than half of the production. The recombination technology is not limited to the use of natural gas, but can be used to produce hydrogen from any compound rich in elemental hydrogen, while about 4% of hydrogen is produced by electrolysis, where a direct current is applied to electrolyze water into hydrogen and oxygen, and the different types of electrolytic baths can be divided into alkaline electrolysis (AEL), proton exchange membrane electrolysis (PEM) and solid oxide electrolysis (SOEC), depending on the electrolyte and charge carrier. However, the cost needs to be further reduced to meet the economic efficiency.

Hydrogen storage

There are three main ways to transport hydrogen fuel: high pressure cylinders, liquefied tanks, and pipelines. Currently, hydrogen is mainly transported in compressed hydrogen cylinders, which are low cost but have a small capacity and relatively high variable costs; conversely, hydrogen is transported by pipeline, which has high fixed costs but lower variable costs.

The widespread use of hydrogen energy depends on a well-developed hydrogen fuel supply and demand infrastructure to ensure the efficient use of hydrogen energy. In transportation, hydrogen refueling stations are an important part of the fuel supply chain for fuel cell vehicles. The popularity of hydrogen refueling stations is a prerequisite for consumers to move into the use of hydrogen energy. Regardless of the purpose of the hydrogen fuel, the demand for hydrogen and the distance to be traveled should be taken into consideration before evaluating the economic efficiency of hydrogen fuel for transportation.

Hydrogen fuel cells

Hydrogen fuel cells generate electrical energy by reacting hydrogen as fuel and oxidizer. There are

several types of hydrogen fuel cells depending on the type of electrolyte and charge carrier: alkaline fuel cells (AFC), proton exchange membrane fuel cells (PEMFC), phosphoric acid fuel cells (PAFC), and solid oxide fuel cells (SOFC). Among them, PEMFC is suitable for vehicle power source due to its low operating temperature (about 80 ° C) and high efficiency, while SOFC is suitable for cogeneration system due to its high operating temperature (up to 600 ° C). The selection of fuel cells depends on the environmental conditions. Although hydrogen fuel cells are highly efficient and environmentally friendly, the high cost is currently a major issue.

Taiwan's hydrogen energy-related manufacturers are mostly small and medium-sized enterprises (see Table 1), but their technology and capacity have long been recognized by the international community. For example, Chung-Hsin Electric's fuel cell backup system (Proton Exchange Membrane Fuel Cell) has been exported to South Africa, India and Southeast Asia. Porite, Kaori, AcBel, and Plus-Tech are the most important component supply chain for Bloom Energy's fuel cell system (Solid Oxide Fuel Cell: SOFC), a major international manufacturer, with an annual production value of several billion Taiwan dollars.

原材料 (上游)	電池組件 (中游)	系統應用 (下游)		周邊產品	
雙極板	電池組	系統		氫氣供應	系統周邊零組件
亞太	工研院	工研院	高力熱處理	三福氣體	高力熱處理
恩良	中科院	台電	恆昌精密	聯華氣體	康舒
順德	核研所	光騰光電	熠飛綠能	亞東氣體	保來得
禾新	光騰光電	亞太	安華機電	台灣中油	亞太
鼎旭	博研	博研	億鴻系統	甲醇供應	宏進
碳布、碳紙	鼎佳	核研所	協同能源	伊默克	台達電
碳能科技	中興電工	美菲德	碩禾	李長榮公司	漢鐘精機
觸媒	亞太	鼎佳	車測中心	甲醇燃料罐	光洋應用
碧氫科技	新力	中興電工	富堡能源	奇鋐	元寧
重組器	繼茂	光陽	聯合再生	儲氫合金罐	
工研院	順德	群翌	恩柏科技	漢氫科技	
碧氫科技	九豪	新力能源	聯盛數位	博研	
高力熱處理	璞真能源	亞洲氫能		亞太	
中興電工	膜電極組	錫力科技		旭陽科技	
俊鼎	揚志	漢氫科技			
臺禹科機	光騰光電	加百裕			
信通	亞太	能碩			

Table 1 Taiwan Hydrogen and Fuel Cell Related Companies

Under the 2050 net-zero emissions framework, the application of hydrogen is one of the ways that many countries have chosen to transform their energy sources, and in addition to the reuse of industrial residual hydrogen, the application of green hydrogen is the main way to achieve carbon reduction goals. Although the use of renewable energy for power generation can be an environmental and energy solution, renewable energy is intermittent and cannot provide a stable and reliable source of electricity, and by converting excess electricity from renewable energy into hydrogen storage, such as through fuel cells or direct combustion of hydrogen, the stability of energy supply can be further ensured. The development of low-cost and high-efficiency energy conversion and storage technologies will be the key to the combined development of hydrogen and renewable energy.

Application of Hydrogen Energy Technology

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Hydrogen is widely used in the petrochemical, petroleum refining, glass, food and semiconductor industries. Hydrogen can also be used as a fuel for fuel cells to generate electricity or as a source of energy for transportation.

Petroleum refining industry

Since crude oil contains sulfides, which can be toxic to the catalysts in the process, and the oil produced is subject to environmental regulations that limit its sulfur content to prevent sulfur oxides from being generated during combustion, which can cause acid rain and damage the environment, the refining industry often adds hydrogen to remove sulfur from crude oil, which is currently the most extensive use of hydrogen in the industry as a desulfurization process.
Hydrodesulfurization is a catalytic technology widely used to remove sulfur from natural gas and petroleum refinery products such as gasoline, jet fuel, kerosene, diesel and fuel oil. Sulfides in oil mainly include hydrogen sulfide (H2S), mercaptans (RSH), organic sulfides (RSSR) and cyclic sulfides (Thiophene, poly-cyclic thiophene), etc. Sulfides in oil with boiling points below 430°F are more frequent in mercaptans, and the higher the boiling point, the more cyclic sulfides. The presence of these sulfides in the oil will cause environmental and refinery equipment corrosion and other problems, which require the use of hydrodesulfurization process removal, refineries' hydrodesulfurization equipment include the following.

(1) Naphtha hydrodesulfurization

Reduce the sulfur content to below 1 ppm, which can be used as feedstock for restructuring plant to produce heavy group oil.

(2) Naphtha pyrolysis hydrodesulfurization

Reduce the sulfur content to less than 1 ppm and use as feedstock for aromatic hydrocarbon extraction plant to produce benzene, toluene and xylene.

(3) Diesel/Gas hydrodesulfurization

Reduce sulfur content to less than 50 ppm to produce high grade diesel oil.

(4) Vacuu m gas hydrodesulfurization

reduce the sulfur content to less than 0.3%, which can be fed to the catalytic cracking plant to produce catalytic pyrolysis gasoline.

(5) Fuel oil desulfurization

Reduce the sulfur content to less than 0.5%, which can be used not only as low sulfur fuel oil, but also as feedstock for catalytic cracking plant to produce catalytic pyrolysis gasoline.

Hydrocracking is a process in which hydrocarbon molecules in petroleum are

Petrochemical industry

(1) Ammonia

Can be synthesized by Haber-Bosch process, the required composition of synthesis gas is N2: H2 = 1: 3, at a temperature of about 450°C and pressure of 250 bar, the gas mixture through the activated iron oxide catalyst to produce ammonia, the reaction rate is very low, about 10%, so it is necessary to recover and reuse a large amount of unreacted synthesis gas. Ammonia can be used to produce fertilizers, ammonia, urea, melamine, urea esters, nitric acid and other chemicals. 2.

(2) Methanol

Carbon monoxide and hydrogen react at 5-10 MPa (50-100 atm) and 250 ° C to produce methanol by catalytic reaction of carbon monoxide and hydrogen. Methanol can be

used to produce formaldehyde, acetic acid, methyl formate, ethylene glycol, MTO, MTP and other chemicals.

Glass industry

A mixture of hydrogen and nitrogen is used to prevent defects and oxidation in the glass making process.

Food industry

Hydrogen can be used to hydrogenate unsaturated fats into saturated fats, improving the stability of fats.

Semiconductor industry

(1) Hydrogen

Hydrogen is a highly efficient reductant and etchant for the manufacture of semiconductors, light-emitting diodes, displays, photovoltaic components, and other electronic products.

(2) Annealing

Silicon wafers need to be heated above 1,000° C for lattice reorganization or annealing. Hydrogen heats the silicon rods uniformly to facilitate lattice reorganization and removal of oxygen elements.

(3) Epitaxy

Hydrogen is used to treat the surface of the buffer layer to avoid corrosion of the buffer layer and to remove impurities from the buffer layer to facilitate the formation of the epitaxial layer.

(4) Decomposition

Hydrogen can penetrate directly into the film to reduce the crystallinity and improve the insulation properties of the layer.

(5) Stabilizing

The addition of hydrogen can extend the shelf life of important electronic chemicals, such as ethylborane (B2H6) and digermanium (Ge2H6), which would otherwise decompose slowly.

(6) Lithography

Lithography is the process of using light to transfer the pattern of a semiconductor chip from a master called a photomask to a silicon wafer. In the extreme ultraviolet (EUV) production process, tin droplets are stimulated by the laser to emit ultraviolet rays, resulting in the unwanted deposition of tin chips in the light collector, which requires periodic cleaning of the chamber and the use of large amounts of hydrogen to react with the deposited tin to form tin hydride (SnH4), which is then removed using a vacuum pump.

Hydrogen fuel cells

Hydrogen fuel cells use hydrogen and oxygen as feedstock, and the products are water and heat, which do not emit carbon dioxide and cause greenhouse effect. Hydrogen is used as the fuel and oxidized at the anode, while oxygen is used as the reductant and undergoes a reduction reaction at the cathode, and electrons are transferred from the anode to the cathode to generate direct current, forming a complete circuit, and the electricity generated can be integrated into the power grid or used by home users. Hydrogen fuel cells can also be used as a source of energy to move vehicles.

Vision and Limitations of Hydrogen Energy Technology Development

台灣中油股份有限公司
CPC Corporation, Taiwan

Author / Frank Tang

In recent years, it has become a global consensus to address climate change. The 26th United Nations Climate Change Conference (COP 26) in 2021 not only discusses how to achieve the goal of net zero emissions, but also places a high priority on energy transformation, with hydrogen energy promoting the accelerated deployment of renewable energy and power system flexibility, as well as playing an important role in the green and low-carbon transformation of energy use. Over 20 countries have already published or developed hydrogen energy strategies, and hydrogen energy has become one of the means to achieve Taiwan's 2050 net-zero emissions path. According to information released by the Hydrogen Energy Council in January 2020, widespread hydrogen energy applications will be competitive by 2030 as the cost of renewable energy and hydrogen energy decreases.

Currently, countries around the world are developing hydrogen energy as an overall strategic plan on a national level. Taiwan is similar to Japan in that it is an island nation with limited land and natural resources and cannot develop abundant renewable energy sources like Europe. At the same time, the cost of hydrogen production and the maturity of the technology should be taken into consideration to facilitate the promotion of the industry. The following is a description of the research and development vision and limitations for hydrogen production, storage, and application.

Hydrogen production technology

Currently, the mainstream method of hydrogen production is natural gas vapor reforming (SMR). However, since natural gas from fossil fuels is used as the raw material, carbon dioxide is also produced during the process. Also, in order to reduce carbon emissions, carbon capture technology can be used to capture the carbon dioxide produced without releasing it into the atmosphere, so the hydrogen produced by vapor reforming with carbon capture technology is called "blue hydrogen" and is a technology that can be put into research and development and expanded production. Yet, the biggest bottleneck is how to store the captured carbon dioxide, and whether there is a suitable storage site in Taiwan needs to be further evaluated and verified.

The use of renewable electricity and the development of hydrogen production technologies have been considered by the European Union as the main axes of future hydrogen energy strategies, and the hydrogen produced is also known as "green hydrogen." Hydroelectrolysis methods include alkaline electrolysis, proton exchange membrane electrolysis, and solid oxide electrolysis, etc. Currently, alkaline electrolysis is the main axis of commercialization, but its conversion efficiency is low (65-82%), while solid oxide electrolysis is the most popular hydrogen generation technology recently, mainly because it has the highest conversion efficiency (85-90%), and solid oxide electrolysis equipment is gradually entering the industrial growth period, with equipment costs expected to drop significantly. However, in order to reduce the cost of green hydrogen production, excess green power must be used to make it economically viable. In the short term, Taiwan's share of renewable energy is still not high, and we must wait until a large number of offshore wind turbines are built and other renewable energy sources (geothermal and ocean energy, etc.) are invested before we can create economically viable self-produced green hydrogen.

Hydrogen storage technology

The biggest bottleneck in the hydrogen energy supply system is storage and transportation, with the focus on improving the efficiency and safety of long-distance hydrogen transportation. Currently, high-pressure hydrogen (>700 bar) is the most widely used and the most technically mature, and has been used in hydrogen carriers and hydrogen refueling stations. Only Kawasaki Heavy Industries in Japan has developed HySTRA technology and built a demonstration station for liquid hydrogen reception at the Port of Kobe,

and will complete its first long-distance marine transportation demonstration between Australia and Japan in early 2022. Taiwan's energy supply system is similar to Japan's, and when the technology for transporting liquid hydrogen is commercialized, it will be possible to plan for a large hydrogen import receiving station. However, dialogue and communication with the public will be required in the future in order to overcome potential resistance from residents when evaluating the construction of receiving stations and long-haul land-based hydrogen pipelines.

Hydrogen applications

• Power generation applications

Hydrogen can be used to generate electricity through hydrogen or natural gas doping, while fuel cells can also be used to generate electricity in high efficiency regions. The former has already been tested by Taipower, and the latter has been developed by domestic manufacturers for low-temperature proton exchange membrane fuel cell (PEMFC) power generation systems. PEMFC features fast start-up and has been mainly used in mobile vehicles (e.g., cars, buses, and drones), while its application in stationary power generation is limited by its low power generation efficiency, therefore, it is mainly used in small and medium-sized domestic cogeneration systems and remote areas for backup power. In Taiwan, CPC has invested in the development of solid oxide fuel cell (SOFC) power generation system technology. SOFC has the advantages of high power generation efficiency, diversified fuel sources, and direct use of natural gas, which makes it more suitable for stationary power generation applications, and therefore has a stable growth in medium and large industrial power generation devices or small-scale domestic cogeneration devices.

• (2) Transportation applications

Currently, hydrogen vehicles are mainly used in passenger cars and large and heavy-duty vehicles, with the passenger car market not having an obvious advantage over electric vehicles. There are still opportunities in the commercial large and heavy vehicle market (e.g., buses, logistics vehicles, and trucks). However, Taiwan does not yet have complete hydrogen energy regulations and standards, and the construction of hydrogen vehicles on the road and hydrogen refueling stations are both projects that need to be overcome in the short term. Currently, CPC is actively engaged in the planning of mobile hydrogen refueling stations and is seeking partners to promote hydrogen carriers as a demonstration project, in the hope of accelerating the development of hydrogen transportation vehicles in Taiwan.

• (3) Industrial applications

In addition to meeting the original demand for industrial hydrogen use, many new net-zero carbon emission technologies have been introduced into industrial technology development; for example, the steel industry uses hydrogen to make steel, and carbon capture and reuse (CCU) requires the introduction of hydrogen to produce synthetic fuels or chemicals. Related industrial applications of hydrogen energy technology are also flourishing.

Taiwan started hydrogen energy research and development about 20 years ago, and some companies are still in operation, but it has not yet been industrialized on a large scale, mainly due to the lack of support from the national hydrogen energy policy and the public's acceptance of hydrogen energy use. The "2050 Net Zero Emissions Roadmap" announced in March 2022 has included hydrogen energy as one of the key carbon reduction strategies, and a special law on hydrogen energy management will be enacted. At present, CPC has introduced a decentralized fuel cell power generation system at a gas station on Qianfeng Road in Tainan, and has become a venue for environmental education to promote green energy and hydrogen civic education. In the future, CPC plans to complete the construction of a mobile hydrogen refueling station and promote a demonstration project for hydrogen carriers, with the state-owned company leading by example in a cooperative model that will accelerate the development and growth of the domestic hydrogen technology and industry.

The Next 20 Years - Transformation of Port Logistics and Carbon Neutrality

東立物流股份有限公司
Tonglit Logistics Co., Ltd.

As a logistics company, Tonglit Logistics is privileged to partner with numerous outstanding international enterprises with the aim of keeping pace with the global development towards carbon neutrality and net zero carbon emissions, thus enabling us to have greater clarity of purpose and a clearer vision of the future path.

Tonglit Logistics is mainly engaged in the logistics service of vehicle imports and exports at the Port of Taipei. In the nearly 20 years since its establishment in 2002 and its official operational beginning in 2004, we have seen a trend of domestic vehicle sales and use, with imported vehicles growing from 13% in 2004 to 48.9% in 2021, resulting in dynamic logistics activities generated by these commercial vehicles. However, the carbon emissions produced by these logistics activities are an inevitable product of these economic activities.

Whether in response to the mandatory requirements of legislation such as the UNFCCC, or the mutual demands of various economies, or even the awakening of corporate sustainability awareness, the entire supply chain is responding to carbon reduction. Manufacturers are producing low-carbon goods: The share of pure electric vehicles imported through Tonglit Logistics compared to other vehicles has increased from 0.1% in 2011 to 3.7% in 2021. 14,000 electric vehicles are expected to be delivered through Tonglit Logistics in 2022, accounting for 6.8% of the estimated 207,000 vehicles handled annually. This doubling rate of growth indicates that brands are accelerating their efforts to reach the goal of net zero carbon emissions by 2050, with a 10-fold increase expected after 2025, upon which electric vehicles or alternative energy vehicles are bound to become the dominant mode of transportation.

However, not only manufacturers, but more important means of transportation in logistics activities, such as transportation machinery, trucks, and ships, are moving in the direction of green energy, exploring various sources of power, including the use of hydrogen and ammonia as energy sources for ships and transportation vehicles, or developing these new energy sources for transportation vehicles. At the same time, many countries are also moving toward green ports, including the installation of on-shore power at terminals and the use of hardware such as electric machinery. As a first-tier member of these ports and an important part of the supply chain, Tonglit Logistics is committed to continuing the mission of greening the supply chain, and it is against this background that the planned "Intelligent Vehicle Industry & Cross Border Logistics Park" is emerging.

"Go Green & Go Smart" is considered as the vision of the Park for the next 20 years. In line with the government's six strategic goals of green energy and renewable energy, the park aims to develop green buildings as the foundation and green power generation sites; to establish an electric and smart smart vehicle logistics platform, and to build a regional transportation hub for e-commerce and smart logistics in the Asia-Pacific region.

"Go Green" aims to establish a 100% carbon-neutral and sustainable park, utilizing solar energy and wind turbines to generate green power for ship docking, infrastructure, electric

vehicle connections, and charging of commercial electric vehicles in the park. In addition, it is intended that the project will be able to connect with the industry's technologies in hydrogen energy development, as well as with the existing hardware and software facilities and environmental resources around the Port of Taipei, in order to assist and facilitate the development of the Port of Taipei into a hydrogen energy demonstration port.

Based on Tonglit Logistics' expertise in automotive logistics and port logistics, "Go Smart" aims to develop and unify all new energy activities in the park, and to control the generation and recycling of energy in the park through a comprehensive intelligent control center and green energy management system. "Vehicle logistics" together with the evolution of vehicles would gradually focus on electric vehicle equipment, with vehicle battery management and charging and discharging system management as necessary additional services. "Port logistics" requires green operations as the foundation. In addition to green buildings, automation and intelligence of logistics providers are standard equipment, and the goal is to use electric carriers or FCVs (fuel cell vehicles) to avoid carbon emissions generated by fuel carriers, whether in the park or even for goods shipped outside the region.

With the aim of green logistics, the park adopts solar energy and wind energy as the basis for power generation, and gradually introduces hydrogen energy, a clean energy source. In addition to the sustainability of our own business, we also support the development of sustainability for our clients and hope to do our part for the earth.

Tonglit Logistics plans to establish a 100% carbon-neutral sustainable park in the Port of Taipei

Chapter.4

Net Zero Carbon Emission Public Aspirations and Commitment

Achieving Net Zero Carbon Emissions

Since the 26th United Nations Climate Change Conference (COP26), countries have resolved to strengthen the review of phased carbon emission reduction targets, and the expectations and pressure from the government, investors and other parties have accelerated enterprises' awareness of the urgency and importance of net-zero transformation. However, according to the "Taiwan Corporate Climate Action Survey" conducted by 2021 World Magazine, it was found that more than 60% of the companies surveyed do not regularly disclose climate related information, and more than 50% of the companies do not conduct GHG inventories, do not understand their own operational emissions, and are not clear about how to reduce and reach their net-zero emission targets.

In the face of the global net-zero wave, companies urgently need to set reduction targets, develop strategies and action plans, establish carbon reduction paths, implement net-zero transformation, and integrate climate issues with daily operation mechanisms.

Refine and Optimize Internal Management Strategies

To explain how to achieve net zero carbon emissions in a more simple way by analogy, it is easiest to understand by using the analogy of weight management, which is common in the lives of ordinary people. When we adopt weight management, the first task is to understand the composition of fat, muscle and other components, so that we can set weight loss goals that suit our own situation; the same goes for promoting zero carbon emissions, companies need to understand the composition and sources of greenhouse gas emissions to set reduction targets.

Secondly, when carrying out weight management, we also need to understand the diet, exercise and other lifestyle habits, draw up a management plan, and gradually adjust; similarly, when promoting net zero carbon emissions, enterprises need to re-examine internal management strategies, amend the old model, according to the reduction target to establish a management approach to promote action plans.

The following is a sequential explanation of how companies can optimize and refine their internal management strategies: introducing greenhouse gas inventories, setting scientific reduction targets, establishing energy management

systems, promoting employee behavior change, and implementing internal carbon valorization.

• 1. Introduction of Greenhouse Gas Inventory

The purpose of greenhouse gas inventory is to inventory the sources and emissions to determine the situation and quantity of greenhouse gas emissions to help enterprises grasp the potential risks, and the inventory information as the basis for setting carbon reduction targets, to help the right medicine to draw up reduction measures.

Greenhouse gas inventory according to the inventory object, scope, different purposes, are divided into two categories: one is the organization (a single company, or factory, or group) as the inventory object, known as the organization-type greenhouse gas inventory; the other is a single product as the inventory object, known as the product carbon footprint inventory.

The information from the organizational GHG inventory is the primary basis for helping companies set company-wide reduction targets, while the information obtained from the product carbon footprint inventory helps companies understand the emissions of specific products and services from raw material

Category	Organizational Greenhouse Gas Inventory	Product Carbon Footprint Inventory
Characteristics	• Reviewing GHG emissions from operations from the perspective of a company (or plant, or group)	• To examine the greenhouse gas emissions over the life cycle of a specific single product from the perspective of that product
Purpose	• Understand the emission sources and emissions associated with the company's operations • Identify the hotspots of emissions from the company's operations as a reference basis for setting company-wide reduction targets and measures	• Understand the emissions of specific products from raw material extraction, transportation, manufacturing, distribution, etc. • Identify the hotspots of emissions for specific products as a reference for setting the carbon reduction targets and measures for specific products
Scope	• Direct emissions: Emission sources owned or controlled by the enterprise (e.g., boilers, in-plant stackers, chilled water host refrigerants, greenhouse gases used in manufacturing processes, etc.) • Indirect energy emissions: Emission sources related to the use of energy but not directly controlled by the enterprise (e.g.: purchased electricity, purchased steam, etc.) • Other indirect emissions: emissions related to business operations, but not directly controlled by the enterprise (e.g., employee commuting, business travel, etc.)	• Raw material extraction: calculate the emissions generated by the raw materials needed to manufacture a specific product at its manufacturing stage • Manufacturing stage: calculate the emissions generated by the energy resources used by the company to produce a specific product • Transportation stage: Calculate the emissions from the transportation of a specific product from the factory to the distributor • Product use phase: calculate the emissions generated when the specific product is used at the customer's end • Product disposal phase: Calculate the emissions generated from the disposal of a specific product at the end of its life.

Because the organizational GHG inventory covers a more comprehensive range, and is the primary basis for enterprises to promote net-zero carbon emissions, the following focus on the nine steps for enterprises to introduce GHG inventory.

Category	Organizational Greenhouse Gas Inventory	Product Carbon Footprint Inventory
Step 1	Convene interdepartmental kick-off meeting	The inventory process covers all aspects of daily business operations. Through inter-departmental kick-off meetings, senior executives explain the purpose and commitment of the inventory, establish an inventory team, and identify the responsible persons for each department to facilitate smooth follow-up work.

Category	Organizational Greenhouse Gas Inventory	Product Carbon Footprint Inventory
Step 2	Make sure that the inventory specifications followed	According to the purpose of the inventory, establish that the international norms followed (for example: ISO 14064-1:2018) or domestic norms (for example: greenhouse gas emissions inventory registration management method).
Step 3	Define the inventory boundary	In accordance with the audit criteria, we identify the business units, subsidiaries, and physical locations to be included in the audit. For example, if an enterprise conducts an audit in accordance with the requirements of the Financial Supervisory Commission, the audit boundary must be consistent with the financial statements.
Step 4	Identification of emission sources	Review the businesses, subsidiaries, or physical locations within the boundary to identify direct sources, indirect energy sources, and other indirect sources of emissions.
Step 5	Collecting activities data	Data collection of usage, purchase, and fugitive amounts based on the raw combustion materials used by the emission source or the greenhouse gases that escape.
Step 6	Selecting emission coefficients and global warming potential values	The corresponding emission coefficients are selected based on the emission sources and activity data. The appropriate global warming potential value is also selected according to the inventory criteria followed.
Step 7	Calculate the carbon dioxide equivalents of seven greenhouse gases	After calculating seven types of greenhouse gas emissions from activity data and emission coefficients, each greenhouse gas was converted to CO_2 equivalent using global warming potential values.
Step 8	Aggregate information to produce documented reports	Consolidate and record the inventory methods, data, procedures, assumptions and estimation results, and issue a greenhouse gas emission inventory and greenhouse gas inventory report.
Step 9	Conduct third-party verification	According to the enterprise's own needs and the inventory specifications followed, a third-party verification agency is commissioned to conduct verification to ensure the integrity, accuracy and consistency of the inventory information.

• 2. Setting Science-based Reduction Targets

After enterprises grasp the operation-related greenhouse gas emissions, reference to the science-based approach to set greenhouse gas reduction targets and pathways. The so-called science-based approach is proposed by the science-based target initiative (science-based target initiative, SBTi) organization to help enterprises calculate, in accordance with the global warming limit of 1.5 ° C under the circumstances, enterprises in the short and medium term (to 2030) must reduce greenhouse gas emissions, as a reduction target value, in order to ensure that the reduction results of enterprises closely follow the global temperature control targets.

The scientific basis of the reduction target will be greenhouse gas reduction and global average warming link explicitly, to strengthen the contribution of corporate action to global targets. SBTi provides standardized calculations to help companies focus on the Paris Agreement and set annual reductions with a 1.5° C warming limit.
The guidance document published by SBTi specifies that the reduction target must cover at least direct emissions (Scope 1) and indirect energy emissions (Scope 2). If a company's other indirect emissions (Area 3) exceed the sum of Area 1 and Area 2 emissions by more than 40%, then Area 3 must be included in the reduction target. In addition, taking into account the differences between industries, SBTi has also developed industry-specific specifications to help companies incorporate industry characteristics when setting targets. After the SBTi certification, the reduction targets of enterprises will be disclosed on the SBTi website, announcing the commitment of enterprises to reduce carbon emissions to the world. As certified companies adopt a consistent methodology, the reduction

targets are comparable and analyzable among them, and help stakeholders to track the progress of emission reduction.

• 3. Establishing an Energy Management System

After taking stock of greenhouse gas emissions and setting reduction targets, in order to achieve the goals. The next step is to start adjusting the old management strategy and establish a carbon reduction action plan. In general, the primary source of greenhouse gas emissions from enterprises, most of them come from direct and indirect energy use, including electricity use, boiler fuel, purchased steam, among others. How to effectively manage energy to reduce greenhouse gas emissions is an essential key to the success of enterprises to achieve net zero emissions reduction.

The ISO 50001 energy management system provides companies with a standard system and process approach to first understand the external challenges (e.g. industry energy saving targets, greenhouse gas emission control, among others) and internal issues (e.g. corporate sustainability considerations, energy saving targets, among others) and establish the objectives and scope of energy management. Second, establish policies and guidelines for energy issues and identify which units or departments are responsible for managing them. If multiple departments are responsible for energy issues within a company, the roles, responsibilities, and authorities of each unit need to be clarified and clearly documented to ensure that all relevant units understand their responsibilities. Further, the responsible unit will lead the process of establishing an energy baseline, collecting energy-related data, setting quantitative energy management targets, establishing performance indicators, and developing a performance evaluation monitoring, measurement, and internal audit system, as well as a continuous improvement mechanism.

The energy management system assists all departments in implementing energy management tasks and responsibilities, and establishes a monitoring mechanism to review the achievement of goals regularly. When enterprises improve their grasp of energy data and make good use of data analysis technology, they can identify high energy-consuming facilities and equipment and precisely promote equipment retirement or process improvement measures to reduce greenhouse gas emissions effectively.

Enterprises can also take advantage of intelligent operating systems and introduce energy management systems (EMS) integrated by software and hardware equipment to monitor energy usage through a visual interface, detect abnormal energy consumption in real-time, and improve immediately with automated control.

• 4. Promote Employee Behavior Change

If a company is to promote zero carbon emissions successfully, it is necessary to integrate zero commitment into the corporate culture and help internal employees understand and recognize the meaning and impact of zero transformation on the company's daily operations. Only when employees affirm and support the company's zero vision and goals, emission reduction strategies and action plans can be integrated into the operations of all departments.

Enterprises can take the lead through climate change, net zero emission reduction and other related education and training courses to gradually build employees' environmental awareness and start to pay attention to climate change-related issues. Further lead the staff of each department to brainstorm and consider what role the current industry and the products and services provided by the company can play under the global zero trend, and then narrow down the scope to what influence each department has and what changes they can make.

After taking stock of the company-wide and departmental influences and possible carbon reduction measures, enterprises can design various mechanisms, such as spotlighting and rewarding departmental low-carbon actions, holding innovative carbon reduction competitions, among others, to promote employees to change their behavior and thinking in daily life and business level, so that the low-carbon transformation of enterprises is no longer just a "top-down" directive, but a "bottom-up" joint collaboration.

• 5. Implementing Internal Carbon Valorization

Internal carbon valorization (or internal carbon pricing) is a way for companies to internalize

the external costs of greenhouse gas emissions by putting an explicit price on greenhouse gas emissions, which helps companies grasp the costs of carbon management and facilitates convergence with carbon prices in external carbon markets. Depending on the purpose and the current carbon reduction process, companies can choose the appropriate carbon pricing mechanism: internal carbon fee, shadow price, and implicit price.

An internal carbon fee is a fixed price per ton of greenhouse gas emissions. Each department will multiply the price by the amount of greenhouse gas emissions it emits to calculate the cost. The carbon fee collected can be used to provide dedicated funding for internal carbon reduction efforts or to reward departments for achieving reduction targets. However, the internal carbon fee that each department is required to pay may be limited by the functional characteristics of the department, so how to reasonably collect and allocate the carbon fee needs to be planned appropriately.

In practice, the price is based on the theoretical price of carbon dioxide per tonne, and most companies use future climate related policies or changes in the carbon market to estimate the cost of carbon emissions. If companies use shadow pricing, it is easier to link future carbon related financial risks and prepare for external carbon costs in advance. Shadow pricing also helps companies to consider climate risk in their medium to long-term investment decisions, and is a risk management measure.

The implicit price is the internal price of carbon based on the cost of reducing greenhouse gas emissions in the past and the cost of one ton of CO_2 equivalent. Since the calculation is based on investment actions that have already occurred, it is difficult to reflect the actual cost of carbon emissions, to provide forward-looking information for corporate risk management, and to create cross-departmental capital flow opportunities within the company. As a result, although the implied price mechanism has the advantage of being easy to calculate, in practice it is rarely used by companies.

Cross-industry / enterprise Technology Innovation and Exchange

Innovation and technology is the key to carbon reduction for enterprises. Since the industrial revolution to digital innovation, emerging technologies have provided various solutions for human life. In the face of climate change, enterprises actively grasp low-carbon technology applications and innovative research and development, and accelerate the introduction of commercial applications to convert climate risks into business opportunities, reverse the wrong perception of "carbon reduction = profit loss," and create a corporate body of "the more carbon reduction, the more profit."

Through cross-industry cooperation and joint development of net zero solutions, enterprises can break through the constraints of insufficient resources and over-concentration of a single skill in the talent pool, and through knowledge and technology sharing, they can not only achieve joint carbon reduction, but also develop new business opportunities and create a net zero ecosystem.

From the integration of the industry value chain to promote cross-industry zero technology innovation and cooperation model, it helps enterprises to more effectively promote low-carbon transformation, and the results can actually be reflected in the enterprise's scope 2, and greenhouse gas emissions in scope 3. Starting from the enterprises themselves, on the one hand, they cooperate with upstream suppliers to research and develop low-carbon raw materials, components, and net-zero energy, among others. On the other hand, they work with downstream customers to develop business models that reduce carbon emissions of products and services at the use and disposal stages, leading to a paradigm shift in the value chain, expanding results and potential to capture the net-zero market further.

• 1. Innovation in Collaboration with Suppliers

Suppliers are the most important partners of enterprises, including raw material production and related transportation and logistics, energy supply, and contracting services, among others. Without these suppliers, the operation of enterprises will suffer a severe impact. This relationship is also reflected in the carbon emissions of enterprises. According to the report "Zero Carbon Emissions Challenge: Opportunities in the Supply Chain"

published by the World Economic Forum, for the food industry, through the innovation of raw materials and processes, cooperation with suppliers to reduce deforestation can reduce emissions by about 45%; for the electronics industry, through the cooperation with suppliers in raw materials, processes and energy supply net zero, can achieve about 55% of the reduction results.

Michelin, an internationally renowned tire manufacturer, has committed to achieve sustainable tires for all its tire products by 2050, and to achieve total carbon neutrality in raw materials, components, logistics, and its own operations. In order to achieve this goal, Michelin began to set up in 2012, and worked with IFP Energies Nouvelles, a French energy and transportation research unit, and Axens, a petrochemical manufacturer, to launch the Biobutterfly project with the support of the French Energy and Environment Administration.

The Biobutterfly project aims to develop biomass materials (wood, rice straw, corn, beets, among others) into synthetic rubber, replacing the original petroleum-based raw materials, with the goal of making Michelin's tires fully biomass-based synthetic rubber. The goal is to make Michelin's tire products fully biomass-based synthetic rubber, which will not only increase the recyclability and sustainability of the products, but also reduce the carbon footprint of the raw materials.

The 10-year partnership made significant progress in 2019, successfully extracting butadiene, a critical synthetic rubber feedstock, from ethanol made from biomass. Michelin has also announced the completion of a demonstration production in 2020, which is expected to produce 20 to 30 tons of biomass butadiene per year, and the technical validation to start commercial mass production in 2021.

In addition to biomass synthetic rubber, Michelin is also working with Pyrowave, a plastic chemical recycling company, to develop ways to extract recycled styrene from waste plastic containers to replace styrene, another essential raw material used in the manufacture of spun tires. Michelin and Swedish tire pyrolysis company Enviro are working together to develop a way to recover carbon black from scrap tires and use the recovered carbon black to produce new tires, thereby reducing the use of virgin raw materials.

Through cross-industry collaboration, Michelin has successfully launched innovative products, releasing MotoETM products with 33%-40% sustainable raw material content in 2021 and increasing the proportion of sustainable raw materials to 40%-46% in 2022, successfully achieving the medium-term goal of using an average of 40% sustainable raw materials in all product lines by 2030.

• 2. Innovation in Collaboration with Clients

More often than not, we hope to maintain a close and long-term partnership with our customers. Through various communication and cooperation, we can identify customers' needs in advance, provide innovative services and help them solve their problems. If we can develop innovative solutions together with our customers, we can not only help them reduce costs and carbon emissions, but also develop new low-carbon business opportunities.

As a major producer of petrochemical raw materials in Taiwan, LCY Chemical Company mainly produces plastics, thermoplastic elastomers, solvents, among others. It also supplies isopropyl alcohol and acetone, which are critical in the cleaning process of many semiconductor and LCD companies in Taiwan. The company works with its customers to recycle used isopropanol from the electronics industry and recycle it into the same level of isopropanol that can be used in the customer's manufacturing process. This not only reduces the potential environmental impact that may be caused by improper disposal procedures by the customer, but also reduces the environmental impact of LCY Chemical's own production of isopropanol.

The isopropanol waste left behind by semiconductor manufacturers after the rinsing process contains 90% water and 10% isopropanol, which used to be incinerated by semiconductor manufacturers without any recycling method. LCY Chemical found that incineration was easy and convenient, but caused unnecessary greenhouse gas emissions and wasted resources. Therefore, we took the initiative to promote cooperation with our customers, and LCY Chemical Company was responsible for transporting the waste isopropanol from the customer's end to the chemical company's manufacturing process for separation and filtration to produce 60%-70% pure isopropanol, and then distillation and purification

to become electronic grade isopropanol with a purity of over 99.9999%, which is the same as the product provided to the customer at the beginning, and then returned to the customer's manufacturing process.

Through the cooperation with its clients, LCY has successfully developed new services that not only reduce greenhouse gas emissions, but also received the Taiwan TCIA Circular Economy Award and the Triple R Best Partner Award from semiconductor clients.

• 3. Linking the Value Chain to Promote Net Zero Emission Reduction

When enterprises conduct greenhouse gas inventory and develop reduction strategies, they not only need to clarify their own operational emissions, but also need to grasp the relevant carbon emissions from upstream suppliers, transportation and logistics, and downstream customers when using products, in order to achieve a comprehensive reduction. However, in practice, many enterprises encounter difficulties in clarifying the emissions of upstream and downstream manufacturers, in addition to incomplete data, there may also be many inconsistencies in the calculation method, the definition of margins, resulting in enterprises facing the net zero target is still challenging to move forward.

In order to find a solution, the food industry value chain in Brazil started a cross-industry collaboration in November 2021. Initiated by AMAGGI, a grain producer; BRF, a food brand group with operations in 117 countries; Rumo, Brazil's most extensive rail logistics service provider; Raizen, a biomass energy company; and SINAI Technologies, a software platform service provider, the partnership aims to collect, calculate, and forecast greenhouse gas emissions data from the global food supply chain, and The project aims to collect, calculate, and forecast greenhouse gas emissions data from the global food supply chain, and share the data and information with each other to promote the industry to take action to mitigate climate change and promote decarbonization.

The participating companies would use the information platform of SINAI Technologies, a software platform service provider, to share greenhouse gas emission data of the whole value chain from planting, crop production, trading, transportation and logistics, livestock breeding, food production, food distribution, among others from Brazil to the world. The goal of the project is that in the future, this database will not only help value chain partners understand carbon emission hotspots, but also help local food buyers identify which products are low-carbon and serve as a reference point when purchasing food.

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

Introduction

The ECCT established the Low Carbon Initiative (LCI) in 2011 to introduce European policies and showcase the best European low carbon solutions across a broad range of industries, to raise awareness about sustainable development and promote the adoption of low carbon solutions in order to help Taiwan to reduce its carbon emissions. The LCI aims to demonstrate what European and leading multinational firms are doing to address sustainability challenges and help to promote low carbon solutions by engaging local industry, policymakers and the public to work together to meet the targets set by the Taiwan government and to deal with rising energy costs.

LCI Structure

The Low Carbon Initiative, supervised by the LCI Steering Committee, has seven categories and four working groups. In 2017, the LCI set up seven categories: Green Energy, Green Financing, Energy Efficiency, Green Mobility, Smart Cities, Smart Manufacturing, and Circular Economy. To respond to Taiwan's net zero by 2050 target, the LCI has further created the four working groups under the seven categories.

Four Working Groups

- **Green Finance, ESG and CPPA working group**

This working group is to collaborate with the government and different stakeholders on promoting ESG & sustainable investment, and fair and transparent green electricity trading in Taiwan.

- **Energy Saving and Green Building working group**

This working group is to promote energy saving and green building best practices in Taiwan through high level roundtable dialogues with government and events organised with LCI members and partners.

- **Eco-mobility & Eco-logistics working group**

This working group is to promote using green electricity for EV infrastructure, efficient grid & power dispatch systems, alternative fuels, hydrogen, and eco-logistics in Taiwan. The working group also encourages setting up pilot projects for eco-mobility & eco-logistics in various municipalities.

- **Sustainable Supply Chain working group**

This working group is to advocate for responsible production and consumption in collaboration with government and industry. The working group also arranges site visits to successful examples of sustainable supply chains.

Contact LCI

Contact Us: Sammy Su, Director of ECCT LCI
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To know more about the LCI

LCI Members

The LCI has received acknowledgement and support from the highest levels of government, industry and academia and has formed strong partnership with key stakeholders in Taiwan. The LCI's membership has risen notably from 14 to 91 since 2013. The LCI member companies of 2022 are listed in alphabetical order:

LCI Trade Office Members

Model Spirit Leading International Businesses

台灣中油股份有限公司
CPC Corporation, Taiwan

The formation and development of CPC

CPC was established in Shanghai on June 1, 1946, initially under the aegis of the Council of Resources -the precursor of today's State-owned Enterprise Commission, Ministry of Economic Affairs.

Following the ROC government's relocation to Taiwan in 1949, the corporate headquarters was set up in Taipei, and the company's affiliation was transferred to the Ministry of Economic Affairs. Its business scope and facilities are carried out throughout Taiwan, encompassing importing; procurement; exploration; production; refining; storage, and distribution of oil and gas. In addition, CPC produces petrochemical raw materials.

In line with both the global trend and environmental protection, in 2003 CPC instituted a policy for sustainable development.

On February 9, 2007, the board of directors approved to change the company's English name from "Chinese Petroleum Corporation" to "CPC Corporation, Taiwan."

On June 17, 2016, the board of directors approved a revision of the company's articles of association and moved its headquarters from Taipei City to Kaohsiung City.

CPC's capital now stands at NT$130.1 billion and its turnover in 2021 totaled NT$908.9 billion.

Sustainable Operation Policy

• CPC's Sustainable Operation Policy

- Comply with both Taiwan's national regulations and international protocols.
- Practice comprehensive clean manufacturing methodology to protect the environment.
- Conserve water and energy resources through efficient utilization.
- Place importance on fulfilling CSR commitments and expanding its service area.
- Establish indicators for environmental protection while maintaining transparency.
- Actively research and develop products while expanding new areas of business.

In 2005, CPC set up the Sustainable Operations Promotion Committee, with a focus on strategy formulation and objective setting, to address sustainable operation issues. The company's actions for sustainable operation fall into four major fields: environmental and ecological conservation; social care; strategy formulation and development; and environmental accounting and information. The Committee's level was upgraded in 2007 and it is directed by the CPC's Chairman personally. CPC's President holds the post of associate director of the committee, and the Vice Presidents, Spokesman and CEOs of the five major business units serve as committee members. Since 2008, it has recruited external scholars and experts as its members. The committee convenes three times a year to discuss reports and proposals regarding the aforementioned four fields. In this way, the committee is able to gain a timely grasp of the social pulse, promote sustainability issues and keep track of implementation progress.

With regard to communication with stakeholders, apart from providing related information in a specific section of its website for this purpose and issuing annual reports, CPC has released annual Sustainability Reports since 2007 for explanation and disclosure purposes to show its determination to communicate with all stakeholders. Such efforts have been acclaimed by society and received multiple awards. In

the future, CPC will apply the UN's Sustainable Development Goals (SDGs) as benchmarks for its own sustainable development program, continue to highlight sustainable operation issues through the work of the Sustainable Operations Promotion Committee, and disclose information related to sustainable development. CPC strives to benefit both "environmental protection", "economic development", and "social care" and work with all parties to create a better future.

2021 Affirmation and honors

• CPC's Sustainable Operation Policy

- Reader's Digest Trustworthy Brand Platinum Award for 21st year in succession.
- Readers Digest Trustworthy Brand Gold Award, Lubrication Oil Product Category for 3rd year in succession.
- In the 2021 Asia Corporate Excellence & Sustainability Awards (ACES), awarded the "Sus-tainability Award—Top Sustainability Advocates in Asia", and Chairman Shun-Chin Lee named the "Leadership Award—Individual—Outstanding Leaders in Asia Award."
- 2021 Asia Responsible Enterprise Awards (AREA) awarded "Green Leadership Award" and "Social Empowerment Award."
- Received nine major awards in the Taiwan Corporate Sustainability Awards (TCSA) including Comprehensive Performance Award-Taiwan Top 50 Sustainable Enterprise Award, Enterprise Sustainability Report Awards-Energy Industry Platinum Award, and seven Outstanding Case awards.
- Taiwan Sustainability Action Award (TSAA) awarded a gold and two silver awards, showing the best model of sustainable development of enterprises.
- Received eight major awards in the 18th National Brand Yushan Award, including two National First Prizes with 95 Unleaded Gasoline and Smart and Green e-Stations.

前言

序言

第一章｜國際淨零碳排趨勢與因應

第二章｜企業共同響應淨零碳排

第三章｜萬眾注目的解方－氫能應用與發展

第四章｜淨零碳排－眾志成城

歐洲在臺商務協會理事長 前言

張瀚書
歐洲在臺商務協會 理事長

歐洲在臺商務協會對於台灣環境保護以及永續發展的投入可追溯到 1989 年，當時商會創設了環境保護委員會。經過多年來不斷努力，在 2012 年進一步成立「低碳倡議行動」（Low Carbon Initiative, LCI），跨出了在永續發展議題上重要的一步。自那時起，LCI 分享、倡導其眾多會員的先進技術、解決方案和做法，成為幫助台灣各界實現低碳未來的重要夥伴。在低碳發展方面，歐洲不但是先驅，並且仍然是當前的領導者。歐盟在創建永續發展的政治和法律框架方面扮演了標竿的角色，並率先承諾至 2050 年實現淨零碳排的目標。同時，歐洲企業在研發低碳能源解決方案與技術方面亦持續處於領先地位。透過政府與企業的積極作為，創造了全新的供應鏈和商業模式。

歐洲商會支持台灣承諾 2050 年達到淨零碳排，無論是通過正在進行的能源轉型，還是經由制定系統策略，減少製造業、交通運輸、建築和農業等部門的碳排放。歐洲商會會員公司透過在各個產業部門的行動，積極幫助台灣實現其目標。

繼 2018 年歐洲商會與中油公司成功發表《下一代能源轉型報告書》後，LCI 再次與中油公司攜手合作，於今年共同出版歐洲商會 – 臺灣中油「淨零報告書」。本報告亦展示了台灣中油和歐洲商會 - 低碳倡議行動的會員公司，提供台灣和全球最佳實踐案例和解決方案，可供台灣政府採用。舉例來說，亞東工業氣體和道達爾能源公司，合作實現氫氣生產脫碳，並實施大規模二氧化碳捕捉和儲存解決方案 (CCS)，博世提供生產氫氣所需的技術、用於移動和固定應用的燃料電池以及加氫站，高蓋爾茲法律事務所分享了澳洲的氫能政策和發展戰略，默克集團積極開發有助於節約能源的材料，並用環保替代品替代有害材料，米其林公司生產的輪胎可以降低滾動阻力，從而降低耗能，沃旭能源制定了發展氫能堅實可行的策略，萊茵集團提出了浮動式離岸風電的技術及建置，台電公司為綠色能源轉型強化基礎設施的佈建，大江生醫承諾達成零碳工廠和零碳產品，阿特拉斯·科普柯集團以科學基礎碳目標減少其價值鏈中溫室氣體排放，東立物流創建智能綠色碳中和物流園區，渣打銀行提出綠色專案融資的重要性，而睿思再生能源和德國萊因分別闡述在減碳過程中，必須執行的盤查和認證工作的重要性，以協助企業真正達到淨零碳排的目標。此外，德國在台協會和法國在台協會也為該報告提供了實現淨零目標的國家政策和策略。

根據上述案例，再加上可再生能源、儲能、電網基礎設施和建築以減少碳排放方面的更多投資，採用這些案例及解決方案，將有助於台灣更加順利和迅速地達到淨零，特別是與歐洲商會和會員公司合作，可以共同加速台灣邁向淨零經濟的轉型，使台灣成為淨零社會的典範。

張瀚書
歐洲在臺商務協會理事長

台灣中油公司董事長 前言

李順欽
台灣中油公司 董事長

布局淨零 邁向永續

隨著全球暖化升高，氣候變遷加劇，2050 淨零排放蔚為國際共識，能源企業莫不規劃重組轉型，台灣中油也不例外。

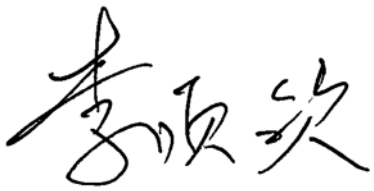
2021 年台灣中油成立「氣候變遷因應工作小組」，進行總體轉型規劃；在政府 2050 淨零排放路徑架構下，歸納以優油、減碳、潔能為策略主軸，涵蓋自進口、煉製生產至銷售端，全面淨零布局。

優油面向，主要發展漸進式 COTC，提高原油製成石化原料的比例並進行高值化，發展基礎材料產業。此外，就是銷售端的優化，所屬智慧綠能站將設置太陽光電和氫燃料電池，並以雲端管理系統儲能；未來還將引進氫能。

減碳面向，目前年碳排 711 萬噸，相較於 2005 年，減量達 38.6%；進一步訂定 2030 年減量 49.5% 之中期目標，並將持續滾動檢討以 2050 年達成淨零排放為長期目標。同時，將利用碳捕捉、再利用及封存 (CCUS) 技術，在 CCU 部分，開發所需之關鍵觸媒，透過煉化工廠碳捕捉轉為甲醇，以有效降低碳排。此外，已完成 5 艘碳中和天然氣之採購，將繼續以此模式支持世界造林及復育計畫。

潔能面向，在生產端，進行地熱開發，後續也將評估規劃發展氫能供應鏈 (HESC)；在銷售端，已建置 4 座智慧綠能站，產能、儲能、用能三合一，全台首座碳中和加油站也在台南前鋒站正式啟用。

台灣中油長期致力於環境永續、社會共融、公司治理 (ESG) 之三贏，追求永續發展；面對淨零大趨勢，深知「不轉型就等死」(Transform or Die)，並相信藉由三大策略規劃的逐步達成，台灣中油將實現 Clean Power Company 新願景，成為帶動台灣永續發展的新動能。



李順欽
台灣中油公司董事長

經濟部部長 前言

王美花
經濟部 部長

歐盟是全球淨零轉型的領導者，不僅領先其他主要經濟體承諾於 2050 年達成「氣候中和」，更進一步提出「綠色新政」，擘劃邁向淨零排放所需法規制度、政策架構與技術路徑，其相關制度已成為其他國家參考效法的標竿，而歐洲企業研發的低碳解決技術與方案亦居全球領先地位，成為各國也是臺灣落實淨零轉型的重要夥伴。

歐洲在臺商務協會長期投入臺灣環境保護議題，並於 2012 年成立低碳倡議行動 (Low Carbon Initiative, LCI)，針對綠色能源、綠色金融、能源效率、綠色交通、智慧城市、智慧製造及循環經濟等 7 項核心領域，與臺灣政府部門及產業界分享歐洲最佳低碳方案與規範，有效協助臺灣提升永續發展認知，促進我國公私部門節能減碳。

回應全球淨零趨勢，臺灣已於 2022 年 3 月發布 2050 淨零排放路徑，並規劃透過風電 / 光電、氫能、前瞻能源、電力系統與儲能、節能、碳捕捉利用及封存等 12 項關鍵戰略逐步落實淨零。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，而歐盟無論在淨零轉型的制度規範、再生能源或氫能等前瞻技術等領域都處於世界領先地位，期待臺灣與歐盟能夠攜手合作，共同投入相關技術研發與商業應用，一同為全球淨零貢獻心力。

王美花
經濟部部長

歐洲經貿辦事處處長 前言

高哲夫
歐洲經貿辦事處 處長

歐盟氣候行動週是我在 2019 年於歐洲經貿辦事處到任時所參加的頭幾場活動之一。而今年，我很高興再次展現歐盟對台灣氣候問題的承諾。

我們正面臨嚴峻的氣候挑戰，其規模及嚴重性是顯而易見的。氣候變遷產生的不利影響在全球都可感受到，這對我們整個地球和所有人民都是威脅。台灣當然也不例外。台灣因其島嶼地形，特別容易受到因氣候變遷而加劇的暴雨和洪水的影響。

為克服氣候挑戰，歐盟執委會於 2019 年 12 月提出綠色新政，其目標為在 2050 年將歐盟轉型為一個現代化、有效運用資源且具競爭力的氣候中和經濟體。實現氣候中和不僅能為未來世代確保一個健康的地球，而且還將有助於改善當今人們的福祉。

在過去的三十年裡，歐盟一直站在全球應對氣候變遷的前線。歐盟所採取的行動包括投資實用技術解決方案、賦予公民權力、並在在工業政策、金融和研究等關鍵領域一致推動氣候目標，同時也確保社會公平。面對氣候挑戰，各行各業都有必須扮演的角色——從能源產業、工業、交通、建築、農業和林業都至關重要。

台灣雖未簽署《巴黎協定》，但多次表示將遵守其減少碳排的國際義務。我要特別對台灣承諾於 2050 年實現淨零排放表示歡迎。氣候變遷是全球威脅，只有透過全球合作才能克服。

這就是為什麼歐盟在氣候行動積極支持其國際夥伴，也是為什麼我很高興能夠發表於臺灣中油 - 歐洲商會「淨零報告書」。朝向氣候中和邁進的過渡既是一項緊迫的挑戰，也是打造更美好未來的機會。我們能展示歐洲不同產業為實踐低碳的最佳作法與解決方案，以協助台灣減少碳排放。

這份報告在 2022 年歐盟氣候行動週的第一天發布，象徵著我們為倡導一個更永續的世界而共同努力。本報告中分享的策略和計畫只是我們打造永續未來的開端。我希望閱讀此報告能啟發更多朝向我們共同的淨零目標推進的嶄新做法。

現在是採取行動的時候，而這項聯合倡議是必要的一步。我們今天所做的選擇將決定我們的未來。前行的道路充滿挑戰，但也充滿機會。我們必須努力尋找新的方法來贏得這項全球的挑戰，讓我們的孩子在和平的星球上過上有尊嚴的生活。這不是過於理想化或天真的追求，而是為了我們的價值觀、遵循科學、強化經濟和打造更美好的未來。

高哲夫
歐洲經貿辦事處處長

黃正忠博士 序言

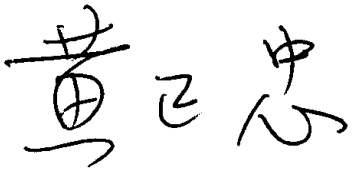
黃正忠 博士
安侯永續發展顧問公司
董事總經理

先進國家的淨零行動，驅動著系統性的產業轉型，包括再生能源、電動車與氫燃料車等低碳運具、循環營建、低碳製造及智能資通訊科技等。隨著新技術解決方案、市場和政策機制，以及消費者行為等變化，全球將進入快速發展的淨零轉型。企業要參與這場改變，不僅需要了解淨零對企業的重要性，更需要全方位縝密規劃淨零策略與行動的落地。

綜觀國際能源總署 (IEA) 淨零報告，全球技術關注及國家策略中，氫能源扮演極為關鍵的角色，是各界引頸期盼的技術選項，由於氫具有零碳分子特性，且因熱值高、燃燒速度快，依目前國際技術評估為替代傳統化石燃料之最佳可行方案。

氫能的運用，仍存在許多挑戰。首先，氫氣必須透過化石燃料或再生能源的能量轉換，產製並儲存，本質上屬於「能源載體」；同時氫氣的特性，在運輸與儲存特別困難，因此氫能發展，必須克服來源供應、運輸儲存及能耗成本等瓶頸，這也是必須面對的挑戰。本報告特別邀請歐洲商會 (ECCT) 低碳倡議行動 (LCI) 夥伴就淨零碳排與氫能的運用與發展，從全球倡議、國家政策至企業推動實務進行分享。

安侯永續發展顧問股份有限公司分別於 2015 年、2018 與歐洲商會低碳倡議行動合作編制「提升台灣產業能源效率 - 與歐盟攜手共進」及「下一世代能源報告：共策台灣能源轉型」報告之後，有幸於今年再度攜手合作編制「2050 淨零最佳實踐報告」，亦希望透過本報告呼籲台灣政府和企業應更積極透過政策制定和資金計畫，投資前瞻性技術：氫能、碳捕捉、再利用及封存 (CCUS)、氫燃料汽車、浮式風機等，以支持國家和企業推動的淨零排放路徑。另外，透過觀察發現，由於政策、資金和新市場的機遇，全球金融業紛紛提出淨零轉型金融行動，特別在氫能、電池儲能、智能電網和節能技術等，已吸引數十億美元的資金投資，可見未來淨零商機無限，我們冀望透過本報告書最佳實踐的案例，讓政府與企業能有更多元的視角，共同創造跨國界、跨領域的合作關係，攜手邁向 2050 淨零碳排的未來。



黃正忠 博士
安侯永續發展顧問公司 董事總經理

第一章
國際淨零碳排趨勢與因應

淨零碳排風潮來襲

氣候變遷議題於始於西元 1992 年在巴西召開「地球高峰會」，自此每年基於「聯合國氣候變遷綱要公約」(the United Nations Framework Convention on Climate Change，簡稱 UNFCCC) 每年度展開聯合國締約國大會（Conferences of the Parties，簡稱 COP）。自 1997 年在日本京都召開的第三屆締約國大會（COP3），為溫室氣體減量立下重要的里程碑。2007 年聯合國政府間氣候變化專門委員會」（Intergovernmental Panel on Climate Change, 簡稱 IPCC）發表第四次評估報告，更明確指出人為溫室氣體排放是造成全球平均溫度上升的主要原因，科學證據亦指出全球暖化所造成之負面影響將危急貧窮人口；並模擬減量目標及相對經濟影響，亦提出適應及減緩方案。

在確立人為因素導致溫室氣體排放與全球溫度上升後，往後的聯合國締約國大會皆以《京都議定書》作為精進主軸，期間歷經多國政治角力與拔河，終於在 2015 年第二十一屆締約國大會（COP21）達成突破性的發展。會議中通過《巴黎協定》(Paris Agreement)，同意將全球暖化升溫控至於攝氏 2 度 C 之內，並以控制在工業化前平均水準的攝氏 1.5 度內為目標進行減碳規劃，期望能共同遏阻全球暖化趨勢。除此之外，協定中也明確定出全球溫室氣體排放必須於 2030 年前減量 45%、並於 2050 年前達到淨零排放。

接續 2018 年 IPCC 同步發布 1.5 度 C 特別版報告，進一步將全球氣候目標設定為限制升溫攝氏 1.5 度 C，並於報告中提及淨零排放 (Net Zero Emissions）之概念，也促進全球從國家至企業的展開的淨零賽局。在此版報告中，IPCC 針對常見淨零二氧化碳排放 (Net zero CO_2 emissions)，又俗稱碳中和 (Carbon Neutrality)、淨零排放 (Net Zero Emissions）提出明確定義，兩者最大不同之處在於碳中和僅針對溫室氣體中的二氧化碳減量，而淨零排放則是涵蓋現行七大類溫室氣體，其減量的範疇更為廣大，詳見下方列表。

專有名詞說明	定義	溫室氣體減量範疇
淨零二氧化碳排放 Net zero CO_2 emissions	IPCC 定義為 當人為二氧化碳排放量在特定時間內，透過人為消除二氧化碳的方式於大氣中相互平衡時，即實踐淨零二氧化碳排放，又稱碳中和 (Carbon Neutrality)	僅針對溫室氣體中的二氧化碳
淨零排放 Net Zero Emissions	為當全球人為造成的溫室氣體之排放量與移除量於大氣中相互平衡時，即實踐淨零排放	涵蓋現行 7 大類溫室氣體包含二氧化碳 (CO_2)、氧化亞氮 (N_2O)、甲烷 (CH_4)、氫氟碳化物 (HFCs)、全氟碳化物 (PFCs)、六氟化硫 (SF_6) 及三氟化氮 (NF_3)

氣候緊急事件綠天鵝敲響淨零醒鐘

在全球溫度持續上升的狀況下，造成近幾年極端氣候事件層出不窮。國際清算銀行（BIS）發布《綠天鵝報告》（The Green Swan）指出，氣候衝擊將造成下一個系統性金融風險。全球最大再保險公司慕尼黑再保指出，2021 年全球天災損失約達 1,200 億美元，僅次於 2017 年的 1,460 億美元紀錄，其當年度天然災害造成將近 1 萬人喪生，與 2020 年的數據相當。若同步納入沒有投保的損失，整體災損金額達 2,800 億美元，創下史上第四高紀錄。面對全球極端氣候綠天鵝事件，不僅將造成大量傷亡與物種滅絕，更會考驗企業在氣候風險下的應對。為此，每年度的聯合國氣候變化綱要公約締約方大會，也將持續扮演達成淨零排放的重要政策與推動指標。

國際間因應淨零碳排的政策作法

COP26 會議決議與影響

在 2021 年 11 月，各國領袖在為期兩週的第 26 屆聯合國氣候變遷大會 （COP26）中達成多項決議，其中包括通過《巴黎協定》第 6 條，奠定未來國際碳交易的基礎，以及近 200 個國家簽署的《格拉斯哥氣候公約》，首次將「逐步減少化石燃料」納入決議文本，傳達了煤炭時代即將結束的信號，並要求各國檢討加強 2030 年國家自定貢獻（Nationally Determined Contributions, NDC）目標強度，須於第 27 屆大會（COP 27）前提交 2050 年長期低碳發展策略。各國和各企業在 COP26 簽署與淨零碳排相關條約 / 承諾如下表所示：

條約 / 承諾	Description
《巴黎協定》規則手冊	通過《巴黎協定》第 6 條，奠定未來國際碳交易的基礎，決議未來碳權買賣不可重複計算，以及只有在 2013 年以後認證的經認證的排放量 (Certified Emission Reductions, CER) 才能繼續使用
格拉斯哥氣候公約	• 逐步削減「未使用碳捕捉技術的燃煤發電」 • 逐步淘汰「無效率的化石燃料補貼」 • 要求各國檢討加強 2030 年國家自定貢獻（Nationally Determined Contributions, NDC）目標強度，並須於第 27 屆聯合國氣候變遷大會（COP 27）前提交 2050 年長期低碳發展策略 • 已開發國家未能兌現 10 年前的承諾，亦即每年提供 1,000 億美元協助脆弱國家，因此敦促已開發國家 2025 年前須付清欠款且直到 2025 年，協助開發中國家因應氣候變遷 • 要求快速加大乾淨電力系統及能源
全球甲烷承諾	105 個國家簽署《全球甲烷承諾》宣示在 2030 年前減少當前甲烷排放量 30% ，但中國、俄羅斯、印度與伊朗並未加入未加入
全球煤炭轉型乾淨能源聲明	４６個國家（其中包括全球前十大燃煤大國的南韓、印尼、越南、波蘭等）簽署，包括以下四項條款：擴大部署乾淨能源發電、逐步淘汰燃煤發電、停止新建燃煤電廠、確保公正轉型等
乾淨能源轉型國際投資聲明	25 個國家（包括英、美、德、法）簽署，承諾在 2022 年前停止海外化石燃料投資
中美關於在 21 世紀 20 年代強化氣候行動的格拉斯哥聯合宣言	在 2020 年代將建立管理溫室氣體明確框架與環境標準、強化乾淨能源轉型、提倡產業脫碳與電氣化、消除非法森林砍伐、發展循環經濟如綠色設計與永續資源、減少甲烷與二氧化碳排放，並將針對各自的減排計劃互相交流資訊與解決方案等。美國承諾將會在 2035 年達到 100% 的無碳污染電力目標；中國大陸則表示將在「十五五規劃」（第 15 個五年計劃，2026 年至 2030 年），逐步減少煤炭使用。
格拉斯哥淨零金融聯盟	代表 450 家金融機構、130 兆美元資產的「格拉斯哥淨零金融聯盟」（Glasgow financial alliance for net zero, GFANZ）簽署了協助朝向全球淨零排放發展的永續金融原則。
格拉斯哥領袖森林與土地利用宣言	全球超過 100 位領袖共同承諾，將在 2030 年前終止森林濫伐與土地流失等問題，並籌集近 140 億英鎊（約 5.2 兆新臺幣）公私資金處理相關議題。
格拉斯哥突破倡議	超過 40 國家（佔全球七成以上的經濟體）領袖簽署倡議，簽署國同意優先針對鋼鐵、道路運輸、農業、氫能和電力五大行業，協調並制定全球標準和政策，促進產能上升、價格下降，致力於 2030 年使綠能成為可負擔、易取得和具吸引力的選擇，並創造２０００萬個新職缺。
零碳車承諾	包括福特汽車（Ford）、通用汽車（General Motors）、捷豹路虎（Jaguar Land Rover）、賓士（Mercedes-Benz）、富豪汽車（Volvo）在內的 11 家汽車製造商，承諾在 2035 年前，主要市場全部銷售零碳新車，意味著在未來電動車將成為主流。
綠色航運承諾	200 家企業承諾在 2030 年前實現零碳船舶和燃料的規模化和商業化，另有 22 國簽署了《克萊德班克宣言》（Clydebank Declaration），計劃在 2025 年前成立六條綠色航線，航行在此航線的船隻須使用低碳或零碳燃料，路線將橫跨亞洲到美國，沙烏地阿拉伯到中國與印度，並希望 2030 年後增加航線。

綜上所述，COP26 會議中除了正式宣告燃煤時代即將終結，奠定未來國際碳交易的基礎，各國和各企業在淨零路徑上所必須面對的甲烷、護林、能源、交通以及氣候融資等議題上也達成了前所未有的進展，並且以將控制升溫氏 1.5 度 C 為全球共識。因此，可以預期將會有更多國家訂定更有雄心的減碳目標，通過更嚴格的法規，來加速能源轉型、徵收碳稅、鼓勵運具電動化。同時，許多企業也會儘速在 2020 年審視其經營策略，特別是格拉斯哥突破倡議所提及的鋼鐵、道路運輸、農業、氫能和電力等五大行業，將促使各國配合格拉斯哥突碳倡議未來協調產生的全球標準，全球綠色金融投資將迅速成長。

各國宣告淨零碳排之現況說明

截至 2022 年 6 月，全球 198 個國家中已有 129 個國家、佔全球九成 GDP、涵蓋 88% 溫室氣體排放總量，承諾達成淨零排放，其中 21 個國家 (如英國、歐盟、加拿大、日本、韓國等) 將淨零排放立法 (資料來源：NET ZERO TRACKER，擷取自：https://zerotracker.net/，2022)。各國 / 地區碳排放減量目標如下表所示：

國家 / 地區	減量目標
英國	2030 年較 1990 年減量 68%，2050 年淨零碳排
歐盟	2030 年較 1990 年減量 55%，2050 年碳中和
美國	2030 年較 2005 年減量 50%~52%，2050 年淨零碳排
加拿大	2030 年較 2005 年減量 40-45%，2050 年淨零碳排
中國大陸	2030 年碳排放達尖峰，2060 年碳中和
日本	2030 年較 2013 年減量 46%，2050 年淨零碳排
韓國	2030 年較 2017 年減量 40%，2050 年淨零碳排
澳洲	2030 年較 2005 年減量 26%-28%，2050 年淨零碳排
印度	2030 年碳排放強度[1] 下降 45%，2070 年淨零碳排

以下將進一步剖析重點國家英國、歐盟、美國之國家淨零排放相關政策與方針，提供讀者完整的淨零發展脈絡。

● 英國 - 全球首個國家將溫室氣體減排納入法案

2008 年英國即公告氣候變遷法（Climate Change Act, CCA），訂立 2030 年、2050 年英國境內溫室氣體排放須分別減少 34% 與 80%，並由主管機關－能源暨氣候變遷部（Department of Energy and Climate Change, DECC），設定溫室氣體排放量上限。英國也成立獨立運作的氣候變遷委員會（Climate Change Committee, CCC），由具備能源、經濟或科技背景之學者或專家組成智庫提供將官決策建議。2019 年此組織更進一步發布英國於 2050 年前達到淨零排放，緊接於 2020 年英國首相公布《綠色工業革命》(Green industrial Revolution) 十項計畫，包含再生能源、金融發展、碳捕捉技術，並加強力道將溫室氣體排放目標設定為於 2030 年前減排 68%、於 2050 年達到淨零排放，希望透過此政策於全球變遷扮演領導者的角色，並從中發展重要的創新技術。作為第二十六屆締約國大會 (COP26) 的東道主，英國也於大會期間宣布成立全球第一家淨零排放金融中心，以金融力量推助淨零發展。

1 碳排放強度是指每單位國民生產總值 (GDP) 所產生的二氧化碳排放量

● 歐盟 – 目標成為 2050 年前世界上第一個氣候中和大陸

歐盟執委會（European Commission）自 2019 年底啟動《綠色新政》（European Green Deal），包含制定未來三年要推出 50 項政策的行動路線圖，旨在促進歐盟經濟的永續發展，將氣候及環境挑戰轉化為所有政策領域的機會，實現整體轉型期間的正義與包容性，並設下中期目標為於 2030 年前減少 55% 溫室氣體排放，並期望於 2050 年前世界上第一個氣候中和大陸（climate-neutral continent）。2021 年為落實其 2030 年前減少 55% 溫室氣體排放目標，歐盟提出氣候變遷大計《55 套案》（Fit for 55 package），共有十二項施政措施，包含擴大歐盟碳交易體系（Emissions Trading System，ETS）、完善歐盟碳邊境調整機制（Carbon Border Adjustment Mechanism，CBAM）、2035 年禁售燃油車、2030 年前提升再生能源比例達 40%、逐步取消航空業與航運業的化石燃料免稅政策，發展自然碳匯以及落實公正轉型設立社會氣候基金（Social Climate Fund）。其中對台灣企業影響最大的政策莫過於在於 CBAM，預計於 2023 年進行試行，並在 2026 年針對高碳排產品如水泥、電力、肥料、鋼鐵、鋁業。若進口到歐盟，必須購買配額才能將其產品銷往歐洲市場。此法案也進一步催生台灣建立碳交易制度的急迫性，其主要因素在於進口商若可提出產品已在原產國繳交過碳稅或碳費，則可折抵所需購買的 CBAM 憑證數量，可見氣候變遷議題已跨越環境議題擴大至國際經濟貿易議題，攸關我國出口產業競爭力。

● 美國 – 史上最大氣候變遷投資案

美國氣候法治於歐巴馬任期內推動《氣候行動方案》（Climate Action Plan）展開，包含設定以 2005 年為基準，於 2030 年前減少溫室氣體排放 30% 以及管制甲烷外洩、提高汽車的燃料效能標準等措施。但於川普執政後以《美國優先能源計畫》（An America First Energy Plan）加速開發化石燃料產業，甚至退出巴黎協定。在 2021 年新任總統拜登上任後，除重返巴黎協定外，也宣告 2030 年前將美國溫室氣體排放量削減 50% 至 52%，2050 年前達到淨零排放之氣候目標。其與氣候相關政策包含達 1 兆美元的基礎建設法案 (Infrastructure Investment and Jobs Act)，驅使美國製造產業脫碳並促進再生能源產業發展與帶動綠色就業。緊接著美國公布《重建美好法案》（Build Back Better Act）綱要，包含氣候變遷、學齡前兒童教育、醫療補助等議題。針對氣候變遷政策，包含提供稅收抵免，降低中產階級家庭採用清潔能源和電氣化的成本、確保發展美國清潔能源技術與製作業脫碳，並創造綠色就業機會、維持轉環境正義，40% 收益將轉為弱勢社區建設、投資於海岸復育、森林管理和土壤保育等相關自然解決方案。

台灣相關法令因應作為

我國於 2022 年 3 月正式公布「臺灣 2050 淨零排放路徑藍圖」，提供至 2050 年淨零排放之行動路徑，並由國發會、環保署、科技部、經濟部、交通部及內政部等相關部會共同推動，以四大轉型策略（能源轉型、產業轉型、生活轉型與社會轉型），兩大治理基礎（科技研發與氣候法治）的方式來引領臺灣 2050 年的淨零轉型。其中強化氣候法制基礎的部分，不論是溫室氣體減量及管理法的修訂、碳定價政策的實施，或是綠色金融政策的推動皆受到社會大眾關注，其中又以環保署與經濟部的因應政策備受關注。

● 1. 環保署於臺灣淨零轉型下的因應政策

在臺灣過去推動低碳轉型，推動溫室氣體減量時，「溫室氣體減量及管理法」即為重要的法源基礎。當時是依照巴黎協定，以本世紀末溫升不超過 2°C 作為規劃，因此在 2050 淨零轉型過程中，我國也參照國際上控制升溫 1.5° C 作為目標，於 2022 年啟動「溫室氣體減量及管理法」修法，修改為「氣候變遷因應法」，並明確將國家長期減量目標修為 2050 年溫室氣體淨零排放。

設定明確溫室氣體減量目標之前，最重要的即為溫室氣體排放數據的盤點，沒有準確的數據，將難以設置有效的減量目標。日前金管會於 3 月正式啟動「上市櫃公司永續發展路徑圖」，要求所有上市櫃公司於 2027 年前完成溫室氣體盤查，最晚 2029 年前完成溫室氣體數據之查證，並依照產業與資本額進行逐步性的政策推動。為因應大量企業碳盤查的需求，環保署已於 2022 年 5 月發布新版溫室氣體盤查指引，除了既有溫管法公告應盤查登錄的大型排放源，針對有碳盤查需求的中小企業也提出盤查作業的指引，以提供產業淨零轉型基礎。

在淨零轉型的過程中，碳定價被國際間視為一項不可或缺的溫室氣體排放減量的政策工具，也隨著歐盟公布碳邊境調整機制（CBAM），加速國際間對碳定價的重視程度。若我國無碳定價相關政策，未來產品出口歐盟時，也將被要求出口國要求繳交碳關稅，可能會使得出口商品競爭力降低，因此在「溫室氣體減量及管理法」修法中，也將碳定價作為重要的修訂重點之一。碳定價制度的規劃，也分為兩個面向進行推動：

(1) 徵收碳費

其徵收對象將會以不同排放源類型、國家溫室氣體階段管制目標分階段進行推動。且規劃專款專用於溫室氣體減量、發展低碳、負排放技術等。在碳費價格的部分則會考量產業競爭力決定適當的費率，也將鼓勵碳費徵收對象提出自主減量計畫，設定符合國家減碳路徑的減量目標，經核定後將可適用優惠費率，但目前碳費適用之費率尚未明確的共識，待後續修法進行適當的碳價費率規劃。

(2) 碳交易市場建立

現階段為穩健逐步推動碳交易發展，將持續以鼓勵企業採行自願減量，並給予減量額度，並建置交易平台提供給有減量責任或需求者。發展初期將不以金融商品形式進行推動，未來也將因應巴黎協定國際合作機制，研析透過國際合作之方式探詢共同減碳可能性，並適時導入以逐步發展碳交易市場。

2. 經濟部於臺灣淨零轉型下的因應政策

經濟部在推動淨零轉型主要透過三項轉型策略，分別為能源淨零轉型、產業淨零轉型與社會公正轉型。在能源淨零轉型方面，以推展再生能源、增加燃氣發電的占比、減少燃煤發電的使用為當前的推動目標，並進一步打造無碳能源與電力系統、最大化再生能源的使用、積極發展氫能與碳捕捉封存技術為長期發展方向。在產業轉型方面，透過輔導產業減碳，以設備汰舊換新、低碳燃料轉換、智慧節能管理的方式進行推動，並期望達成產業循環經濟模式、採用無碳燃料等淨零願景。而淨零轉型過程中，必然會影響到不同的利害關係人，經濟部也將透過提前分析影響對象、研訂協助與保護配套機制、溝通可能誤解及建立認知等方式同時推動社會公正轉型。

在氣候法制基礎方面，經濟部透過推動「能源管理法」、「再生能源發展條例」與「電業法」之修法，持續完善能源需求管理與綠能發展環境，修法重點如下所示：

(1) 能源管理法

在既有針對能源大用戶節能要求、用電器具能效管理等管制措施外，將再透過強制能源供應業公開能源銷售統計資料，協助地方政府等團體精進規劃能源管理措施及效益分析；並透過提高罰緩、公布違法名單等方式，促使業者遵守節能規範。

(2) 再生能源發展條例

減少再生能源設置空間限制並增加利用彈性，就不同再生能源特性設定不同程序及調整機制，以加速行政作業，增進再生能源量能與擴大設置。

(3) 電業法

明確儲能設施定位，建構儲能商業模式，如容量市場與輔助服務交易，提升儲能建置誘因，並持續精進再生能源發電業申請程序，以利再生能源之設置。

在推動淨零轉型無碳燃料方面，未來將規劃設立氫能管理專法，以推動氫能燃料發展。目前則先透過「能源管理法」明確授權指定能源產品管理範疇，作為未訂定專法前管理之依據，並持續關注國際氫能技術發展與國內使用規劃，推動氫能管理專法立法作業，針對氫能輸入、輸出、生產、銷售業務之經營許可申請、變更、撤銷與廢止程序、設施設置條件、安全要求及無碳燃料認證等事宜進行規範。

3. 臺灣 2050 淨零排放政策之建議

我國 2050 淨零排放路徑藍圖中，目前規劃出來未來淨零社會願景，訂定轉型過程中各項關鍵議題的因應策略，但未於不同的較近程的時間尺度上有明確的規劃目標與配套措施，可能使得各產業於淨零轉型中較無明確的執行方向。且目前公布的路徑多數著墨於不同產業未來燃料使用、製程轉型與循環經濟等技術面轉型建議，較難確切考量到各產業間之結構問題，也較不易判斷是否該產業皆適用目前公布的路徑，建議可對於不同產業進行多場次的溝通，並由個別產業中不同規模之公司與專家學者共同進行商議，進一步訂出產業別的淨零轉型指引，以加速整個產業的淨零轉型。

在電力結構轉型的規劃中，已提出未來的電力成長的規劃，且預估了未來再生能源設置的成長，但在大力推動再生能源發展的同時，電力穩定性也是一項重大議題。也因電力有季節性、時段性的分別，因此發電設備也得分成基載、中載及尖載三類。其中因再生能源間歇性、非基載用電的特性，若未有明確的科技研發及技術突破，以評估再生能源發電作為基載電力的可行性，可能也使得逐步降低火力發電，推展再生能源之政策受到影響，降低電力供應穩定性。建議可更明確對於儲能技術之評估與工商界進行溝通，協手產業共同推動再生能源推動，以獲得產業界對於未來電力穩定性的信賴。

在零碳轉型過程中，牽涉技術、社會、經濟、政治等多面向的轉型，公正轉型自然成為推動淨零轉型的關鍵之一。目前於淨零排放路徑藍圖，對於落實公正轉型及公民參與的社會支持體系多為說明公正轉型與公民參與之治理機制，說明將以「政策目標平衡性」、「社會分配公正性」、「利害關係包容性」的治理原則進行推動，尚未有明確的因應措施與時間期程。建議對於淨零推動之公平轉型有更進一步的規劃，如合理的補償措施與獎勵機制等，以避免相關措施擴大社會不平等的發生。並於相關政策執行與訂定過程中，確保相關弱勢群體的參與，以得到不同利害關係人的聲音，使推動轉型的過程中，能減少衝突，達成具公平正義的零碳轉型。

臺灣儲能與電動車輛相關標準檢測及驗證之政策和推動進展

政府政策、淨零標準

經濟部標準檢驗局制 (修) 定並建置儲能與電動車輛相關國家標準、檢測能量及驗證制度，以確保臺灣實踐淨零排放路徑過程安全、公平並與國際等同。

依據臺灣 2050 淨零排放路徑及策略，儲能與電動車輛將是實踐低碳能源與運具電動化必要項目之一。經濟部標準檢驗局 (以下稱標準局) 為確保臺灣實踐淨零排放過程安全、公平並與國際等同，調和國際電工委員 會 (International Electrotechnical Commission, IEC) 等國際標準機構標準為 CNS 國家標準、建置在地化檢測能量並推動產品驗證制度。

以下說明臺灣在儲能與電動車輛相關標準檢測及驗證之政策和推動進展。

併網式電能儲存系統

因再生能源比例成長而影響電力系統穩定度，儲能系統便成為再生能源比例提升與強化電網之解決方案之一，但因電池具高密度能量，若品質不良或系統設計不當，將導致短路起火等意外事故。標準局在儲能相關標準檢測及驗證推動工作如下 :

(1) 標準

併網式電能儲存系統重要零組件（如單電池與電池系統）國家標準 CNS 62619(含鹼性或其他非酸性電解質之二次單電池及電池組－應用於產業之二次鋰單電池及電池組的安全要求) 與 CNS 63056(含鹼性或其他非酸性電解質之二次單電池及電池組－應用於電能儲存系統之二次鋰單電池及電池組的安全要求)，已分別於 2020 年 12 月 14 日及 12 月 07 日公告，其調和自 IEC 62619 與 IEC 63056，併網式電能儲存系統國家標準 CNS 62933-5-2(併網式電能儲存系統之安全要求 - 電化學系統)，預計於 2022 年 6 月公告，其調和自 IEC 62933-5-2，供各界參採並作為作為台灣儲能系統安全之依據。

(2) 檢測能量

經財團法人全國認證基金會 (TAF) 認證之實驗室，單電池及電池系統零組件計有 6 家以上。另標準局規劃於新竹科學園區 - 銅鑼基地，新建檢測能量達 360kW/360kWH 具特殊消防、防火防爆、試驗污染防制能力之大型儲能電池安全檢測試驗室，預計分別自 2024 年 10 月提供 MW 級功率調節系統 Power Conditioning System (PCS)、2025 年 7 月提供儲能機櫃 (Rack) 及 2025 年 12 月提供電池管理系統 (BMS) 檢測服務。

(3) 驗證制度

為確保儲能系統設置與後續運行安全，將導入專案驗證 (Project Certification) 管理架構，依據國家標準與國際標準，研擬相關檢驗技術規範與驗證制度。其中併網式電能儲存系統重要零組件（如單電池、電池系統與家用儲能電池系統）自願性產品驗證 (VPC) 制度，已於 2022 年 5 月 16 日公告實施。大型戶外儲能案場 VPC 制度，預計自 2022 年 11 月公告實施。

電動車輛 - 可充電儲能系統

淨零路徑中，運具電氣化也為減碳主要方式之一，標準局在電動車輛電池相關標準檢測及驗證推動工作如下 :

(1) 標準

電動車輛儲能統國家標準 CNS 16160(電動道路車輛之電氣安全及可充電儲能系統安全特定要求)，已於 2021 年 12 月 24 日公告，調和自 UN/ECE Regulation No. 100，電動車輛儲能標準已臻完整。

(2) 檢測能量

經財團法人全國認證基金會認證之實驗室計有 1 家。另標準局新建大型儲能電池安全檢測試驗室，預計自 2025 年 1 月提供電動車輛之全尺寸鋰電池組檢測服務。

(3) 驗證制度

電動車輛之鋰電池組 VPC 制度，預計自 2022 年 8 月公告實施。

電動車輛充電設備

在運具電氣化的浪潮下，其充電基礎設施將益發重要。據估計，台灣電動自小客車數量至 2025 年，將至少達 16.4 萬輛，充電站點普及化為運具電氣化成功的主要因素之一，標準局在電動車輛充電設備相關標準檢測及驗證推動工作如下：

(1) 標準

電動車輛充電系統相關國家標準包括一般安全要求 2 項 (CNS 15511-1、CNS 15511-23 電動車輛傳導式充電系統－第 1 部：一般要求、第 23 部：電動車輛直流充電站 + 補充增修 1)、通訊要求 1 項 (CNS 15511-24 電動車輛傳導式充電系統－ 第 24 部：電動車輛直流充電站與電動車輛間充電控制用數位通訊)、電磁相容要求 1 項 (CNS 15511-21-2 電動車輛傳導式充電系統－第 21-2 部：電動車輛以傳導式連接至交流 / 直流電源的要求－非車載電動車輛充電系統的電磁相容要求) 及插頭插座纜線組等計 4 項 (CNS 15700-1、CNS 15700-2、CNS 15700-3、CNS 15700-3-1 電 源 端插頭、電源端插座、車輛端插頭及車輛端插座－電動車輛傳導式充電－第 1 部：一般要求、第 2 部：針對交流刃片及導電嘴配件之尺度相容性及互換性要求、第 3 部：直流及交直流綜合型端子與接觸導管類型車輛端耦合器之尺度相容性及互換性要求、第 3-1 部：使用熱管理系統之直流充電用車輛端插頭、車輛端插座及纜線組)，已分別於 2021 年 6 月至 12 月陸續公告，調和自 IEC 61851 與 IEC 62196 系列國際標準。標準中包含歐美與日本等地區所使用之充電介面，可提供國內消費者依據不同廠牌車型使用。同時為保障國內電動車車主權益，亦於 2021 年同時納入 Tesla Proprietary Connector (TPC) 充電介面於國家標準。

(2) 檢測能量

經財團法人全國認證基金會認證之實驗室計有 3 家以上。

(3) 驗證制度

電動車輛充電設備 VPC 制度，已於 2022 年 1 月 13 日公告實施。

結語

標準局為達成淨零排放目標，已就儲能與電動車輛規劃，進行國家標準制 (修) 定，建置檢測能量與驗證制度。預計於今 (2022) 年 11 月，儲能與電動車輛儲能系統及其供電設備自願性產品驗證 (VPC) 制度將全數公告實施，並提供服務。而檢測能量涉及特殊測試設備與環境所需儲能電池安全檢測試驗室新建工程，預計自 2024 年陸續完竣並提供服務。標準局亦將持續配合國家發展策略，做好標準檢測驗證相關業務規劃和執行。

儲能電池安全檢測試驗室新建工程願景圖
(新竹科學園區 - 銅鑼基地預定 2025 年 1 月提供檢測服務)

臺灣邁向 2050 淨零轉型

2050 淨零排放、氫能、能源效率

因應全球淨零排放趨勢，臺灣將致力透過「低碳 - 零碳」與「能源 - 產業」之淨零轉型架構，拓展氫能發展潛力與技術應用，打造無碳能源環境，並提升工業與製造業能源效率，強化產業節電措施，加速產業全面低碳轉型，共同協助能源產業邁向淨零轉型之目標。

背景

1992 年聯合國通過「氣候變化綱要公約」，喚起全球對減碳的重視，在經過京都議定書、巴黎協定等國際公約演進後，減碳已成為各國無可避免的責任。自 2021 年年初 G7 氣候領袖會議起，追求淨零排放已成為全球共同的目標與趨勢。因應全球減碳趨勢，各國紛紛宣示淨零排放目標，截至 111 年 6 月 13 日止已有 132 個國家、臺灣以及歐盟宣示淨零排放目標。各國淨零轉型規劃除致力減碳，亦將淨零視為國家未來經濟的新成長動能，如：英國將淨零轉型視為「綠色工業革命」，以及日本訂定「2050 碳中和成長戰略」等。

臺灣 2050 淨零轉型推動做法

我國於今 (2022) 年 3 月 30 日正式公布「2050 淨零排放路徑」，期結合各界力量，讓淨零轉型成為臺灣發展的新動能，並建構科技研發及氣候法制兩大面向基礎環境，推動能源、產業、生活、社會等四大轉型策略，逐步實現 2050 淨零排放之永續社會。

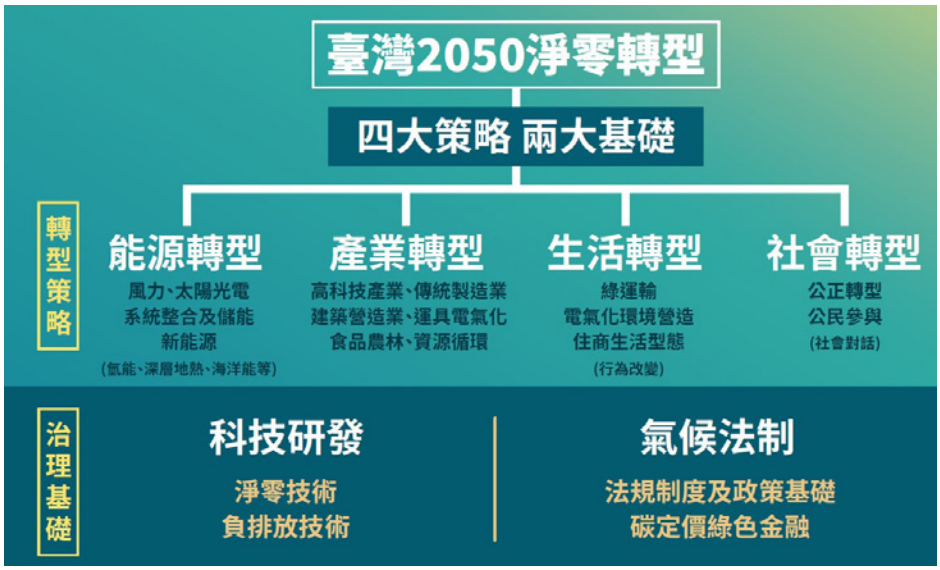


圖 1、臺灣淨零轉型推動做法
(資料來源：臺灣 2050 淨零排放路徑及策略總說明)

依據環保署 2021 年國家溫室氣體排放清冊報告，能源及產業部門為主要排放部門，為邁向淨零排放，我國將採「低碳 - 零碳」與「能源 - 產業」的 2X2 淨零轉型架構，先實現低碳，再邁向零碳。

在能源部門，短中期優先建置技術已成熟的太陽光電、風力發電，同時增加天然氣減少燃煤，長期則極大化再生能源布建，並提供誘因扶植具本土化優勢之地熱、生質能與海洋能等前瞻能源；在產業部門，依不同產業別，透過「以大帶小」策略，先「輔導減碳」，再推動「產業轉型」。期望透過能源供給端，打造零碳能源系統，並由能源需求端，推動產業提升能源使用效率，逐步朝向淨零轉型目標邁進。

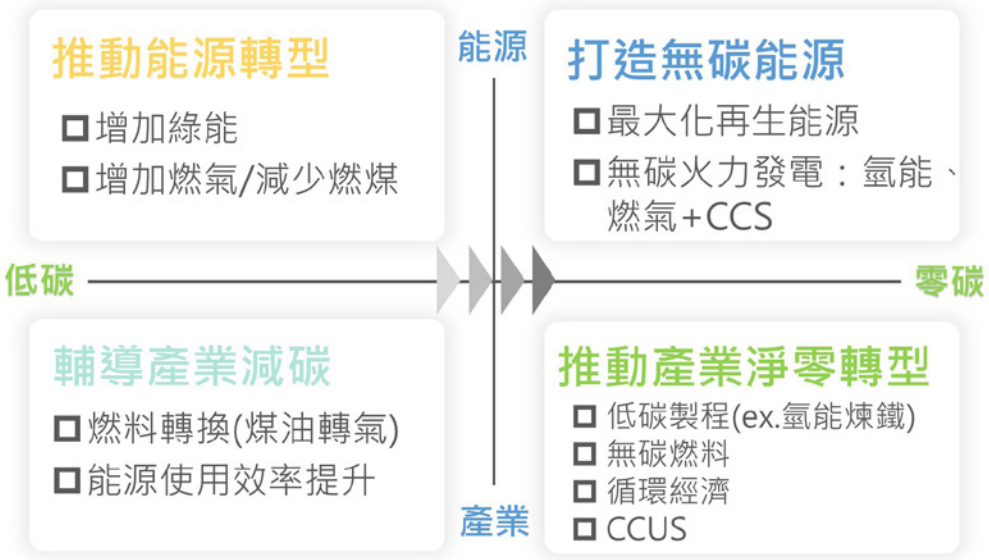


圖 2、「低碳 - 零碳」與「能源 - 產業」淨零轉型架構

「低碳 - 零碳」：拓展氫能發展潛力

鑑於各國將氫能視為未來減碳技術，如德國與歐盟等國家，以離岸風電剩餘電力電解水生產綠色氫氣，提供氫能車等移動式載具使用，並發展氫氣混入天然氣管線作為燃料等運輸、儲存及配送技術；日本、南韓、中國等國家，以發展氫能車等移動式載具為目標，並自澳洲等國家進口氫氣以提升氫氣供應量。

我國 2050 淨零路徑亦將氫能列為重點發展技術，不僅提供無碳電力 (約占電力供給 9-12%)，也作為替代化石燃料或製造業原料等重要減碳角色。同時成立「經濟部氫能推動小組」，針對氫能供應、應用及輸儲三大面向，研議我國短中長期可能面臨的議題及推動策略，並展開與主要氫能生產國家合作對話。

● 開發氫能供應來源

考量國內再生能源將優先因應電力負載需求及綠電用戶需求，尚無再生能源餘電生產氫氣，因此短期仍需仰賴透過天然氣經蒸氣重組產生氫氣，以及利用工業之副產品氫氣，並評估與國外合作進口氫氣可行性，以滿足我國氫氣需求；長期除持續關注主要氫氣出口國 (如澳洲) 氫氣生產技術發展，及早確保氫氣供氣氣源，並隨著我國再生能源設置量加速發展，逐步擴大由再生能源生產氫氣。

● 發展氫能應用技術

以全氫 / 混氫發電、鋼鐵製程導入氫氣、鋼化聯產等應用為發展方向。在能源部門方面，規劃於台電公司既有燃氣或燃煤發電機組示範驗證混燒氨之發電技術，並逐步提高氫氣混燒比例；在產業部門方面，以碳中和為目標，將煉鋼冶金高爐之燃料由粉煤改為含氫氣體（以氫氣為替代燃料）以轉為低碳高爐，如中鋼公司發展「氫能煉鋼」，減少製程排放之技術，以及「鋼化聯產」技術加氫轉化 CO 或 CO_2 為高價值化學品，並擴大產業應用範疇，及適時評估國際合作或直接引進相關應用技術可行性。

● 建構氫能輸儲基礎設施

因應氫氣應用需求所需建構基礎設施，短期配合產業與發電使用需求，中油公司運用天然氣既有設施評估氫氣進口與運輸儲存設施建置地點；中長期則配合氫能應用場域建構氫氣基礎設施。

「能源 - 產業」：提升工業及製造業能源效率

依據 IEA 發布之 2050 全球能源部門淨零排放路徑圖報告中，特別強調能源效率是最快速且最具成本效益之措施。考量我國工業部門能源消費遠高於其他部門，因此在節能工作推動上，亦以工業及製造業能效提升為重點，目前以強制

性規定與誘因機制為推動方向。

● 強制性規定

為強化能源大用戶每年節電 1% 成效，依據「能源用戶訂定節約能源目標及執行計畫」規定，每年建立能源查核制度，並訂定節約能源目標及執行計畫；工業能源大用戶 2015~2020 年平均年節電率為 1.76%，較未施行前述措施 (2010~2014 年) 平均年節電率 (0.98%)，提升 0.79 倍。

我國於 2012~2016 年陸續制定公告石化業、電子業、鋼鐵業、水泥業、紡織業、造紙業六大產業之能效規定，並針對上述產業之單位產品耗能標準或主要耗能設備效率情況逐步加強效率管理。

● 誘因機制

為提升企業能源效率及競爭力，推動節能改善補助，導入能源技術服務業專業技術，並鼓勵加速汰換老舊設備，補助購置高能源效率之空壓機、風機及泵，提升生產效能與設備能源效率；另輔導大用戶透過產業製程改善、公用設備汰換、設備維護保養等機制，以及強化中小能源用戶節能技術服務量能，增加節電成效。

結語

面對 2050 淨零轉型，我國將極大化再生能源布建及持續評估國際氫氣供應量，配合氫能應用場域建設所需基礎設施、國際安全標準規範等資訊，建構我國氫能發展環境，並持續精進節能各項法規與誘因機制，持續提升工業及製造業能源效率。同時引導資源投入能源與產業淨零轉型，打造零碳能源系統，加速關鍵技術研發，推動產業龍頭及大型企業透過供應鏈體系，協助中小企業建構減碳能力與分享減碳技術，加速產業全面低碳轉型，以落實淨零轉型之長期願景目標。

游振偉
經濟部能源局局長

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專長
- 能源節約能源措施推動、技術服務及宣導
- 產業規劃
- 工安環保
- 產業園區規劃開發管理組，擔任過工業局主祕及副局長，並出任行政院科技會報辦公室參事兼副執祕，行政歷練豐富

第二章
企業共同響應淨零碳排

科學基礎減碳目標來提升我們的雄心

能源效率、壓縮空氣解決方案

為了創造一個永續的未來，我們致力於實現科學基礎減碳目標，以減少我們直接營運 (例如 : 製造、車輛和辦公室)、供應鏈以及使用能源導致的排放。

世界迫切需要低碳解決方案，而我們的創新正在推動轉型。我們的技術對於電動汽車和太陽能等現有低碳技術至關重要，它們是能源生產、能源儲存、智慧製造流程、交通運輸等新興低碳技術的一部分。

作為領先的全球設備商，我們甚至可以透過營運、物流、產品設計以及我們的產品所提供的動力所需的能源產生巨大的影響力。事實上，超過 90% 的碳排放來自於使用我們的產品。

為確保我們實現氣候目標，集團制定了兩項基於科學的目標，以根據《巴黎協定》減少溫室氣體排放。

科學基礎減碳目標意味著您承諾按照巴黎協議的目標採取行動，將全球氣溫上升幅度控制在攝氏 1.5 度以下，以及透過減少供應鏈的排放，將氣溫上升幅度控制在攝氏 2 度以下。

此外，與我們集團氣候目標不同的是我們基於科學減碳的目標是為整個供應鏈的基礎，包括使用階段。它們也被設定為絕對減量，與銷售成本無關。

「這象徵著我們對減碳改革的承諾。透過提高我們的遠大雄心，我們將挑戰自我，並幫助客戶和其他業務夥伴做同樣的事情。此外，這將開闢新的商機，幫助我們吸引所需的人才，並將我們確立為技術驅動者。」總裁兼首席執行官 Mats Rahmström 說。

集團以 2030 年為科學目標，以 2019 年為基準年。這目標已經通過科學基礎減量目標倡議的專家的驗證和批准。

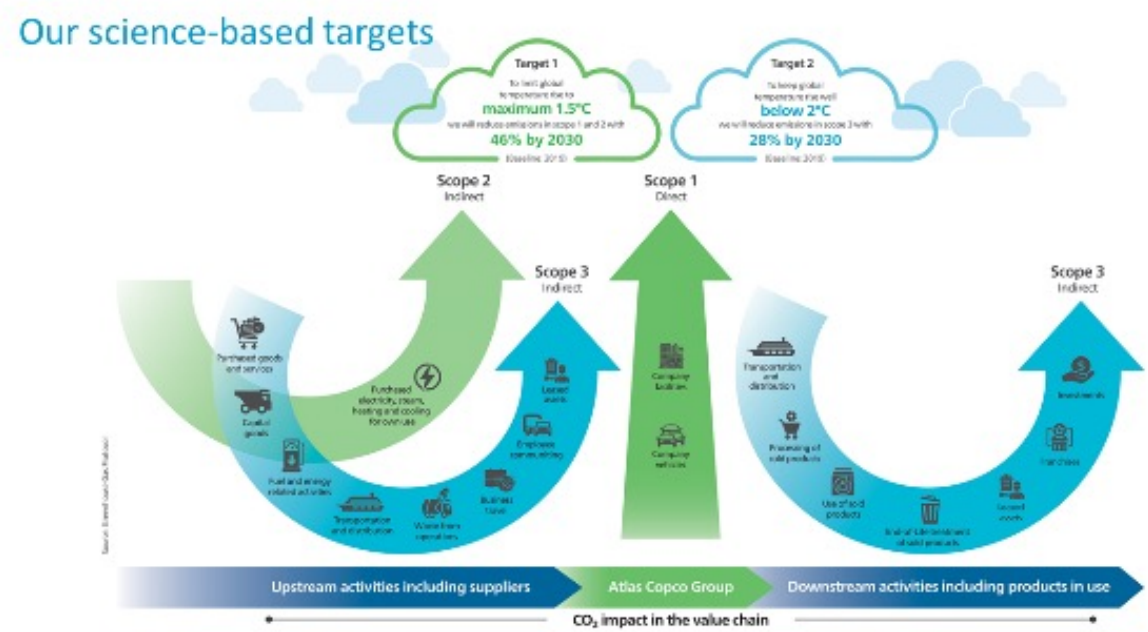
這個科學的目標由聯合國機構支持的獨立組織基於科學的目標倡議進行驗證。世界自然基金會和其他氣候領袖。目標分為 3 個範圍，通常涵蓋公司的整個供應鏈。

範疇 1 著重於公司透過直接營運所產生的氣候影響。例如，它可以是公司車輛或工業過程中產生的排放。

範疇 2 著重於為您自己的營運提供動力所需的能源產生的間接排放。

範疇 3 著重於上游和下游活動中的間接排放。它可以是來自商務旅行、購買的材料和零件、運輸、租賃資產等的排放。範疇 3 還包括來自客戶使用的已售產品的排放。

承諾科學基礎減碳目標的公司都有望能夠解決所有相關排放問題。



目標 1
購買的能源和我們自己的營運產生的排放

我們的第一個目標涉及我們直接營運的排放和我們購買的能源（範疇 1 和 2）。在這裡，我們將根據巴黎協議減少溫室氣體排放，將全球氣溫上升限制在最高 1.5°C (2.7 °F)。

為此，我們設定了到 2030 年將供應鏈這部分產生的碳排放量減少 46% 為目標。

我們主要致力於：
- 在我們的設施中改用無石化燃料，並使用太陽能、風能或其他無石化燃料。
- 在我們的服務車隊和其他公司車輛中使用低排放車輛。

目標 2
上游和下游活動

我們的第二個目標涉及在我們直接營運之外、上游和下游活動（範疇 3）中產生的排放。

在這裡，我們將根據巴黎協議減少排放，以將全球氣溫上升幅度控制在低於攝氏 2 度（3.6 華氏度）的範圍內，因為供應鏈的這部分超出了我們的控制範圍。

為實現這一目標，我們設定了一個目標，即到 2030 年將上下游活動的間接排放量減少 28%。

由於，大部分的碳排放來自於使用我們的產品。我們將主要關注：
- 不斷提高我們產品的能效，確保以最佳方式使用和維護。
- 設計越來越多由電力驅動的產品，而不是柴油或空氣。
- 最大的減少來自我們的產品以最環保的方式供電。這將是一個挑戰，但可以通過支持我們的客戶轉向無石化燃料來實現。例如，我們可以與當地能源供應商合作，以增加在當地和全球網絡中獲得無石化燃料的機會。

共同努力

我們的科學基礎減量目標設定為 2019 年，兩個目標將至少每五年進行一次檢查，以確保符合最新的氣候科學，並且與我們業務的性質和規模相關。

「重要的是要注意，無論我們出售多少種產品，我們都致力於尋找減少絕對排放的方法。」集團永續發展副總裁 Sofia Svingby 說。

「實現這些目標需要集團所有部門的共同努力。我們的兩個科學基礎減碳目標是基於每個業務領域和部門的個人氣候目標和績效的綜合目標。這意味著我們都必須擁有所有權，並盡其所能進行所需的改進和改善。」Mats Rahmström 說。

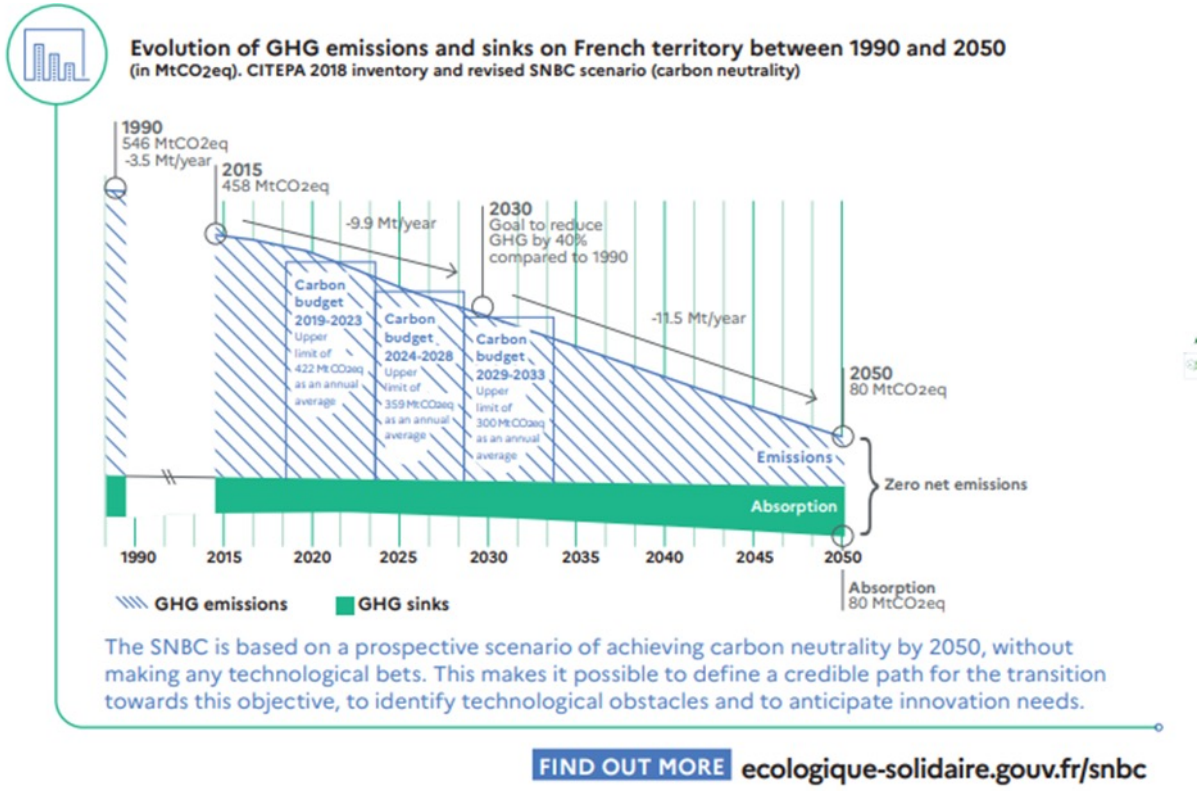
「在向低碳社會轉型中發揮引領作用，完全符合我們公司的宗旨。正是我們的創新能力和工業理念使我們的客戶能夠成長並推動社會向前發展。這就是我們創造更美好明天的方式。」Mats 總結道。

法國推動永續共榮轉型 邁向碳中和

BUREAU FRANÇAIS DE TAIPEI 法國在台協會

各國在簽署《巴黎協定》下承諾將平均氣溫上升限制在 2° C，或在可能狀況下將平均氣溫上升限制在 1.5° C。為了達到 IPCC 在 21 下半世紀實現全球碳中和之建議，先進國家呼籲各國盡快實現碳中和。

法國透過法律承諾在 2050 年前達到碳中和，其方法是將 1990 年法國溫室氣體總排放量除以 6 方法下設定其偉大目標。具體而言，相較於法國二氧化碳排放量在 2015 年 4.58 億噸及 2018 年的 4.45 億噸排放量基準下，法國必須在 2050 年前大幅減少到 8 千萬噸二氧化碳為艱鉅挑戰。為達到這一目標我們必須付出龐大的心力，並對現有的生活方式、消費和生產進行深刻的轉變。然而，我們同時也視此項挑戰為一個轉機：促使我們創造力和創新能力受到啟發 ，並使我們能夠重新思考我們的經濟模式，同時保持其創造就業機會的能力。不僅如此，碳中和所帶來的影響也使我們的健康新生活邁向更永久、更循環、更有彈性及更尊重的新模式，這意味著法國低碳路徑為過渡中的經濟指引出一個成功的公共政策。



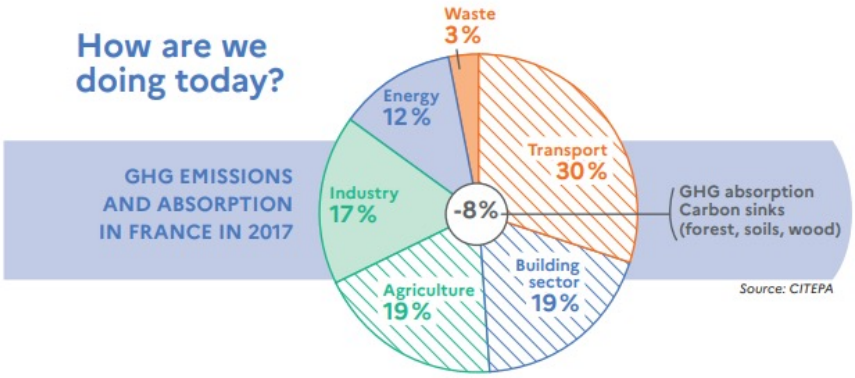
國家低碳策略（Stratégie Nationale Bas-Carbone，SNBC）為法國針對氣候變遷所擬定的策略規劃，提供各大產業邁向低碳經濟轉型的活動指導原則。

策略包含減少法國溫室氣體排放的短中期目標、碳預算，以及另外兩項願景：達到碳中和，也就是在 2050 年前達到淨零排放（此為 2017 年七月設定的目標，並已立法規定），並減少法國人的碳足跡。低碳策略每五年會進行徹底的修訂。

1- 交通場域：法國排放最多溫室氣體的產業（2015 年全國佔比 30%）

由於溫室氣體排放皆與能源相關，因此低碳策略的目標是 2030 年的排放量比 2015 年減少 28%，並在 2050 年讓交通運輸完全脫碳（decarbonisation）。

該假設預估 2015 年到 2050 年間，平均每年可減少 3.8 Mt CO_2 eq 的排放量；但在 1990 年到 2015 年間，平均每年溫室氣體排放增加 0.5 Mt CO_2 eq，而近期的 2005 年到 2015 年間，平均每年僅下降 0.8 Mt CO_2 eq。



2017 年運輸業占了法國境內溫室氣體總排放量的 29.9%，等於 139 Mt CO_2eq，自 1990 年到 2004 年間大幅提升了 18.9%，而在 2004 年到 2009 年間下降 7.9%，但 2009 年開始到 2016 年，又提高了 2.0%，主要原因是路面交通量大增。即便自 2005 年起生物燃料與新能源車輛有長足的發展，大幅降低路面交通的碳排量，卻仍無法抵銷總排放量。

若要達到 2050 年的碳中和目標，意味著運輸產業要全面脫碳，根據交通類型改用電動車、生物燃料和沼氣。不過可預見，到了 2050 年航空運輸與國外海運仍需要使用部分的非生物性燃料。

SNBC 預估，2050 年的移動需求仍會持續成長，但和目前趨勢相比，移動需求與經濟成長的關聯將愈形薄弱。SNBC 也針對引擎效率和引擎類型進行了有力的假設。SNBC 推估以下五種方式：推動車輛燃料脫碳；加強車輛能源性能以減少能源消耗；透過提升循環經濟等方式控制能源需求；交通型態轉變；最佳化客用與貨物運輸車輛的使用效率。

車輛燃料使用效率方面，電氣化的效率相較熱能約達兩到三倍，長遠來看應以電氣化為解決方案，尤其是對汽車而言（2040 年後的汽車銷售 100% 為電動車），電動車仍需大力推動，2022 年的電動車銷售量還需要增長五倍才可達標（根據 2018-2022 年汽車產業策略協議中的承諾）。到了 2030 年，新車銷售量佔比應為：35% 自用電動車、10% 自用油電混合充電車。車輛耗能效率方面也應加強，尤其是熱能車。值得一提的是，SNBC 預期 2030 年，新車目標實際耗能為 4 L ／ 100 公里。新型電動車應在 2050 年前達到 12.5 kWh ／ 100 公里的標準（與目前相比約減少 40%）。

載貨需求可選擇更均衡的混合式能源（可再生氣體、電力、生物燃料），因為此類運輸工具的引擎內部壓力較高，電氣化的速度也會比汽車慢。載運重物的車輛能源效率亦將大幅改善。依引擎類型不同，2050 年前能源效率可望改善 35-40%。

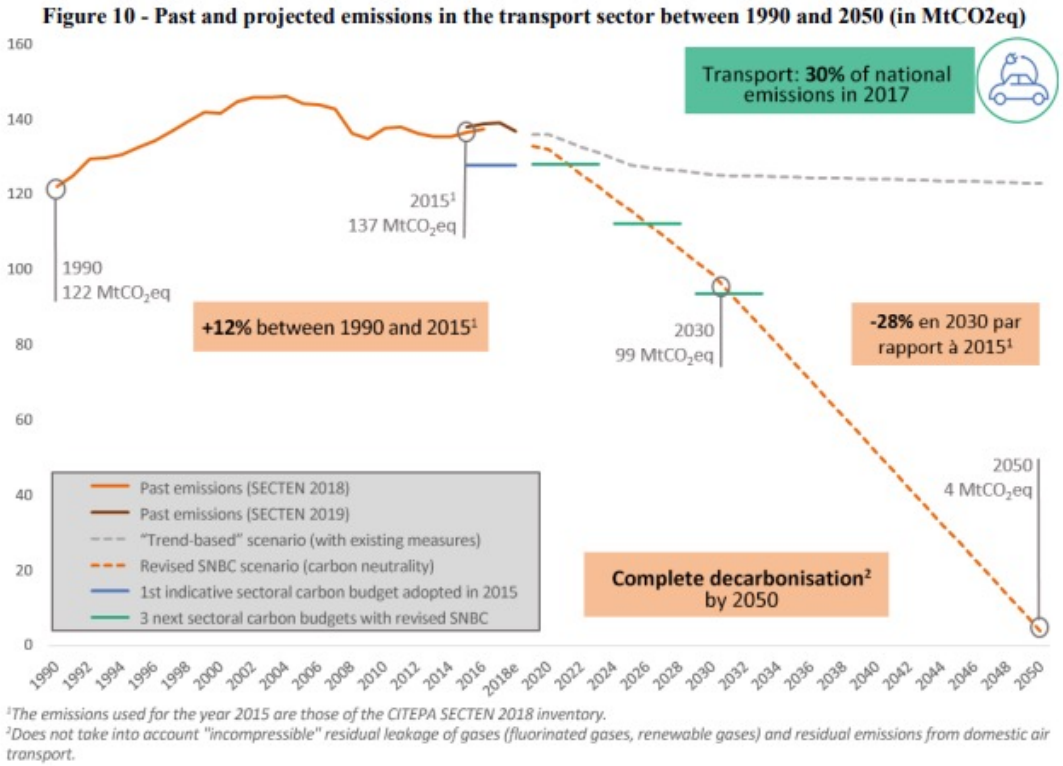
改善能源效率與脫碳將適用所有類型的交通運輸。SNBC 也期望在 2050 年前，航空業的生物燃料使用佔比可達 50%。

2050 年前，國內河海運可達全面零碳排放，國外海運則預期脫碳 50%。

SNBC 預估旅客與貨物的載運量攀升皆可有效控制，運輸模式也會朝主動式運輸、大眾運輸、散裝運輸發展，並最佳化車輛使用。

2015 年到 2050 年，各種運輸方式的每公里載客量總計提高 26%，與一般上下班情況相比較為緩和，可能的原因是遠距上班趨勢增加與城市擴張受限。2030 年後，以單車代步的佔比會增長 4 倍。大眾交通運輸則會顯著增長 7%，共乘和共享汽車亦會有相同幅度的增長。整體來看，2015 年到 2050 年的自用車輛數量受限，將會減少約 2%。

貨運的每公里載貨噸數會增長 40%，但由於循環經濟的發展與在地資源運用，增長率比一般上下班情況低。鐵路與河運會持續發展，重物運輸的承載比率亦會提高。2050 年前，重物運輸的成長率將維持在 12%。



2- 國家低碳策略與一般基準情境內容

- 提供碳稅價格信號，鼓勵低碳發展（標準化歐洲各國的燃料稅、內化道路使用的外部成本）、強化既有市場機制（歐盟排放交易體系 ETS、國際空運碳抵消與減排 CORSIA），加速航空運輸脫碳。

- 為配合產業能源轉型，針對車輛能源性能訂定遠大目標，包含客運車輛（目標為 2030 年內燃車輛實際耗能減少至 4 L／100 公里，2050 年前電動車達 12.5 kWh／100 公里，目前數據為 17.5 kWh／100 公里）、重物運輸（目標為 2040 年實際耗減至 21 L／100 公里，相比 2015 年降幅為 40%）、以及空運和海運。除能源效率提升，亦針對車輛脫碳訂定遠大的目標，例如：
  - 2040 年前，100% 輕型車皆達到零碳排。
  - 2050 年前國內海運全面零碳排，在法國所有港口倡導低碳行動，並鼓勵改用其他低碳科技（電池、生物燃料、氫能、風帆等）
  - 空運方面，以生物燃料取代大部分的化石燃料（2050 年達 50%），積極開發氫能與電動型飛機。

- 鼓勵各種形式的運輸發展，尤其針對車輛汰換和基礎設施改造提供支援（生質能天然氣燃料補給設施與電動車充電設施）。

- 鼓勵地方政府與企業採取零碳排措施，並邀請他們一起參與潔淨能源移動政策施行（部署低碳特區、減碳排放行動方案與車隊汰舊換新等）。

- 鼓勵改用節能減碳的運輸方式，例如鐵路或大眾運輸工具，並倡導主動節能，例如以自行車代步（目標為 2030 年前佔短程運輸 12%，2050 年前達 15%），養成規律運動習慣亦有益身體健康。

- 最佳化貨運車輛的裝載容積與重量，讓物流程序更加順暢（2050 年前將重物載運量從原本的每車 9.8 噸提升到 12 噸）。

- 倡導居家辦公、車輛共乘、選擇最短路程與循環經濟，以控制旅運需求成長（2015 年到 2050 年間，所有運輸工具載客量總計提升 26%）與貨運需求（2015 年到 2050 年間，提升 40%）。

考量到空氣品質問題，運輸產業必須快速進行規模化轉型，連帶因為改善碳排放問題，空氣品質也能連帶受益。為減少土地佔用的情形，能源轉型亦需限制運輸設施的建置。

TRANSPORT

GHG EMISSIONS REDUCTION TARGETS COMPARED TO 2015

2030: -28%

2050: **Complete decarbonisation** (with the exception of domestic air transport).

HOW?

- Improve the energy performance of light and heavy vehicles, with a target of 4l/100 km in 2030 for private combustion vehicles.
- Decarbonize the energy consumed by vehicles and adapt infrastructures to reach 35% of sales of new electric or hydrogen-powered passenger cars in 2030 and 100% in 2040.
- Control the growth in demand for transportation by promoting telecommuting, car sharing, short routes and optimising the use of vehicles.
- Encourage a shift towards the least emitting modes of passenger and freight transport (public transport, train) and support active modes (cycling, etc.).

默克：以永續推進人類進展

企業策略、科技、淨零標準

以科學與科技為核心的默克是一個橫跨醫療保健、生命科學與電子科技三大領域的企業。從推進基因編輯技術發展，到醫治最難對抗的疾病，甚至是發展未來智慧裝置，默克致力開發為人類生活帶來正面影響的高科技。設立至今 354 年，默克將永續經營的理念實踐在每一項行動上，持續打造和社會與環境共好的企業模式。

臺灣為回應全球永續趨勢、改善氣候危機，於 2021 年加入全球 197 國的「2050 淨零碳排行列」。歐盟更將於 2026 年起開徵碳關稅，帶動世界永續轉型。在淨零排放的趨勢之下，環保與經濟已經不是選擇題，而是必選題，兩者必須兼顧。過去受限於技術發展，在發展經濟的同時往往會犧牲掉環境。但擅長解決全球棘手問題的默克，早就開始思索如何透過科技解決環境與社會問題。

透過三大永續目標，推進人類文明進展

默克致力於「以好奇心推動人類發展」，並訂定了永續發展三大目標 (如圖 1 所示)，包括推進人類發展、創造永續價值鏈，以及減少生態足跡。從生產營運延伸到幫助客戶推出更綠色的終端產品，默克以科學與科技實力帶來綠色解決方案。

圖 1 默克永續發展三大目標

以永續科技造福人類

第一個面向「推進人類發展」，旨在 2030 年前以創新的永續科技造福全球 10 億人口，為客戶發展綠色產品解決方案幫助，並減少對環境的衝擊。默克開發出得「液晶智慧窗」為其中範例。利用液晶材料的特性，默克將特殊液晶材料注入於兩片透明導電膜的玻璃之間，當受到電壓驅動時，液晶的方向會在一秒鐘內從隨機位置移動為整齊排序。該技術能控制陽光的透光率，有效阻擋室外強光產生的熱能，維持舒適的室內溫度，並省下高達 30% 的電力。未來「液晶智慧窗」將落實在綠建築、各種場域及交通工具，為生活打造更節能、舒適的空間感受，也為漸趨成熟的顯示器產業開拓新商機。

創造永續供應鏈

第二個面向為建造永續且透明的供應鏈，並在 2030 第二個面向為建造永續且透明的供應鏈，並在 2030 年達成永續價值鏈目標。默克串聯上下游一起建立綠色供應鏈，以 Together for Sustainability（TfS）稽核標準，確保供應商能達到永續標準。近年來，默克也致力於數位轉型，在各個生產中心導入智慧工廠系統 (MES)，透過製程改善、自動化產線建置等措施，從下單到出貨一切數位化，不僅一張紙都用不到，廠區的用水量及用電量明顯下降，還能即時追蹤生產與出貨進度。在全球，默克亦陸續將數位化導入在生產與研發流程與系統，將有助解決現階段全球半導體供應鏈所面臨的挑戰。

減少生態足跡

第三個面向則是較其他企業早十年，訂在 2040 年實現氣候中和，並於全方位減少生態足跡。默克的溫室氣體目標日前通過了最嚴格的科學基礎減碳目標 SBTi（Science Based Targets Initiative）之審核，確立其有助於將全球平均升溫控制在攝氏 1.5 度內。在此方向之下，默克訂下 2030 年範疇一 （直接排放） 用電產生排放與範疇 2（間接排放） 溫室氣體排放強度降低 50%，與範疇三在價值鏈上每歐元碳排放減少 52% 的承諾。為展現決心，還將範疇 1 和範疇 2 目標的實現將關係到默克集團執行董事會之薪酬。

在台灣深耕超過 30 年的默克，在台有四座生產中心，默克也檢視自身製程，持續從廠區建置、產品生產、製程減廢與回收再利用等面向，全方位實踐永續精神。在生產製程部分，設置能源使用紀錄與監測系統，提高水電利用效率；並在生產過程中，逐步採用綠色化學物質替代方案，減少有害化合物產生。透過各面向措施，達到的具體成果，包括減少了相當於 21 座大安森林公園的碳排放量、節省了 31 座奧林匹克標準游泳池的用水量、並在 2021 年的廢棄物影響環境指數下降到 21%。

除此之外，提升在地化生產及檢視物流方式對於碳足跡有巨大的貢獻。默克於 2021 年 12 月宣布將在高雄建立全球首座半導體材料大型生產與應用研發中心。此舉不但強化半導體供應鏈穩定性，透過在地生產還能減少碳足跡。默克也考量科學園區內的生態環境，將在建設新廠房的同時以最大限度保留或充分運用現有佔地超過的 1,800 棵植栽。另外，全球物流大約排放全世界 8-10% 的碳排放量，因此默克將大部分的醫療保健藥品從空運轉為海運，並能大幅減少碳足跡。
循環經濟是不可缺少的永續良方。由默克員工提出創意點子，將稀有礦產循環再生變黃金，也意外成為半導體材料業界首創鎵鋁合金回收的企業。默克高雄廠在 2021 年產出了 215 噸碘溶液及 470 公斤鎵合金，讓戰略金屬重新回到生產供應鏈，進一步延長其生命週期。

透過員工體現永續文化

再偉大的願景，尚需仰賴員工的每日落實，才得以累積實現。在台灣，默克啟動了永續發展計畫，除了持續規劃一系列永續舉措，也強化同仁的永續思維，並培養日常行動，例如連續兩年關燈 1 小時共累積減少約 36 噸碳排放，以及與舊鞋救命國際基督關懷協會合作由同仁捐贈二手衣鞋包。默克員工也協助紮根下世代科學家，透過全球志工星火 SPARK 計畫，迄今已有逾 38% 默克同仁曾擔任志工，投入參與由科技部主辦的「臺灣科普環島列車」及與淡江大學合作的「化學遊樂趣」，將科普實驗帶入偏鄉學校。

默克在全球淨零排放浪潮裡，透過科學與科技的角度，推動全面性的永續積極作為，也因此有機會獲得各界肯定，包括台灣默克集團連續 2 年獲得《遠見》CSR 暨 ESG 企業社會責任獎外商組首獎之殊榮。

作者

李俊隆博士現為台灣默克集團董事長，負責默克集團及其子公司在台的發展策略。同時他也擔任台灣美國商會理事、台灣顯示器產業聯合總會和台灣平面顯示器材料與元件產業協會常務理事、以及歐洲商會、德國商會會員代表。

李俊隆 博士
台灣默克集團董事長

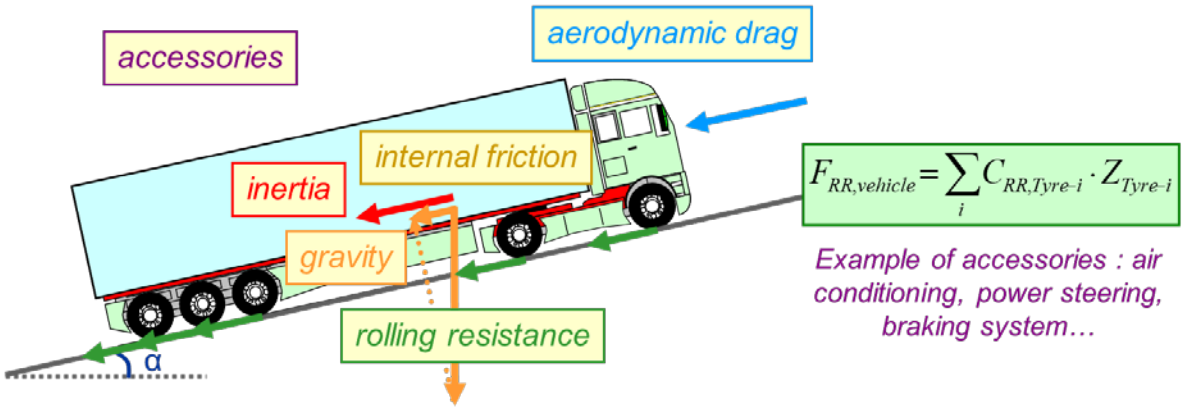
輪胎
如何貢獻減少碳排放

米其林的可持續發展願景 (企業策略)、推動打造低碳環保的生態系統 (政府政策)

「一切皆可持續」願景促使整個米其林集團不斷尋求人、環境以及利潤之間的合理平衡。人、利潤、環境這三個支柱中的每一個都被轉化為具體的行動。在環境方面，米其林的目標是到 2050 年實現碳中和（製造和能源），並為幫助米其林使用者實現碳中和做出貢獻。
米其林致力於推動打造低碳環保的「生態系統」，首先是建立輪胎標籤系統，輪胎標籤規則有助於消費者在更換輪胎時做出明智的購買決定，因為標籤強調了輪胎在燃油效率、安全性和噪音方面的性能。同時，這些標籤也推動了製造商不斷創新，力爭讓自己的輪胎在不同類別中名列前茅；再者在碳稅或碳權方面鼓勵使用低滾動阻力輪胎用戶，尤其是在運輸產業，在台灣實現淨零碳排放願景的路線圖中，低滾動阻力輪胎可顯著減少運輸過程中的碳排放；因此，我們建議制定政策，鼓勵運輸商使用低滾動阻力輪胎以減少二氧化碳排放。想要真正實現零碳排的未來，離不開所有利益關係人的合力，這包括政府、企業、研究機構、投資機構、公益組織、大學、個人等等。多年來，米其林集團在研發低碳綠色的產品和服務之外，努力推動打造可持續出行的生態系統，鼓勵更多企業和個人參與到節能減排中來，讓減碳排更加可持續。

車輛的受力和油耗

車輛行進必須克服的五種阻力 : 為了移動一個物體，我們必須施加力量，因而消耗能量。對車輛而言，能量消耗決定了燃料消耗。舉個簡單的例子：要向前移動手推車，您必須推動它，換句話說，要付出努力。如果負載較重、要推上陡坡、逆風或手推車輪軸未潤滑，則所需的努力會增加。我們已經提到了四種阻力：



Driving with 10kg/t tyres is as if the vehicle was climbing a permanent 1% slope

- 慣性，取決於車輛的質量和速度的變化
- 重力，取決於坡度和質量
- 風阻，取決於風、運動速度和車輛的形狀
- 旋轉部件的內摩擦力

要付出的努力還取決於地面和手推車本身。我們都知道，在堅硬的地面上推手推車比在柔軟的地面上更容易。同樣地，安裝適當充氣的充氣輪胎的手推車比安裝充氣不足輪胎的手推車更容易被推動。這就是第五種阻力：滾動阻力。

什麼是滾動阻力？

滾動阻力 (RR) 對車輛行駛所需的能量有重大影響。因此與內燃機車輛的燃料消耗（約 20%）或電動汽車的電池續航里程直接相關。輪胎設計有助於降低滾動阻力。

讓我們確保我們了解輪胎滾動阻力的概念。顧名思義，滾動阻力是指汽車輪胎在地面上滾動時所承受的阻力。這種阻力的主要原因是輪胎變形、翼阻力和與地面的摩擦。.

滾動阻力越大，克服它所需的能量就越多。因此，輪胎滾動阻力對油耗（以及輪胎的使用壽命）有相當大的影響。滾動阻力增加 30% 會導致 3% 到 5% 的燃油消耗增加。

在相同的路面和路況下，有幾個因素會對輪胎的滾動阻力產生影響：胎壓、胎面、內徑、寬度或輪胎使用的材料或其結構。例如，關於胎壓，在法國道路上進行的研究 [1] 表明，超過 50% 的汽車在低於所需輪胎壓力至少 0.3 bar 的情況下運行。這導致滾動阻力顯著增加：0.3 bar 的充氣不足增加 6%，1 bar 的充氣不足增加 +30% [2]。

[1] 2000 年在米其林 "Fill up the air" 行動期間在法國高速公路上收集的數據。
[2] 1 bar = 14.503773773 psi

關於油耗，低滾動阻力輪胎可以造成多大的差異？

低滾動阻力輪胎（也稱為 LRR）的設計旨在減少能量耗散，從而節省燃料。這是經由應用在輪胎各個方面的創新來實現的：

- 輪胎結構、形狀和胎面花紋：輪胎的結構通過內部簾布層的幾何形狀和性質以及胎面的設計對輪胎的變形程度產生巨大影響，從而影響滾動阻力。
- 輪胎的重量：對於相同的變形，物體質量越大，溫度上升越多。
- 輪胎中使用的橡膠混合物和各種成分的優化：它是減少輪胎吸收能量的主要進步來源。

「輪胎的油耗佔了總油耗的五分之一。」米其林科學與創新傳播總監 Cyrille Roget 解釋，「這與輪胎滾動阻力有關。如果考慮我們消耗的全部燃料量，這些節省是並不是微不足道的。」

得益於低滾動阻力輪胎，燃油效率的提高不僅讓您的荷包受益，它們也是朝著更環保駕駛邁出的一步。對內燃機車輛而言，通過減少燃料消耗，您還可以減少對石化燃料的使用。對電動車而言，更長的續航里程意味著對電網的需求更少，在歐洲，電網 40% 的能源來自燃燒石化燃料的發電廠。

米其林的「可持續發展」願景

「一切皆可持續」願景促使整個米其林集團不斷尋求人、環境以及利潤之間的合理平衡。人、利潤、環境這三個支柱中的每一個都被轉化為具體的行動。

在環境方面，米其林的目標是到 2050 年實現碳中和（製造和能源），並為幫助米其林使用者實現碳中和做出貢獻。

米其林「一切皆可持續」願景成為現實的一個例子是 2021 年發表的 MICHELIN e PRIMACY。 MICHELIN e PRIMACY 是第一款採用生態設計和購買時「碳中和」的米其林輪胎 [3]。此外，MICHELIN e PRIMACY 也是市場上第一個發布環境產品聲明 (EPD) 的輪胎 [4]。

另一個例子是卡車輪胎的 MICHELIN X® LINE™ ENERGY™ 系列。由於較低的滾動阻力以及在整個使用過程中可以刻溝和翻新的能力，它可以在輪胎的整個生命週期內盡可能地減少二氧化碳排放。

[3] 自 2010 年以來，米其林已將其所有工業場所的二氧化碳排放量減少了 25%，並致力於到 2050 年實現碳中和。米其林致力於資助旨在吸收或避免二氧化碳排放的項目，並利用這些項目產生的碳權與米其林 e.PRIMACY 輪胎生產相關（從原材料的提取到運輸給客戶）的殘餘排放相抵。本計劃與 Livelihoods carbon fund 合作完成
[4] www.environdec.com/Detail/?Epd=19867

推動打造低碳環保的「生態系統」

● 建立輪胎標籤系統

在歐洲，消費者購買輪胎時可以在輪胎標籤上找到滾動阻力等級，分類從 A 到 E，這有助於輪胎用戶了解輪胎的滾動阻力。輪胎標籤規則有助於消費者在更換輪胎時做出明智的購買決定，因為標籤強調了輪胎在燃油效率、安全性和噪音方面的性能。同時，這些標籤也推動了製造商不斷創新，力爭讓自己的輪胎在不同類別中名列前茅。

● 在碳稅或碳權方面鼓勵使用低滾動阻力輪胎用戶，尤其是在運輸產業

在台灣實現淨零碳排放願景的路線圖中，低滾動阻力輪胎可顯著減少運輸過程中的碳排放；因此，我們建議制定政策，鼓勵運輸商使用低滾動阻力輪胎以減少二氧化碳排放。

● 凝聚所有利益關係人的力量

想要真正實現零碳排的未來，離不開所有利益關係人的合力，這包括政府、企業、研究機構、投資機構、公益組織、大學、個人等等。多年來，米其林集團在研發低碳綠色的產品和服務之外，努力推動打造可持續出行的生態系統，包括 Movin'On Summit (開拓前行峰會)，Movin'On Lab （開拓前行實驗室）等，鼓勵更多企業和個人參與到節能減排中來，讓減碳排更加可持續。

毛行健
台灣米其林輪胎 (股) 公司
董事長

作者

自 1993 年起服務於米其林，歷經財務、信用、物流及資訊管理，與不同產品線之銷售主管。隨台灣市場之成長，強化米其林品牌深耕台灣之決心，Jay 於 2008 年領先輪胎業界，引進汽車保修加盟品牌 – 馳加汽車服務中心，創造截然不同於傳統輪胎行業的嶄新消費體驗。而在 2012 年 Jay 調派至大中華區，表現深獲肯定，並於 2016 年榮任台灣米其林首任台籍董事長，領導米其林成為台灣消費者知名度最高之輪胎品牌。

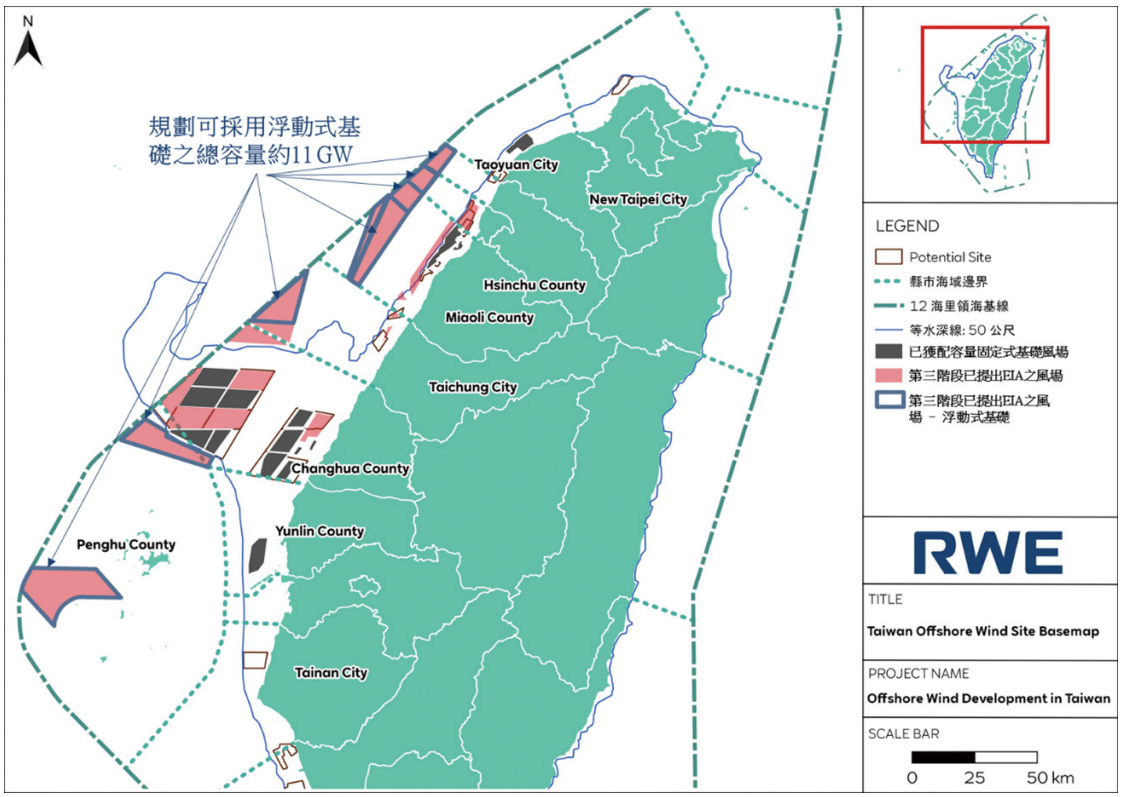
浮動式離岸風電助攻淨零轉型政策明確化為關鍵

浮動式離岸風電

RWE

建議政府於 2022 年前推動每案 100MW 以上具商業規模的浮動式示範風場，並於 2023 年完成選商，以促使後續大型商業規模浮動式風場順利開發，成為台灣淨零轉型的重要助力。

根據「台灣 2050 淨零排放路徑及策略總說明」，離岸風電肩負 2050 年前目標累計達 40-55GW 裝置容量的重任，為台灣是否能完成淨零轉型的關鍵之一。從公開資料來看，截至 2022 年 5 月，目前已提出環評並預計投入區塊開發的離岸風電計畫總容量約 16GW（已扣除重複場址），其中有超過半數的風場位於水深較深的海域，較難以採用固定式基礎，因而需要考慮採用浮動式基礎（詳下圖）。再加上根據目前的政策規劃，從今年開始，政府每年將釋出 3GW 的容量進行選商，固定式基礎的風場預計將於今年和明年獲配完畢，因此我們可以預期自 2024 年開始，浮動式風場將成為市場主力，為淨零轉型助攻。



然而，在缺乏明確的政策引導下，浮動式風場在台灣的開發與建置有著很高的不確定性。

即使包含萊茵再生能源的部分開發商已於環評程序提及將採用浮動式技術，但各離岸風電計畫僅就環境影響的角度進行初步評估，並藉此和環評委員溝通可能會有的議題，不代表已有完整的資訊足以降低開發風險，以及足夠的能量完成浮式風場建置。再者，即使浮動式風機技術已在國外已驗證可行，但台灣的環境地理條件、在地供應鏈能量、法規程序限制等，皆會影響建置進度，如在相關資訊不足的狀況下直接落地台灣，建置進度恐將因潛在的各項開發風險延遲，影響政府設定的離岸風電建置目標達成率，以及未來併網發電的效益與穩定性。

與此同時，韓國已有 5.9GW 浮動式風場取得電力業務許可證，第一階段 504MW 將於 2024 年開工，是目前世界上最大的浮動式風場項目。日本政府亦保留相關預算，目標在 2025 年啟動浮動式示範風機計畫，並在產業界的建議下，可能設定 2030 年浮動式風場目標 2-3GW 且維持躉購費率制度。兩國因此成功獲得全球運輸與安裝業者的注目，亦為浮動式供應鏈在亞太的目標市場，大幅增進兩國製造業搶進全球浮動式市場的機會。

為保持台灣在亞太地區離岸風電市場的領先地位，以及讓已經投入大筆資金和人力、物力的台灣供應鏈能有更長遠的未來，呼籲政府盡早明確化浮動式離岸風電政策。我們尤其建議政府可以參照固定式風場在台灣開發的成功政策經驗，採取示範風場引導後續開發的模式，於 **2022 年前推動每案 100MW 以上具商業規模的浮動式示範風場，並於 2023 年完成選商**。根據萊茵再生能源在浮動式風場的經驗，我們認為此政策具有以下優點：

1. 示範風場的推動將被視為台灣正式宣示朝向浮動式風機領域發展，吸引全球工程技術公司、零組件供應鏈及施工業者的目光，將資源配置在台灣。

2. 協助政府掌握風場開發、施工與併網之完整資訊。這些資訊不僅可供政府檢視相關政策是否需要調整，亦可提供開發商作為大型風場開發規劃參考，降低開發風險以確保風場可以如期如質完成建置穩定供電。

3. 固定式風場和浮動式風場之差異不僅是水下基礎採用的形式不同，各零組件亦須做相應的調整以符合更嚴峻的風場環境條件和浮動式平台。示範風場將給予台灣廠商明確動機與誘因投入浮式風機產業鏈，累積學習經驗，提升產品熟練度並降低成本，帶動產業升級轉型。

我們已經看到第二階段的離岸風電計畫在有示範風場引導的前提下，仍面臨包括疫情干擾、在地供應鏈能量不足、環境調查資料不完整的狀況導致建置進度不如預期。因此，浮動式風場如未有示範風場引導，將面臨更嚴峻的開發挑戰。

期待政府能考慮盡早推動浮動式示範風場計畫，以促使未來獲配的浮動式風場能如期施工、完成併網，成為台灣的淨零轉型的重要助力。

許韋婷
萊茵再生能源資深公共事務經理

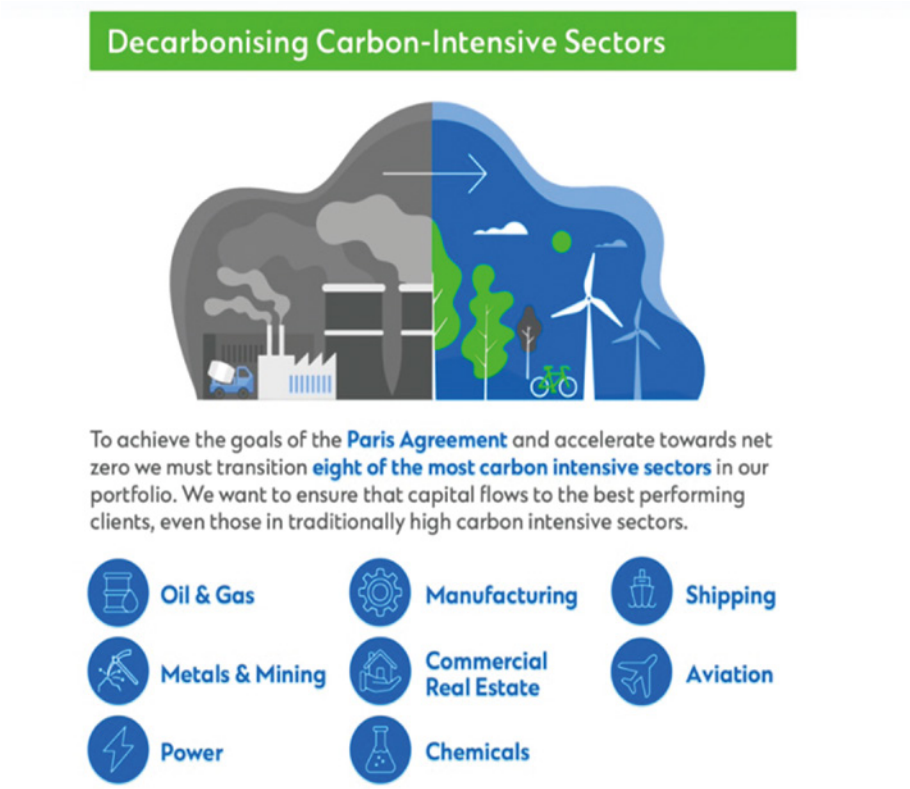
作者

許韋婷，萊茵再生能源資深公共事務經理，有超過十年政策溝通相關經驗，對能源轉型有高度熱誠，嫻熟再生能源政策與相關法規。過去曾任職於 NGO、政黨、顧問公司和智庫，已有五本政策相關著作出版。

把握良機
渣打銀行啟動轉型金融行動

2021 年 5 月 13 日，渣打銀行啟動了永續金融轉型行動，朝成為全球最負責任以及最永續的銀行的目標邁進。

目前全球正朝向淨零排放目標過渡，這也是現階段我們共同面臨的最大挑戰。根據渣打的零碳經濟報告指出，全球有 55% 的高階主管表示，他們的公司在淨零排放的轉型過程速度仍不夠快，而 78% 的投資者表示，大多數商業領袖尚未採取必要的行動來落實淨零排放的目標。以 2030 年底前實現全面淨零排放的時程來看，目前已經投入的資本支出還不到總需求的一半，因此我們必須立即採取行動。



永續金融轉型行動是渣打致力推動淨零排放目標的承諾。我們的目標是減少因融資而產生的碳排放，並積極協助客戶轉型，同時將全球最需要減少碳排放量區域中，將碳排放密集度高的前八個產業列為優先轉型對象。我們轉型過程中，不僅表現傑出的客戶能獲得資金的挹注，就算是碳密集型產業的客戶也能貢獻一己之力。

危機即是轉機

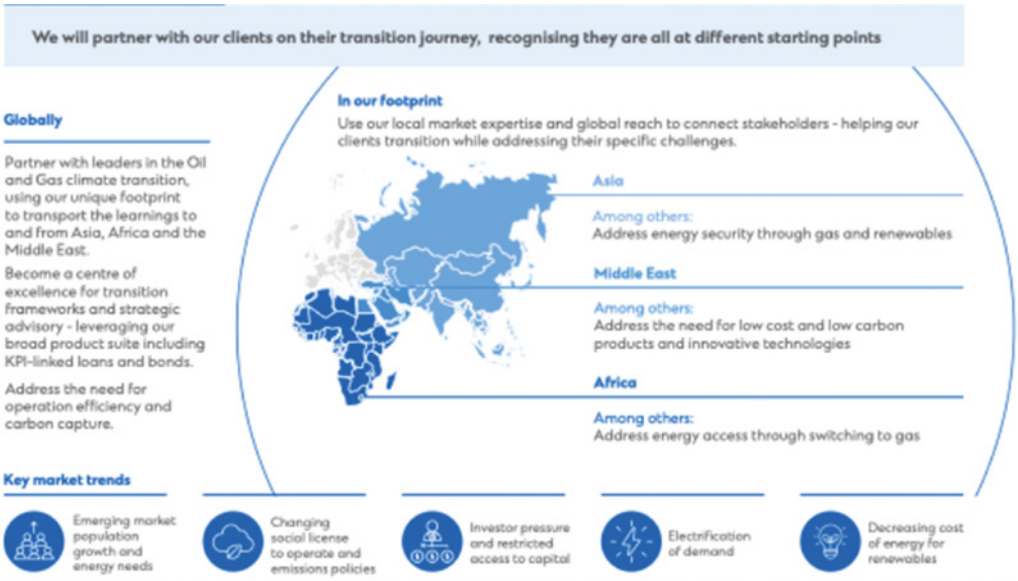
渣打的業務推動是奠基於對實體經濟的支持。然而，在轉型過程中，為傳統產業和技術提供資金仍遠遠不足以達成目標。儘管我們在綠色金融方面已經取得長足進展，但對於永續金融轉型的行動仍需要更多的高度關注。為了加速相關進展，我們持續透過諮詢服務和投融資方案，在不減緩經濟發展的前提下，加速削減碳排放的進程，全力支持客戶淨零排放轉型，並不以現階段已推出的產品組合（包括：永續指標連結貸款、綠色債券和衍生型商品、綠色專案融資和 ESG 永續諮詢服務）而自滿，還將不斷創新，以因應未來的挑戰。

- 針對在推動永續目標與渣打有志一同，並已做好準備的客戶，我們預計在 2030 年前，投入 3,000 億美元以支持綠色轉型。
- 對於剛起步的客戶，我們則提供針對特定產業的行動方案，協助客戶為邁向低碳未來提前做好的準備，並依所在的區域量身提供相對應的規畫。
- 至於尚未啟動氣候轉型計畫的客戶，我們將協助其確定最相關的轉型方向，以便客戶能制定與渣打目標一致的氣候轉型方案。

石油和天然氣產業

石油和天然氣產業所產生的直接排放溫室氣體（範疇 1 和範疇 2)， 約佔全球二氧化碳排放量的 10%。進一步與電力以及運輸等其他產業的最終用途 (範疇 3) 相結合時，直接排放量則激增近 3 倍。其中，約 50% 的碳排放量來自於渣打深耕的亞洲、非洲和中東等市場。

為了達成渣打在 2050 年前投融資項目全面淨零排放的目標，我們以短、中、長期的策略來有效減少我們在石油及天然氣產業因融資而產生的相關碳排放。同時，我們也必須兼顧維持產業支持經濟發展和提供就業機會的動能不變。



在全球，渣打與全球石油和天然氣氣候轉型領域的領導者合作，將我們在相關領域的經驗與成果引介到我們營運的亞洲、非洲和中東等市場。我們的目標是成為淨零排放轉型領域中協助架構規劃與提供策略建議的典範，同時運用關鍵指標連結貸款與綠色債券等產品的市場領導地位。

多元方案協助客戶加速淨零排放轉型

各個市場、地區和企業都會因政策、技術和資金的差異，以不同的速度進行轉型。

• 國際性石油公司－非政府控制的公開發行石油公司 (約佔石油與天然氣產業碳排放量的 15%)

這些客戶正承受著龐大的公眾和政策壓力，多數企業設定積極的轉型目標，有利於以較大的規模和速度朝淨零排放目標邁進。

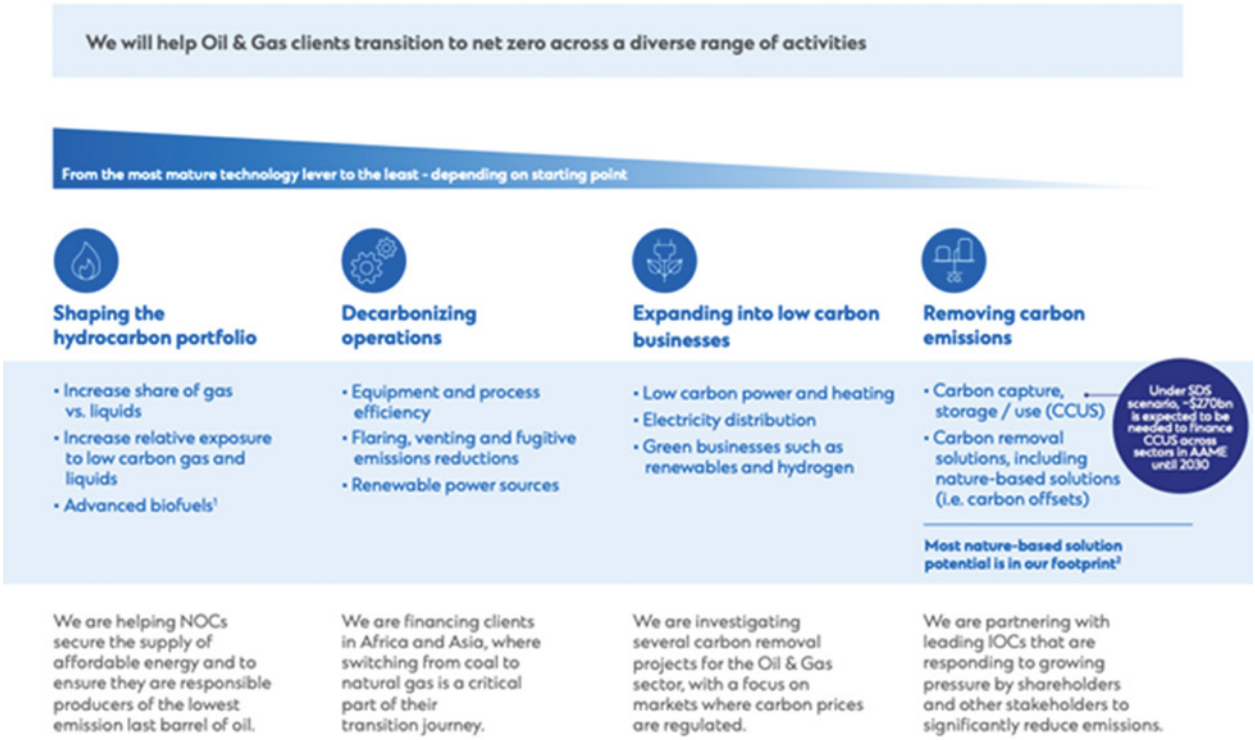
• 國有石油公司－由政府控股的石油公司 (NOCs，約佔石油與天然氣產業碳排放量的 55%)

• 小型獨立公司和中型公司 (約佔 O&G 排放量的 30%)

分散在價值鏈的各個不同環節，根據地理位置的不同，面臨不同的公共和政策壓力。許多人已經開始了氣候之旅，以跟上推動能源獲取的更廣泛工作。

結論

在渣打銀行，我們不斷審視自己的主張，並尋求更好的方法來實現此一目標。目前對我們而言，最為重要的一件事，是協助客戶實現淨零排放。作為父母、消費者和社會成員，我們都與此有利害關係，因此必會推動淨零轉型成功。



1 **Advanced biofuels** are defined by the IEA as sustainable fuels produced from non-food-crop feedstocks, capable of significantly reducing lifecycle GHG emissions compared with fossil fuel alternatives, and which do not directly compete with food and feed crops for agricultural land or adversely affect sustainability.
2 Source: https://nature4climate.org/wp-content/themes/tnc-V3/ncs-world-atlas-mapper/index.html#

儘管全世界都已意識到，淨零排放勢在必行，但有時我們發現，企業並不確定該從哪裡開始、該怎麼做，而這就是我們的工作。我們可以提供客戶所需的支持和建議，以加快他們的淨零旅程。

渣打銀行在這裡支持我們的客戶，使他們能夠轉型到淨零排放。然而，這並非沒有條件。對於排放量最高產業的客戶，我們已將他們在 2022 年底之前必須有可信的轉型計劃，作為我們的金融條件之一。我們相信，那些尚未制定計劃的公司會開始行動，因為現實是人們已開始意識到脫碳的必要性。一些公司只是需要一個發展藍圖。我們將在此提供協助。

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道達爾能源集團正在進行的 CCS 專案

政策、基礎設施

道達爾能源集團 (TotalEnergy) 在挪威、比利時、荷蘭、英國和丹麥的主要二氧化碳運輸和封存專案，以及該公司工業場所中的二氧化碳捕獲方面扮演著主要角色。道達爾能源集團的 CCS 專案主要目標是安全和永久封存來自天然氣加工和工業過程中的二氧化碳，以減少大氣排放。從這些尖端專案中，我們學到了一個關鍵知識，即需要大規模開發專案，以顯著降低二氧化碳每噸封存的單位成本。就這一點而言，產業界、專案開發商和政府之間顯然需要新的思維方式和深度合作，讓 CCS 成為一種負擔得起的脫碳解決方案。

道達爾能源的首批碳捕捉和封存 (CCS) 專案主要集中於歐洲，藉由擴展 CCS 到工業規模的有利環境推動著。在全球其他地區，該公司仍在持續推動業務發展，為下一波專案做準備。道達爾能源將借鑒其在歐洲的經驗，並進行必要的調整，以滿足各地區的需求。今天，道達爾能源在歐洲領導著主要的二氧化碳運輸和封存開發專案，包括：挪威的北極光專案，這是全球第一個商業化的 CCS 鏈;比利時的 Antwerp@C 專案，它是歐洲主要的二氧化碳中心之一；荷蘭的 Aramis 和 Azur 專案，分別涉及到在枯竭的氣田中封存二氧化碳；以及我們 Zeeland 煉油廠的藍氫生產專案，最後是英國的 Northern Enendance Partnership 專案，主要目標是將二氧化碳封存在一個深鹼水層中。

在挪威海岸卑爾根 (Bergen) 附近，一個碼頭的建設工作已經展開，將接收運載二氧化碳的船隻。這些船隻將在奧斯陸和其他歐洲工業區附近，於 -25° C 和 1.8MPa 壓力條件下，裝載液態二氧化碳。道達爾能源和其合作夥伴 Equinor 以及殼牌 (Shell) 在該地點建造了首個商業化二氧化碳運輸和地質封存設施 (各佔三分之一)。這個專案突顯出挪威對 CCS 的信心，這可以追溯到 1996 年，當時挪威大陸棚 (Norwegian continental shelf) 上的地質封存首次注入了二氧化碳，以減少 Sleipner 氣田的排放。2008 年，類似的技術被重複用於減少 Snøhvit 油田的排放，道達爾能源是其合作夥伴。為確保足夠封存容量、封存層的密封性，以及二氧化碳在岩石中的注入性，這些專案對二氧化碳地質封存點的選擇實施了嚴格的驗證程序。

Sleipner 和 Snøhvit 專案以及其他已運作多年的專案 (GCCSI，2021 年) 均已證實，CCS 是一項成熟的技術 (Loria，2021 年)。
道達爾能源在這些大型 CCS 專案中累積了豐富的經驗。

工業和能源生產基地的脫碳

道達爾能源的 CCS 專案旨在安全並永久封存天然氣加工和工業過程中的二氧化碳排放。透過多個專案的執行，已經確定規模效應能顯著降低每噸二氧化碳的封存單位成本。這一發現可透過對以下專案的研究來進行說明。

Aramis 專案和二氧化碳

由道達爾能源與殼牌公司、Energy Beheer Nederland (EBN) 和 Gasunie 共同在荷蘭開發的二氧化碳物流專案 Aramis，將提供大規模、靈活的二氧化碳運輸服務，並開放離岸二氧化碳封存 (圖 1)。
道達爾能源參與了和 Aramis 專案相關的完整 CCS 鏈。在捕捉方面，它將在道達爾能源和 Lukoil 的合資企業 Zeeland 煉油廠生產藍氫。荷蘭的目標是到 2030 年時，將排放量在 1990 年的排放基礎上減少 59%，這將透過在 2030 年將二氧化碳成本設定為每噸 125 歐元來達成。Zeeland 煉油廠有 60% 的排放來自氫氣生產裝置上的甲烷重整。投資約 2.5 億歐元，將能減少每年 90 萬噸二氧化碳排放。

捕捉到的二氧化碳將經由船舶運輸到鹿特丹港 Maasvlakte 工業園的二氧化碳中心，從那裡透過一條新的海上管道運輸，注入到之前的離岸氣田。

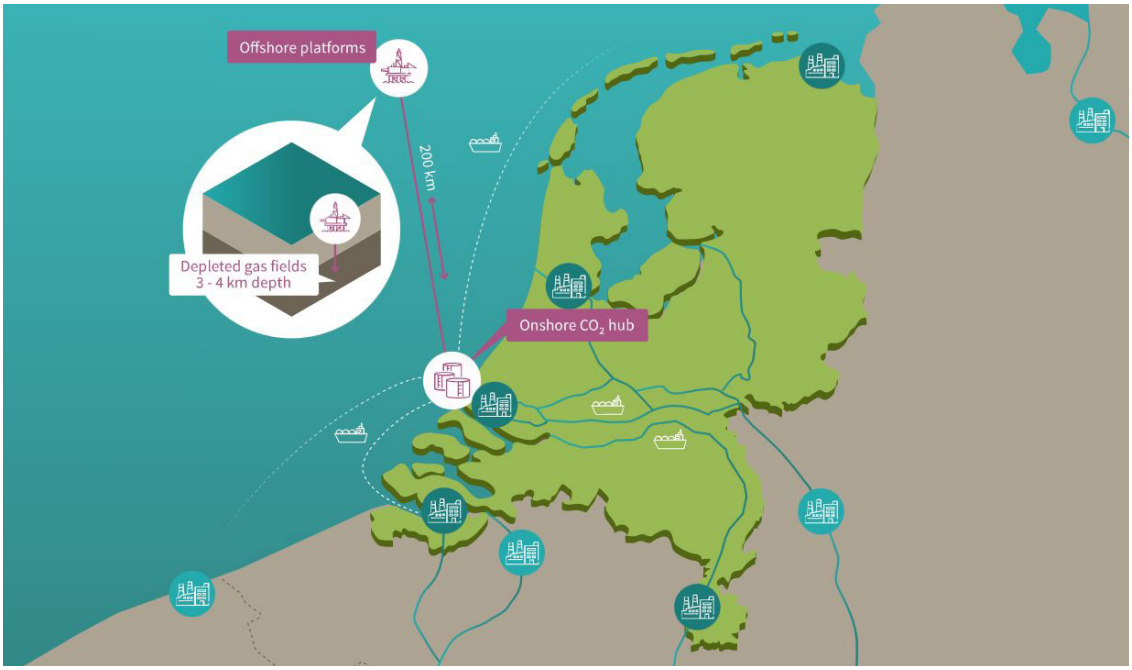

圖 1：荷蘭 Aramis 專案中的 CCS 鏈 (Aramis，2021)。

Aramis 專案的最初目標，是每年封存 500 萬噸，到 2030 年有可能每年封存超過 800 萬噸。枯竭的氣田預估有 4 億噸二氧化碳封存能力。投資決定預計將於 2023 年決定，2026 年開始首次注入 (圖 2)

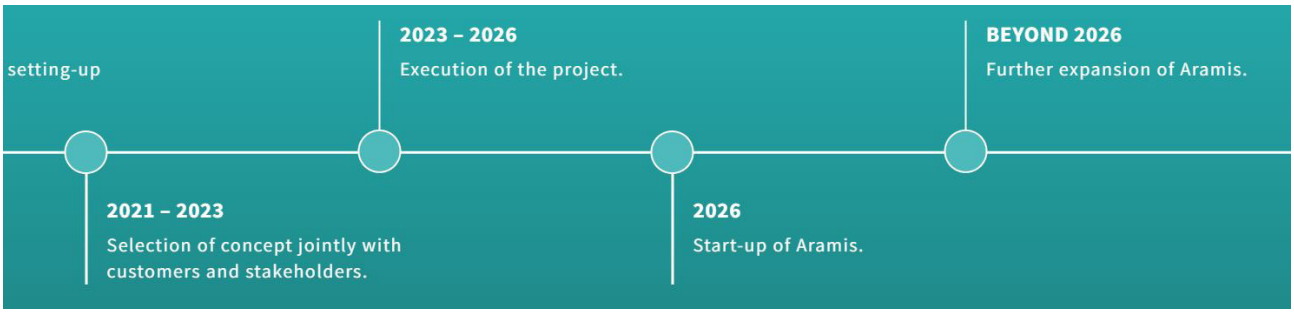

圖 2：Aramis 專案建置時間表 (Aramis，2021)。

這個專案顯示合作對於同一流域的排放者的重要性。道達爾能源以類似的方式針對在安特衛普 (Antwerp@C，2021 年) 和諾曼第 (道達爾公司，2021 年) 建立其他二氧化碳中心的可能性進行研究。與液化空氣公司、Borealis 公司、Esso SAF 公司和 Yara International ASA 公司共同負責 Seine Axis 脫碳計劃；與液化空氣公司、巴斯夫公司、Borealis 公司、ExxonMobil 公司、INEOS 公司、Fluxys 公司和安特衛普港共同負責 Antwerp@C 專案，道達爾能源已決定就聯合開發二氧化碳收集基礎設施、建設二氧化碳液化工廠和二氧化碳臨時封存地點的技術和經濟可行性展開研究。到 2030 年，這些中心可以協助 Seine Axis 每年減少多達 300 萬噸、安特衛普每年減少 900 萬噸的二氧化碳排放。

在這兩個專案中捕捉到的二氧化碳隨後將被輸送到離岸地質封存點。

北方耐力夥伴計劃 (Northern Endurance，NEP)

英國的提賽德和亨伯賽德地區，是我們 CCS 策略的一個良好範例，皆被英國當局於 2021 年 10 月 19 日選為本世紀

20 年代中期將實現脫碳的兩個地區之一。儘管合格的排放者要到 2022 年晚些時候才能選出，但收集和封存的專案已經選定：北方耐力夥伴關係 (NEP)，其中包括英國石油公司、Equinor、國家電網、殼牌公司和道達爾能源集團。其目標是為提賽德和亨伯賽德這兩個工業集群的排放者提供運輸和封存服務，這兩個集群現在被歸類為東海岸集群（圖 3）。兩條海底管道將把亨伯和提賽德與一個鹽水層封存地點連接起來。這個離岸專案的初步開發將需要鑽探五口海底注入井。

除了東海岸集群工業脫碳目標以外，還有可能利用天然氣進行新的低碳發電，以彌補可再生能源的間歇現象。一座 860MW 的淨零提賽德 (NZT) 發電站將成為英國第一個配備二氧化碳捕捉系統的商業化燃氣發電站。今天，NZT Power 是 Equinor 和 BP 作為營運商之間的協作項目。

這兩個地區的既有深水港和鐵路，讓未來有可能接收透過海運或鐵路運輸的二氧化碳。到 2026 年，每年可以收集和封存 400 萬噸二氧化碳，目標是隨著其他產業的到來，到 2030 年達到每年 1,000 萬噸。

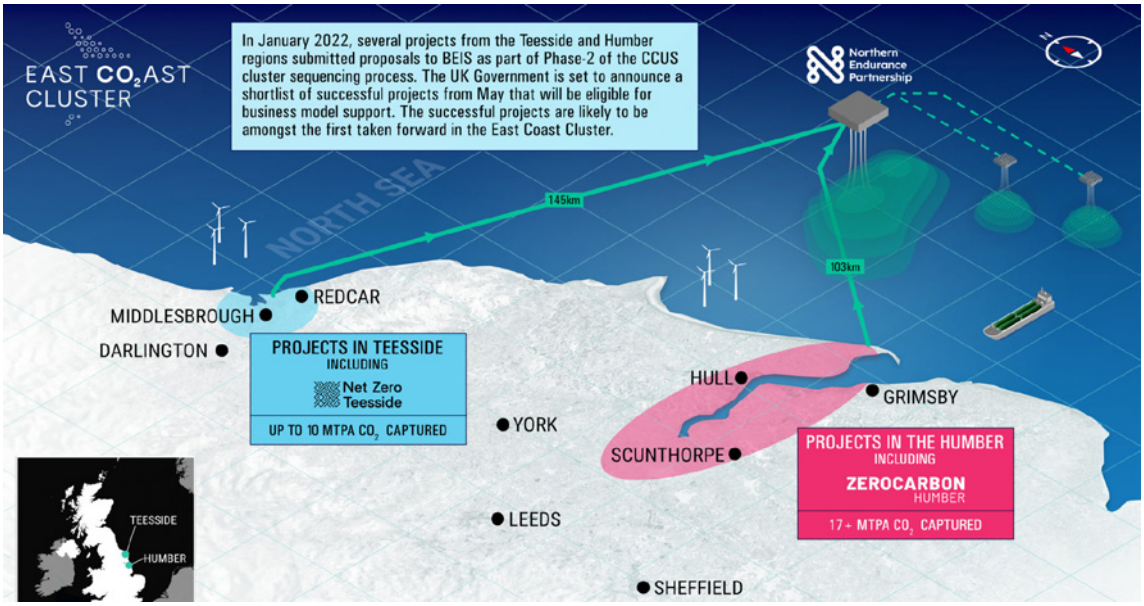

圖 3：東海岸集群淨零專案 (蒂賽德，2021 年) 示意圖。

上述專案仍處於設計和工程階段。但挪威的 Longship 專案，或者更準確地說是挪威的北極光專案，其海上運輸和封存部分並非如此。該專案已經進入安裝施工階段。

第一個商用 CCS 鏈：挪威 Longship 專案

高昂的投資和營運成本讓民間企業在沒有政府支持的情況下很難投資 CCS。Longship 專案是全球第一個商用化 CCS 專案，其問世主要歸功於挪威政府的大力支持。挪威國營的 CCS 開發公司 Gassnova SF 協調了設計研究。研究建議成立一個新公司，為二氧化碳排放者提供二氧化碳運輸和封存服務。這促成了一家新的公司，爾後又與 Equinor、殼牌和道達爾能源成立了一個對半持股的合資企業。最終，挪威的兩個地點獲選為新的二氧化碳捕捉設施投資地，這些設施的總容量為每年 800,000 噸：Norcem 位於奧斯陸西南部的水泥廠和奧斯陸市的 Fortum 焚燒爐 （圖 4）。

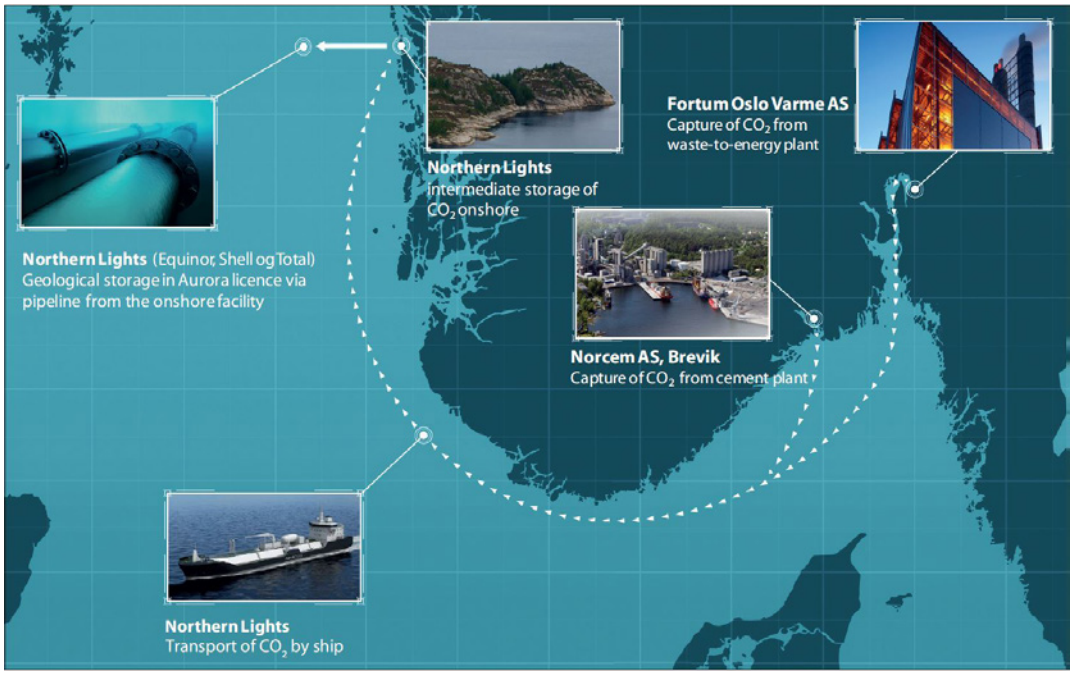

圖 4：挪威的 Longship 專案 (挪威石油與能源部，2019-2020 年)。

北極光 (圖 5) 是 Longship 專案的一部分，涉及運用船舶運輸和封存二氧化碳。這些船舶將把液態二氧化碳從上述二氧化碳捕集點的兩個碼頭，運送到位於挪威西海岸約 750 公里處 Naturassparken 的一個中間封存設施（圖 6）。這些正在興建造的船舶容量將達到 7,500 立方公尺，是世界上最大的二氧化碳運輸船。

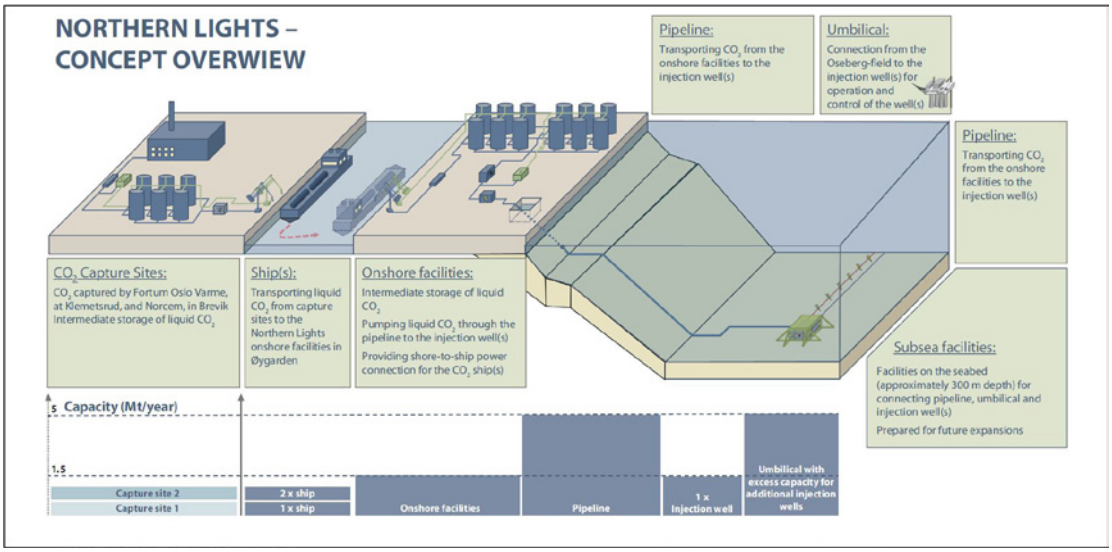

圖 5：北極光 CCS 鏈示意圖 (挪威石油與能源部，2019-2020 年)。

到達臨時封存點後，二氧化碳將透過一條 100 公里長的海底管道泵送，然後經由兩口 2,800 公尺深的海底油井直接注入鹽水層。

由於 80% 的資金來自挪威政府，因此挪威擁有這兩個工業基地的封存權利。

圖 6：位於 Naturassparken 海岸的封存點合成圖 (挪威石油與能源部，2019-2020 年)。

該專案計劃將分幾個階段進行：第一階段將在 2024 年以前，提供每年達 150 萬噸的二氧化碳封存能力。第二階段是到 2030 年將此一能力提升至每年 500 萬噸二氧化碳封存。這種增量將需要額外投資，用於擴充船隊、擴大陸上封存和鑽探新的注水井。海底管道的規模已經過大，因而有可能進行更多的注入。

北極光是歐洲的一項開創性專案。與歐洲排放國的討論已經取得了很大進展，他們對封存多餘二氧化碳的興趣越來越大，讓封存成為工業深度脫碳的解決方案之一。封存容量增加後，隨著時間的推移成本也將降低，低碳產品附加值的提升，可能最終代表在沒有政府支持的情況下，CCS 在商業上也是可行的。

許多國家都正在出現公私合作的夥伴關係，以確定啟動和維持脫碳所需的大規模投資能以最適當方式進行。同樣地，監管機構和二氧化碳封存產業也正在共同努力，確保嚴格監管，以實現二氧化碳的永久封存。

結論：未來的 CCS 專案將在何處發展？

為了達成更快速的發展，我們正在處理自身的多餘二氧化碳排放，並透通過接受第三方產生的排放來擴大我們的系統，特別是在我們營運的工業腹地上。這將創造出脫碳地區，那裡可以建立新興產業，剩餘的二氧化碳被捕捉並運輸到永久的地質封存點。除了深層鹽水層 (那裡的水不適合消費) 外，我們正在將枯竭的碳氫化合物油田轉換為封存地點，從而使它們能夠在脫碳經濟的框架內被重新利用。當然，這些都是集體行動，需要更深地扎根於工業領域的夥伴關係。

在歐洲以外，道達爾能源正在與其夥伴合作，包括一些國家石油和天然氣公司 (NOC)，以開發地質封存能力。在啟動一個專案時，東道國對發展 CCS 作為工業深度脫碳方法的意願，是選擇的一項關鍵標準。規模也是我們選擇開發專案的決定性標準，特別是在歐洲和美國以外的地區，這些地區的二氧化碳價格發現機制尚未建立，需要新的思維方式。

隨著 CCS 專案的規模和複雜性不斷增加，代表有必要與更多夥伴合作，包括：技術領域、海運、管道運輸、二氧化碳排放產業、港口和工業區、能源公司等。

道達爾能源在歐洲開發的第一個 CCS 專案，是未來全球 CCS 發展的跳板。CCS 是一種深度脫碳的方式，是讓政府、地區、產業界和許多民間社會利益相關者實現「淨零排放」目標的方式之一。

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淨零排放
台電的無悔策略

企業策略

面臨氣候變遷、國內外淨零排放趨勢下，產業與民間對零碳電力需求殷切，且配合綠能的大量成長與併網，電力部門上不僅面臨自身轉型挑戰，也將在此波變革中扮演關鍵要角。
為落實電力淨零排放，台電規劃供給面、電網面、需求面三大面向之淨零策略積極推動，扮演國家淨零領航角色，期許與各界共創台灣淨零新願景。

近年來，國際上針對氣候變遷的議題正如火如荼地討論中，在全球化所驅動龐大活絡的工業生產、商業貿易活動下，對於氣候環境所造成的影響已不容小覷。在聯合國的報告中亦指出，本世紀溫室氣體排放量須在 2050 年達到淨零排放，方可能使本世紀 (2100 年) 前溫升控制在 1.5 度內，避免對地球造成更大且不可逆轉的破壞。

在 2021 年聯合國 COP26 氣候變遷大會中，各國除了圍繞在 2050 淨零排放的議題熱烈討論，以及在 2050 年前的短中期的具體目標作討論及設定外，亦提到全球二氧化碳排放量需在 2030 年較 2010 年減少 45%，方有機會在 2050 年達到淨零排放。針對電力部門的部分，未使用碳捕集與封存技術 (CCS) 的燃煤發電，也宣示將「逐步減少」(phase down)，以減少煤炭的使用，並同時敦促各國在今年底 (COP27) 設下更高的 2030 年減碳目標，且將 NDC(National Determined Contribution，國家自定減排貢獻) 從 5 年檢討 1 次，改為逐年檢討。

身處海島地理環境且為獨立電網型態的台灣，在氣候變遷的情勢中，未來受到的衝擊將會更為劇烈，因此如何與國際接軌，積極啟動淨零轉型，是政府、各部門與台電公司不可迴避的挑戰。在近期政府各部會的努力下，今年 (2022 年)3 月 30 日國發會公告 2050 年國家淨零排放路徑規劃與策略，在未來經濟、科技、產業、民生、社會等各面向的環境評估與規劃分析下，電力部門將成為國家淨零的關鍵角色，其中最核心的 3 大重點規劃指標為：

持續成長的電力需求

預估至 2050 年的電力需求年均成長率為 2%±0.5%，最終用電量將落在約 4,200 億度至 5,700 億度之間，即較目前用電量將增加 50% 以上。

電力結構的零碳轉型

再生能源占比達 60%-70%，其中離岸風電將為最大占比；新興無碳能源的氫能占比達 9%-12%；火力機組 + 碳捕集與封存設備占比達 20%-27%。

非電力部門的電氣化

製造部門、運輸部門、商業部門、建築部門等的化石燃料使用透過電氣化轉換，排放量將移轉至電力部門，再透過電力部門的淨零轉型，支持各部門零碳目標。

了解未來電力部門扮演的角色後，台電公司後續對於「技術」的應用導入是重要關鍵。依據經濟部「先低碳、後零碳」策略架構及觀察國內外技術發展趨勢，普遍認知 2030 年後始為淨零前瞻技術成熟化應用之分水嶺。

- 目前至 2030 年階段，我們在前瞻技術成熟的準備時間，仍將在既有能源轉型基礎下，持續推動展綠、增氣、減煤，強化再生能源併網規模與系統韌性，同時針對前瞻淨零技術研發提早布局。

- 2030 年到 2050 年階段，將進入淨零轉型階段，面臨再生能源併網極大化、無碳電力技術成熟化，氫能、氨能、生質能、碳捕集與封存、地熱能、海洋能等新興技術將大規模商業化導入，電網則需以解決綠能間歇性、棄風棄光、系統慣量不足的前提，導入智慧電網、長效儲能、高壓直流輸電 (HVDC) 等相關新電網技術。

在上述的推動脈絡下，歸納電力部門未來的主要挑戰可分為電力供給如何「零碳化」，未來前瞻技術的「應用化」，如何引導其他部門能源使用移轉為「電氣化」，以及透過電網系統「強韌化」，共同建構未來再生能源大量併網下，電力系統的調度穩定、韌性及彈性。基於上述挑戰，台電公司亦進一步規劃以供給面、電網面與需求面三大面向為主之電力淨零排放策

略架構。

供給面部分，短中期透過能源轉型逐步達成發電結構調整，降低碳排，以擴大展綠、以氣代煤為新興技術成熟前之過渡推動重點；長期則導入前瞻技術，透過燃料替代，逐步推動氫氣混燒、氨煤混燒、生質能之技術選項，視技術可行後，持續朝專燒與擴大導入的方向推動，讓傳統火力發電轉型，達成淨零排放。今年已積極與國際技術領先廠商簽署混燒技術合作備忘錄，啟動相關示範計畫。合作對象包括 4 月已簽署的德國西門子公司及即將於 11 月簽署的日本三菱公司。另生質能部分，正評估啟動於台中電廠新建發電機組計畫及興達電廠既有燃煤機組改裝計畫。而最後就再生能源與無碳燃料無法完全取代的部分，將導入固碳技術，目前正於台中火力發電廠建置減碳園區，希望以園區為核心，逐步展開各項測試、示範驗證規劃，逐步擴大各電廠及機組之導入，來達成碳排歸零的最後一哩路。

電網面部分，為配合再生能源大量併網投入各項電網轉型工程。首先，以脫碳化為目的，希望打造友善的綠電併網環境，開放電網資源共享，透過持續強化電力網工程，改善併網容量與系統韌性，逐步落實再生能源極大化與國內能源自主化目標。其次，配合再生能源尖離峰特性與電氣化趨勢，調度需強化需求端資源整合，因而智慧化成為電網重要推動策略。近年正積極建置智慧電網，大量布建 AMI 智慧電表，透過數據及科技的智慧化應用，強化能源管理服務及提升能源使用效率，以紓緩再生能源所帶來夜尖峰負載趨勢下的供電壓力。另外，針對再生能源大量併網後，因太陽光的日間夜間發電量不同所造成間歇性問題，規劃以儲能化的方式將電力移轉至需求尖峰期使用。除建置儲能系統外，將透過輔助服務採購及電力交易平台模式，引入民間儲能資源。長期亦規劃新建抽蓄變頻水力機組，並持續觀察再生能源發展，適時引進製氫技術以氫儲能，運用再生能源多餘電力生產綠氫，將儲能方式多元化。

需求端部分，透過需求面管理措施，減緩用電需求與平抑負載變動。在節約用電部分，推出各項節電措施，包括節能用電診斷、數位智慧服務、台電 APP 等，結合更多智慧、數位的創新工具，讓用戶可以自主掌握用電管理，進而節約能源，降低電力需求；在需量反應部分，除傳統誘因型計畫外，將觀察產業及民生的用電模式，重新規劃各時段的區間費率，讓用戶進而調整用電習慣和時段 (時間帶差異化費率)，以需求端的面向和做法，調整負載變化，以維持電力系統的穩定運作。

總結上述內容，台電公司作為國營事業，穩定供電是我們不變的使命，在未來企業永續發展的路上，落實電力淨零排放將加入我們的核心價值，同步搭配國際趨勢與配合政府淨零路徑，展開具體行動，以提供國家淨零轉型的關鍵動能。我們也期許發揮自身的影響力，扮演國家電力部門中的領航角色，與產業部門、社會各界夥伴共同努力，以實現台灣淨零新願景。

王耀庭
台電公司總經理

作者

國立成功大學電機碩士，前任台電公司副總經理暨配售電事業部執行長，深耕電力系統領域逾 30 年，擁有豐富及專業之電網部門工作實戰資歷，為台電邁向電力淨零目標領航者。

大江大投資 幫 63 國客戶淨零

再生能源、淨零碳排、企業策略

2022 年 422 地球日，我們提出更具氣候野心的目標：除 2030 年 100% 使用再生能源之外，大江生醫目標於 2030 年前降低用水強度達 25%、生產端零廢棄物，並於 2040 年前達成淨零碳排。

大江生醫是國際化的生技設計代工（CDMO）企業，主要產品為保健食品、機能性飲料、護膚品、日用品、醫材及寵物保健等，大江生醫忠於 CDMO 商業模式，透過差異化的產品設計與研發技術優勢，為品牌客戶設計獨有配方，忠於客戶及消費者需求，打造具市場獨特性的商品，至今已銷售至全球 63 個國家。

「企業必須活在未來，不能等到世界積重難返之後才開始管理。」活在未來的企業才能夠生存，而「未來」就立足於企業永續發展——製程改用綠能、大量採用回收材、發展無人化的智慧工廠，都是擋不了的趨勢。這是每次公司會議一再重申的重要戰略。

作為台灣首家加入 RE100 企業 大江生醫積極發展再生能源

2018 年大江生醫成為台灣首家加入 RE100 的企業，承諾 2030 年達成 100% 再生能源。目前持續透過購買台灣再生能源憑證（T-RECs）、與再生能源發電業者簽訂再生能源購電協議（PPAs），以及自建太陽能發電系統自發自用，未來則規劃以自建電廠為主要策略，逐步邁向 100% 再生能源的目標。

以自建電廠為例，大江生醫位於屏東的「精準智造中心」，於 2017 年起導入 ISO 50001 能源管理系統，屋頂全面裝設太陽能發電設備，總設置容量為 1362.24kWh。憑藉著南台灣的日照優勢，大江生醫工廠屋頂每年約可生產超過 100 萬度電（1GWh）。考量廠區的屋頂面積有限，為實現 RE100 的目標，大江生醫同時積極洽談廠區以外的空間，投入再生能源發電裝置，預計 2030 年達到 50% 綠電使用比例。未來將規劃保留與電廠同等面積的生態保育園區、輔導契作農民採用環境友善農法以增加土壤碳匯等方式，積極實踐生態保育的目標。

致力打造零碳營運： 工廠零碳、產品也零碳

除了 RE100 之外，大江生醫也積極響應 EP100、SBTi 等國際氣候倡議，分別針對能源使用效率與科學基礎減量目標作出承諾。

2021 年大江生醫的減碳目標通過 SBTi（科學減碳倡議）審核，將依照最嚴格的 1.5° C 路徑，範疇 1、2 的排放目標將搭配再生能源的使用以及能源效率的提升逐步推動，目標 2030 年前絕對減量 51%；範疇 3 的「購買商品與服務」，將透過供應商的篩選機制以及溝通，減少購買商品與服務之排放量，目標 2030 年前絕對減量 15%（以 2018 年為基準年）。

率先於大江生醫其他事業群，位在屏東農業生物科技園區的四座工廠，透過提升能源使用效率與相關減排計劃，其中，2021 年 S5 機能性飲品廠、S9 機能性食品廠、S12 自動倉儲廠，進行空調送風時程控制、廠區蒸氣串聯、雲端 App 製程控管等多項節能專案，2021 年達成節電約 120 萬度（1.2GWh）之效益。預計 2022 年將進一步節電近 400 萬度電（4GWh）。

實現零碳工廠的同時，大江生醫更進一步與客戶和供應鏈攜手打造零碳保健食品及面膜，從原料開採、生產製造、產銷物流、消費者使用及廢棄物處理，產品生命週期的碳排放量通過 PAS 2060 碳中和驗證，不僅力求提升消費者美麗與健康生活，也盡力降低氣候衝擊。

提升能源生產力 積極響應 EP100 氣候倡議

為提升能源生產力，大江生醫於 2019 年初加入 EP100 倡議，目標 2026 年以前全集團導入能源管理系統，並於 2040 年前提升 35% 能源生產率及能源使用效率（以 2016 年為基準年）。

對此，大江生醫持續投入提升能效的專案及資本支出，包括高能源效率設備升級、更換 LED 照明系統、裝設智慧電表及能源監控系統、結合雲端 AI 運算，達到更全面之能源管理。

2022 年 422 地球日，我們提出更具氣候野心的目標：

除 2030 年 100% 使用再生能源之外，大江生醫目標於 2030 年前降低用水強度達 25%、生產端零廢棄物，並於 2040 年前達成淨零碳排。

永續下一步：發展生物碳匯、持續優化智慧無人工廠、採購綠電

大江生醫目前已建置多個品類之自動化產線，從充填到包裝皆可無人化生產。由 MES 生產管理系統下達指令後，串聯自動倉儲出料再由無人自動搬運車 (AGV) 銜接，能將原料與產品自動搬運到指定的區域，不僅能夠實現全區潔淨，確保消費者的健康與安全，透過智慧製造流程，也能於夜間排程，不排擠日間出貨，進而加快飲料及粉包生產效率，縮短排程達到最快 28 日出貨，提高產值降低用電強度。

2019 年起，大江生醫持續與陽光伏特家合作，攜手合作公益綠電專案——於長照中心、身心障礙托育機構，鋪設屋頂型太陽能板，再以長期合約向社福單位購回太陽能發電所發出的再生能源憑證（T-RECs），同時實現再生能源與社會公益。此長期綠電公益合約共可產生近新台幣 400 萬元收益支持社福團體營運。

此外，大江生醫也親身參與台灣再生能源交易自由化，2019 年在《再生能源發展條例》修法後，與瓦特先生公開簽署再生能源購電協議之合作意向書，成為台灣首批實際完成綠電採購之企業。

未來，大江生醫將積極尋找更多公益綠電之合作對象，例如漁電共生太陽光電案場等，盼能實踐生態與綠電雙贏之局面。大江生醫認為永續即是企業競爭力，往後將繼續執行更多元的永續策略，包含廠端建設與產品設計，並強化供應商對永續的承諾，大江生醫有信心將能持續獲得歐美保健食品與美妝品牌的青睞，拿下國際訂單，證明永續能與企業獲益相輔相成。

林詠翔
大江生醫董事長

作者

大江生醫董事長林詠翔先生投入生物科技領域長達 20 多年，發明獨步全球之生物挖礦平台，打造銷售 63 國的高效能生技保健、醫材產品。林詠翔董事長推動企業永續，帶領大江於 2040 年達到淨零碳排，貫徹其信念「福報與財報能同時擁抱」。

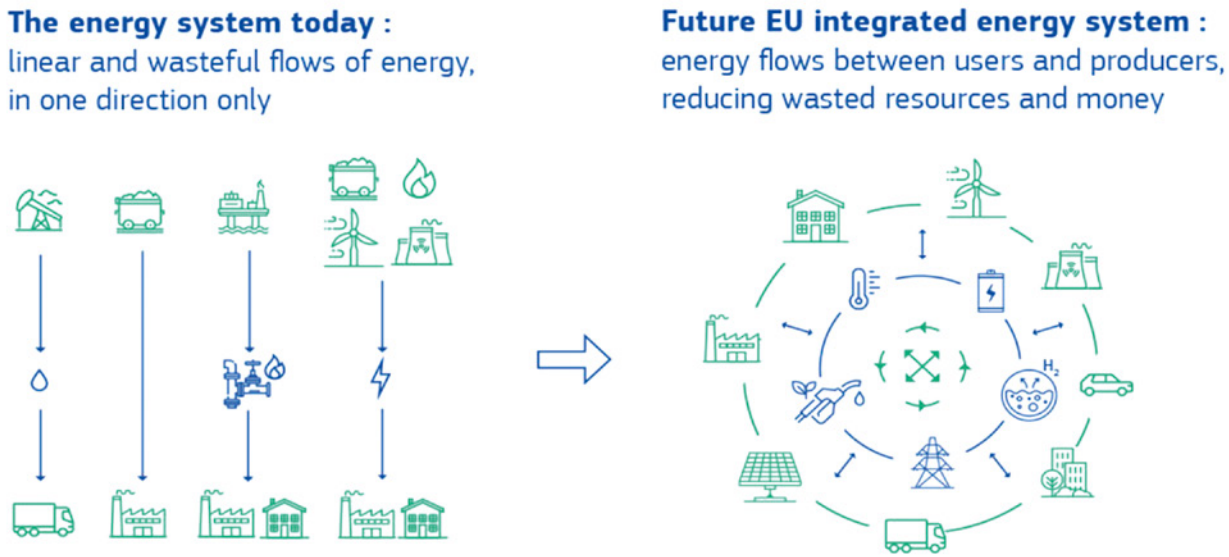
第三章

萬眾注目的解方 - 氫能應用與發展

歐洲推動氫能發展政策與現況

歐盟氫能發展政策

歐盟執委會在於 2019 年年底公布了《歐洲綠色政綱》(The European Green Deal)，將氣候變遷與環境挑戰納入政策並擬定對應行動， 以期在 2030 年達到 50% 至 55% 的減碳目標，並於 2050 年達到溫室氣體排放歸零，而在 2020 年 7 月歐盟執委會所公佈的《新能源系統整合指導方針》(EU Energy System Integration Strategy) 及《氫能策略指導方針》(EU hydrogen Strategy) 中，氫能作為未來歐洲能源系統脫碳的基礎之一，在整合歐盟能源系統及未來的循環能源系統中扮演重要角色，由於其可用於原料、燃料或能源載體和儲能，並可廣泛用於工業、交通、電力和建築領域等領域，因此在《新能源系統整合指導方針》所提到的三大面向中，對於難以實現電氣化的領域，氫能可作為潔淨能源的替代選項。另外，除了制定關於氫的政策與指導方針外，歐盟亦支持許多氫能的發展項目及倡議，其中的關鍵為於同年 7 月所成立的「歐洲潔淨氫能聯盟（European Clean Hydrogen Alliance）」，該聯盟於 2020 年 3 月作為歐洲產業策略指導方針的一部分宣布，並於同年 7 月 8 日與歐盟的氫能策略指導方針同時啟動，以透過該聯盟結合資源、擴大氫能生產規模的投資管道，並建立氫能產業鏈。



資料來源：EU strategy on energy system integration

此外，專門制定的《氫能策略》則規劃在整合的能源系統中，透過由風能、太陽能所生產之再生氫氣[1]（又稱綠氫）以支持工業、交通與能源生產等領域的脫碳進程，該進程包含三個階段：

- **第一階段 (2020 至 2024 年)**

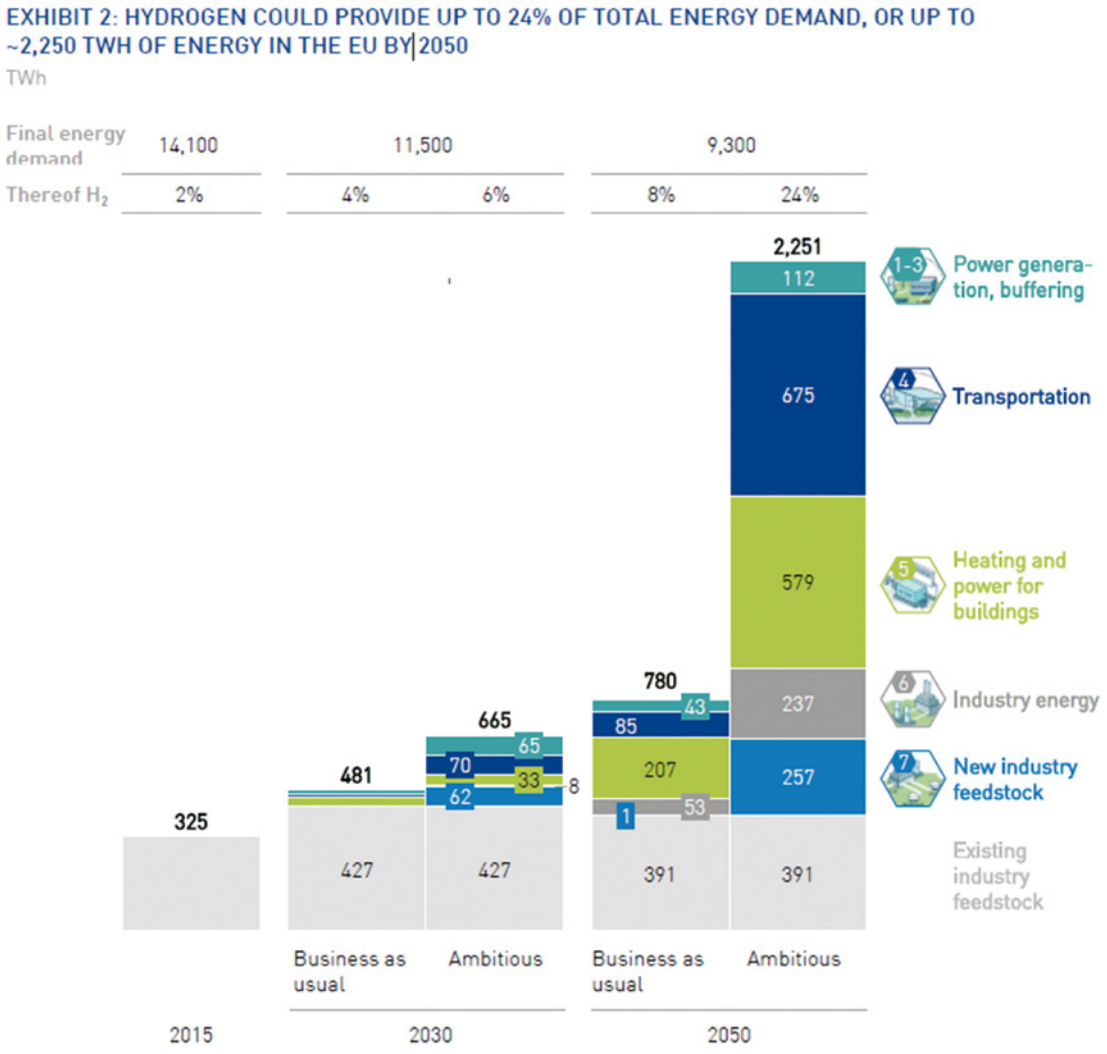
在歐盟安裝至少 6 百萬瓩的再生氫氣電解槽並生產多達 100 萬噸的再生氫氣。

• 第二階段 (2025 至 2030 年)

於 2030 年達到建置 40 百萬瓩的再生氫氣電解槽，並在歐盟生產達 1,000 萬噸的再生氫氣。此外，建立多個稱為「氫谷」(Hydrogen Valleys) 的地區性製氫產業中心，該專用的氫氣基礎設施不僅可將氫用於工業和交通與電力平衡，還能為住宅與商業建築提供熱能，而該些氫谷亦為未來歐洲地區氫能網絡的架構。此階段歐盟的目標係建立一個開放與競爭的歐盟氫能市場，使跨境交易可暢通無阻、氫能供應在各部門之間得以有效分配。

• 第三階段 (2030 至 2050 年)

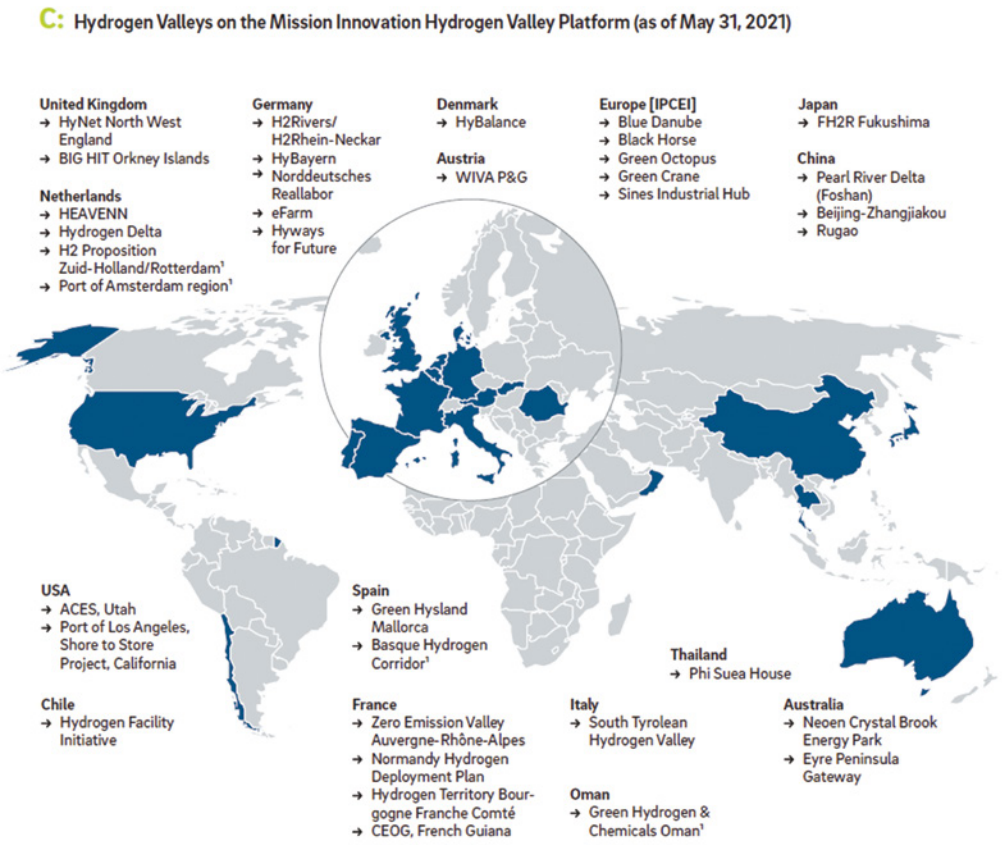
再生氫能技術應成熟且能大規模應用於難以低碳化 (hard-to-decarbonized) 的領域，包含航空和航運到難以脫碳的工業和商業建築等領域，預計至 2050 年，再生氫能可滿足歐盟地區 24% (或 2,250 TWh) 之能源總需求。



3 As part of the Paris agreement, EU member states have committed to achieving the 2-degree scenario and making efforts towards achieving a 1.5-degree scenario. This study anchors on achieving the 2-degree scenario – the necessity for hydrogen and the amount of deployment would be even greater in a 1.5-degree scenario.

[1] 根據《氫能策略》，再生氫氣 (Renewable hydrogen) 係指通過電解水（在電解槽中，由電力驅動）所產生的氫，其電力來自再生能源。再生氫氣的整體生命週期中，其溫室氣體排放量接近於零，此外，其亦可透過沼氣（而非天然氣）或生質能的轉化來生產再生氫氣。

在上述各階段中，「氫谷」作為實現新型氫經濟發展的重要項目，可連結生產、運輸和各種最終用途，為一地區性製氫產業中心，而歐盟在催生氫谷上則成立了「氫谷使命創新平台」(Mission Innovation Hydrogen Valley Platform)，以為大型氫能項目的訊息流通與合作創建一個全球的平台，推動氫谷的發展。



發展現況

在歐盟氫能戰略帶來投資機會與發展的同時，所需面對的挑戰亦艱鉅。除了技術的突破外，成本也是氫能是否能拓展與普及的重要因素。根據國際能源署估計，目前綠氫的價格約為 1 公斤 3.5 至 5.0 歐元，其遠高於灰氫的 1 公斤 1.5 歐元，因此在目前與未來的一段期間內皆不具市場競爭力，而需要長期的投資扶持。因此，可預期的是，為達到歐盟設定的目標，歐盟需長期且大規模的投資再生能源電廠制氫，故綠氫的成本在短期間內將很難下降，整體氫能產業要具競爭力並得以發展將面對巨大挑戰。

根據商業組織氫能委員會（Hydrogen Council）和管理顧問公司麥肯錫的統計，目前全球所公布的氫氣計畫中，有超過半數的計畫皆集中在歐洲，且預計未來十年間規模最大的氫能相關投資都將在歐洲發生，包含綠氫的製造，以及搭配碳捕捉技術從石化燃料產生的氫氣。此外，根據氫能委員會發布的報告，若所有計畫皆能實踐，未來十年全球氫能投資將超過 3,000 億美元，約占能源產業總投資的 1.4%，其中歐洲的投資將占總投資的 45% 左右，惟目前大部分的資金仍尚未到位。

歐洲針對氫能之投資議程如下表所示：

項目 / 年度	2020 年	2021 年
投資議程	透過歐洲氫能聯盟，制定投資議程以刺激氫的生產和推廣使用，並建立具體的項目管道（至 2020 年底）	
增加需求並擴大生產	在委員會即將提出的永續和智能交通戰略以及相關政策及措施中提供氫能相關應用，以促進氫能在運輸部門的使用（2020 年）	• 建立通用的低碳標準，以促進氫氣生產裝置的設立（到 2021 年 6 月），並為綠氫和低碳氫的認證建立通用的術語與歐洲的標準（到 2021 年 6 月） • 制定一個試點計劃，特別是支持低碳鋼和可循環鋼，以及基礎化學品的生產

設計一個支持性架構		• 開始規劃氫氣基礎設施，包括跨歐洲能源和運輸網絡和十年網絡發展計劃（TYNDPs）（2021），同時考慮加油站網絡的規劃 • 在《替代燃料基礎設施指令》修訂和《跨歐洲運輸網絡條例》（2021 年）修訂中加快部署不同的加油基礎設施 • 為氫的部署建立有利的市場規則，包括消除高效氫基礎設施發展的障礙，並通過即將進行的立法審查以確保氫生產商和客戶進入液態市場，以及內部天然氣市場的完整性
促進氫技術的研究和創新	• 啟動 100 兆瓦電解槽和綠色機場及港口的提案，作為 Horizon 2020（2020 年第三季度）歐洲綠色政綱所呼籲的一部分 • 與 SET 計劃（從 2020 年起）協調，指導支持氫價值鏈的關鍵試點項目的發展 • 通過在 ETS 創新基金下發起提案徵集，以促進以氫能為創新基礎的技術示範	建立再生氫能的合作夥伴關係，重點關注再生氫的生產、儲存、運輸、分配和關鍵零組件，以具有競爭力的價格優先用於再生氫能的最終用途（2021）
國際面向	• 加強歐盟在氫技術標準、法規之國際論壇中的領導地位 • 進與南部和東部鄰里夥伴與能源共同體國家的合作，尤其是烏克蘭在再生電力和氫氣方面的合作 • 在非洲 - 歐洲綠色能源倡議框架內與非洲聯盟制定再生氫能的合作進程 • 至 2021 年制定以歐元計價的交易基準	

全球氫能技術與市場發展

• 氫能相關法規盤點

很多國家都已經關注氫 (Hydrogen) 能源的發展，多數先進發展國家已推出相關的氫能源政策。國際能源署預測，到 2070 年全球對氫氣的需求將達到 5.2 億噸。作為應對氣候變化和加快能源轉型的重要舉措，越來越多經濟體更加重視發展氫能產業。國際氫能委員會近期發布的報告顯示，自 2021 年 2 月以來，全世界總共啟動了 131 個大型氫能開發項目，而預計到 2030 年，全球氫能領域投資總額將達到 5000 億美元。世界能源理事會預計，到 2050 年氫能在全球終端能源消費量中的佔比可高達 25%。

能源、化工、製造企業之間的跨界氫能合作蓬勃興起。氫燃料電池汽車投放市場，氫動力火車、船舶、卡車等新興交通工具的研發掀起熱潮。例如，韓國現代汽車投資約 7.6 萬億韓元（約合 64 億美元）用於與氫相關的研發和設施擴建。2021 年 7 月，現代汽車宣布，與現代電氣能源系統公司合作開發專用於移動發電機和替代海事電源供應解決方案的氫燃料電池包。

澳洲於 2019 年發布「 國家氫能策略」，於其中列示 57 個行動方案，提出以 2025 年里程碑，建置氫能中心並創造產業需求，於 2030 年前成為全球氫能經濟主要國家，其三大願景，分別是成為亞洲前三大氫能出口國、取得優良氫能安全規範以及創造國內經濟與工作機會。從供給面來看，澳洲將著重於強化氫能生產技術與提升效率並透過液化、純氫氣管線或地下儲存技術等加強氫氣的供給；從需求面來看，則可分為消費性產品如加氫站、氫動力汽車或航空與船舶使用之合成燃料、工業性產品如將設備加裝氫能輸入孔以及基礎建設如偏遠地區氫能電網之加強三大類。資金方面，澳洲政府欲投入 3 億澳元於「 氫能躍昇基金」，專門用於氫能項目之融資；澳洲再生能源局則管理 7,000 萬澳元「再生氫能建置募資計畫」，募資對象為規模 10MW 以上之替代能源方案。歐盟在 2020 年 7 月時發布《歐盟氫能源戰略》，計劃到 2050 年將氫能在能源結構中的佔比提高到 12%~14%。內容概述了全面的投資計劃，包括制氫、儲氫、運氫的全產業鏈，以及現有天然氣基礎設施、碳捕集和封存技術等投資，並提出進一步加強研發和技術創新 (主要為開發以太陽能和風能所生產的氫)，促進氫能國際合作；法國 2021 年初成立國家氫能委員會，根據法國《國家氫能戰略》，該國將陸續大規模建設安裝水電解裝置、發展電解行業、促進交通工具使用氫燃料電池等，計劃到 2030 年擁有 6.5GW 的電解槽產能，可生產綠氫 60 萬噸、減排二氧化碳 600 萬噸；美國 2021 年 6 月宣布 " 氫能源地球計劃 "，提出在 10 年內實現綠氫成本降低 80% 的目標，由目前每千克 5 美元降至每千克 1 美元，美國能源部也宣布撥款 5250 萬美元資助 31 個氫能相關項目；韓國近年則頒布了全球首個《促進氫經濟和氫安全管理法》，為政府的氫能承諾和設施安全標准的實施奠定法律基礎，使韓國的氫定價系統有更透明的機制，也成立了由政府人士和行業專家共同參與的氫經濟委員會，明確提出到 2030 年普及 85 萬輛氫燃料電池汽車、建設 660 座加氫站；日本也制

定了相關政策著重於氫能應用、氫能運輸和氫能的生產並制定實現目標的措施；新加坡 2020 年宣布一項約 3600 萬美元的低碳能源研究資助計劃，支持氫能等低碳技術的研發；智利 2020 年 11 月發布國家綠氫戰略，目標是到 2030 年生產世界上最便宜的綠氫，2040 年成為世界三大氫出口國之一； 2021 年 7 月，埃及政府發表聲明敦促制定本國氫發展綜合戰略，目標是賦能埃及氫能生產和利用能力，將綠氫納入國家綜合能源體系。

國際能源署指出，隨著太陽能、風能等可再生能源成本的下降，以及電解槽的規模經濟效應顯現，到 2030 年，可再生能源制備的綠氫將在成本上更具競爭力，市場認可度有望進一步提升。氫能產業目前發展仍處於起步階段，面臨基礎設施尚未規模化、低碳氫成本高、應用產業集群不成熟、政策監管尚未完善等諸多挑戰。從目前氫能產業發展現狀看，低碳氫的生產和利用需要各國通過不同的手段加以刺激，配合戰略性投資和財政面的鼓勵。眼下，越來越多經濟體也已確定了加氫站建設目標。截至 2021 年 2 月，歐洲已擁有商業化運營加氫站 200 座。其中，德國已建成約 100 座，並計劃到 2023 年，共建成 400 座加氫站。法國提出到 2028 年力爭建成 400 到 1000 座加氫站。
許多經濟體之間不斷強化雙邊協作關系，確保穩定的供應伙伴關系，推動全球氫供應鏈的形成。歐盟委員會承諾加強歐洲和非洲合作伙伴在可持續發展方面的創新合作，包括專注於氫的歐洲—非洲綠色能源倡議智利與荷蘭鹿特丹港簽署框架協議，未來將向荷蘭乃至整個歐洲出口綠氫阿聯酋馬斯達爾城與德國西門子能源、日本丸紅株式會社等公司達成綠氫生產合作意向，將在馬斯達爾建立一個氫氣生產示範工廠；德國和沙特將在綠氫的生產、加工、應用和運輸領域進行密切合作。
聯合國工業發展組織近年也啟動了工業氫應用全球伙伴關系，以在全球範圍內推廣氫解決方案。該伙伴關系旨在推動戰略對話，加強相關政策、技術和標准的交流與合作。

● 氫能法規限制與推進

在國內的部分，目前台灣政府雖未針對氫能制定相關法規或明文政策，然已積極朝此項目邁進，台灣經濟研究院（TIER）及台灣氫能及燃料電池聯盟（THFCP）積極與諸多清能發展較先進之國家合作舉辦論壇，甚至簽訂備忘錄或協議等。以下表格係國內氫能及燃料電池聯盟近年來為推動台灣氫能發展的合作國家與相關舉措。

合作國家	相關舉措
德國	2021 年 5 月 28 日，台灣燃料電池夥伴聯盟於台德氫能交流視訊會議中向德國北萊茵邦和 30 位德國相關業者及經濟促進單位推廣與討論台灣的產品和技術，並聚焦於我國氫能與燃料電池之相關議題。2021 年 8 月 10 日，經濟部能源局與德國在台協會共同舉辦 2021 台德能源轉型論壇，除了針對雙方能源轉型之相關經驗進行交流外，亦討論氫能相關議題。
英國	於 2021 年 10 月 21 日舉辦之台英氫能應用論壇中，台灣氫能及燃料電池聯盟和蘇格蘭氫能燃料電池協會簽署了合作備忘錄以加深台英在氫能技術與應用上的交流，並討論台灣和英國之氫能及燃料電池產業如何進行雙邊深度合作，亦探討了第三國如印度與馬來西亞等國一同合作的機會。
加拿大	2022 年 1 月 18 日舉辦之加台低碳排放 - 氫能與燃料電池 (HFC) 論壇中，彙集了加拿大和台灣的氫燃料電池產業領導者，共同探討如何進行雙邊合作以達成 2050 淨零碳排之目標，此外，台加雙方亦於此論壇中簽署備忘錄，旨在合作建立產、官、學、研的交流與合作平臺，並推動台、加於氫能與燃料電池技術領域的各項合作與發展

此外，科技部主導之「國家級淨零科技行動方案」已於近日啟動，主要布局 2030 年後所需的節能減碳新興科技，目前正協同各部會、上中下游業者共同盤點所需新興科技，具體技術研發細節將於年底出爐。欲達成此目標，預計將投入低碳及負碳技術經費約 415 億元至 2030 年，主要投資項目為氫能、儲能裝置和智慧電網，並積極爭取與日本、澳洲跨國合作氫能，和德國合作儲能電池。

另在全球其他地區氫能推進的情況如下表所示：

合作國家	國家	相關舉措
歐洲	歐盟	歐盟清淨氫能聯盟計畫在 2030 年前要設立至少 40GW 的再生能源水電解廠，以再生電力（如風能和太陽能）製氫為主，從化石燃料中提取低碳氫能為輔，以在歐洲建立完整的氫能價值鏈，預計於 2050 年達成潔淨氫能滿足全球能源需求的 24%，年銷售額預估近 6,300 億歐元，並於歐洲的氫價值鏈中創造 100 萬個工作機會。
	英國	英國國家氫能戰略則提出到 2030 年，英國預計擁有 5GW 的氫生產能力，用以替代天然氣，並為 300 萬户英國家庭提供電力，以成為全球氫能領域的領導者；至於 2050 年，英國約 20% 至 35% 的能源消費將來自於氫，預計將遠高於全球平均水平（10%）。
亞洲	韓國	2018 年 8 月，韓國政府將 「氫能產業」訂定為三大創新增長戰略投資領域之一，2019 年 1 月，韓國政府發布 《氫能經濟發展路線圖》，將以氫燃料電池汽車和燃料電池為核心，著重於氫燃料 電池汽車、加氫站、氫能發電、 氫氣生產、存儲和運輸、安全監管等面向，預計於 2040 年創造出 43 兆韓元的年附加值及 42 萬個就業機會，並使韓國氫燃料電池汽車和燃料電池的國際市佔率達到世界第一，令韓國成為世界最高水平的氫能經濟領先國家。
	日本	由於日本幾乎沒有能源資源，故其相當重視氫能利用，期待未來能占據氫能產業鏈頂端，成為氫能能源出口國，並提出欲成為全球實現「氫社會」的第一人，於 2017 年及 2019 年分別祭出《氫能基本戰略》及《氫能利用進度表》，主要推進以下二目標：2025 年前，氫燃料電池汽車價格降至與混合動力汽車一致；2030 年前，建成 900 座加氫站，令氫能發電商業化，並持續降低氫氣供應成本，使其能與傳統能源價格競爭。
北美洲	美國	2019 年 11 月，美國燃料電池和氫能協會 (FCHEA) 發佈了《美國氫能經濟路線圖——減排及驅動氫能在全美實現增長》，此路線圖從產業界視角出發，勾勒出 " 建立跨市場和應用的夥伴關係，長久把持全球能源技術主導權 " 的發展圖景。對內，將透過交通運輸、工業原料、備用電源及電力系統等領域的規模化應用，提升全美氫能源需求量，美國能源部將斥資 80 億美元建立區域氫能中心，以擴大氫能在工業領域的應用，另投入 10 億美元降低再生能源產氫的成本、5 億美元支持氫能設備生產和打造國內供應鏈，預計到 2030 年，氫需求將達 1700 萬噸，美國氫能經濟每年將可貢獻約 1400 億美元的收入，並創造 70 萬個就業機會；到 2050 年，達到 6300 萬噸的氫能源需求，不僅每年貢獻約 7500 億美元的收入以及累計提供 340 萬個就業機會外，亦將滿足美國終端能源需求的 14%。對外，則期望能向欲發展氫能基礎設施的地區如歐洲、中國、日本、韓國和澳大利亞出口技術，以維持美國的全球能源領導者地位。

氫能技術投資

由於氫能技術目前仍處於剛起步階段，故全球在氫能技術的投資資金上較其他常見之再生能源少，目前僅有歐洲國家之公部門挹注較多資金投入氫能技術的研發，以推動氫能的發展以及帶動民間方對於氫能技術的投資。一般而言，氫能技術的投資可以參考再生能源的投資方式，故在本小節中首先將從再生能源一般融資實務切入，以說明氫能技術可以採行之融資方案；接著將介紹氫能技術之投資現況。

● 相關金融支援方案介紹

融資來源

再生能源專案的資金來源與一般企業融資相同，均來自於間接融資（債權）和直接融資（股權）的組合。以間接融資而言，可以採取貸款或債券的形式；直接融資可以採取純股權或是准股權的形式（如次級債券，夾層融資等）。以下依據直接融資與間接融資分別介紹常見的籌資方式。

直接融資為資金募集者透過出售、租賃財產或提供服務取得資金，常見直接融資方式為：
1. 非公開市場募資（Private Placement）
2. 股票公開發行
3. 資產證券化
4. 收益型公司（Yield Companies, Yield Co.）
5. 群眾募資

間接融資是指資金供需雙方借助銀行等金融仲介來達成融資交易，常見間接融資方式為：
1. 銀行融資
2. 租賃

綠色債券介紹

另外，再生能源專案也可選擇與一般企業不同的融資方式，如發行綠色債券。「綠色債券（Green Bond）」泛指用途為對低碳環保或綠色經濟投資項目提供資金之債券，發行人承諾其發債籌措資金之用途為對綠色經濟投資計畫提供融通，並由發行機構自行標注為「綠色」。與一般普通債券的區別在於，其資金用途係必須為對環境具有正面效益的「綠色」投資計畫。

1. 綠色債券發行原則

綠色債券是債券發行機構基於自願原則，而提出對債券資 金使用的承諾，因此目前為止國際上並沒有強制的標準或法律規定予以管理，只要發行人說明該資金用途範圍為綠色相關用途，即可自行標註為綠色債券。目前獲得最廣泛認可的標準是「國際資本市場協會（International Capital Market Association，簡稱 ICMA）」與國際大型金融機構於 2014 年合作推出「綠色債券原則（Green Bond Principles，簡稱 GBP）」，主要將募集資金分成 10 種用途：

i. 可再生能源
ii. 能源提升
iii. 污染預防及管控
iv. 生物和土地資源環境永續管理
v. 陸地與水域多樣性保護
vi. 乾淨交通
vii. 永續水資源與廢水管理
viii. 氣候變化適應
ix. 生態效益性和循環經濟產品、生產技術及流程
x. 綠色建築

2. 台灣綠色債券發行概況

台灣綠色債券始於證券櫃檯買賣中心於 2017 年 4 月 21 日發布「綠色債券作業要點」，5 月 19 日順利推動台灣首批綠色債券於櫃買中心掛牌發行，發行者分別為凱基銀行、永豐銀行、中國信託銀行，以及玉山銀行等四家銀行，債券總發行金額達新台幣 51.7 億元。至於台灣首檔綠色公司債券，則由台灣中油公司拔得頭籌。台灣中油公司經評估後選定「天然氣事業部台中廠二期投資計畫」以及「第三座液化天然氣接收站投資計畫」等二項計畫，以「溫室氣體減量」 的綠色計畫類別，於 2017 年 9 月 20 日發行 10 年期綠色債券 28 億元，成為台灣首檔由生產事業發行的綠色債券。

另為建立更完整的永續發展債券櫃檯買賣制度，櫃買中心於 2021 年 4 月 29 日公告並施行「永續發展債券作業要點」，整併「綠色債券作業要點」及「可持續發展債券作業要點」之規定，並新增社會責任債券資格認可及相關規範。依據「永續發展債券作業要點」之規定，永續發展債券範圍係經櫃買中心認可之綠色債券、社會責任債券及可持續發展債券。

而自 2017 年台灣推動發行綠色債券以來，台灣電力公司年年發行綠色債券，截至 2022 年 5 月 9 日已累計發行綠色債券計 438.5 億元，若加上 6 月中預計發行之綠色債券合計達 470.5 億元，為台灣綠色債券發行總額最大的公司。

● 氫能技術投資現況

氫能產業市場投資

目前與氫能產業和氫能技術相關的投資案例較少，現有融資案例多為政府資金或是公部門與民間共同投資。這些融資資金多用於開發氫能產業和研發氫能技術，以下將分別介紹各國氫能市場融資概況。

1. 美國

美國 2021 年 11 月通過規模達 1.2 兆美元的兩黨基礎建設法案，能源部將斥資 80 億美元建立區域氫能中心，以擴大氫能在工業領域的應用，另投入 10 億美元降低再生能源產氫的成本，並挪出 5 億美元以支持氫能設備生產和打造美國國內供應鏈。

2. 加拿大

加拿大的氫能策略建構在既有的政策基礎上，如「健康環境與健康經濟」策略提出 15 億加元之低碳與零排放燃料基金以及近 3 億加元之零排放車購買誘因補貼，以建構完整綠色經濟與潔淨能源環境，促進氫能產業發展。除此之外，加拿大聯邦政府、亞伯達省與加國企業 Air Products 於 2021 年 6 月 9 日宣布共同投資 13 億加元興建世界級液態氫製造廠，預計於 2024 年啟動營運；另外，聯邦政府與亞伯達省於 2021 年 6 月宣布投資 920 萬加元啟動「亞伯達省零排放卡車電動化」開發氫能與電能混合動力卡車，以及投入 230 萬加元興建加氫站，積極發展藍氫產業轉型低碳經濟。

3. 英國

2020 年 2 月，英國的商業、能源和工業戰略部（BEIS）宣布了 一項 9000 萬英鎊的綜合計劃，其中 2800 萬英鎊專門用於開發氫能項目，包含興建兩座歐洲有史以來最大型的低碳氫能發電廠。其中一座為 HyNet 項目，該項目由 Progressive Energy Limited 統籌主辦， 與 Johnson Matthey、SNC Lavalin 和 Essar Oil 合作，將在英國第一個使用碳捕獲與封存技術的淨零工業區開發氫能生產設施。從 2025 年起，HyNet 項目將建設新的基礎設施，同時升級和再利用目前從事生產化石燃料的基礎設施，以使用最先進的技術在英格蘭西北部和北威爾士生產、儲存和分配氫能。該發電廠生產的氫能將用於附近的聯合利華生產基地以及皮爾金頓的 Greengate 玻璃廠——這將會是全球玻璃製造廠中首次使用氫能。此外，2021 年 10 月，英國財政大臣在 2021 年預算和支出審查中確認，英國政府計劃於 2022 年至 2025 年期間花費 2.4 億英鎊給淨零氫基金（NZHF），以支持新的低

碳氫能項目的商業部署，目標於 2030 年實現 5GW 的氫能生產。

4. 德國

目前在德國已有公共資金投資氫能技術的先例。在工業用氫能方面，德國聯邦教育和研究部已為「Carbon2Chem」項目提供超過 6000 萬歐元的資金，該項目將研究如何利用生產鋼鐵中所產生的工業氣體以製造可用於燃料、塑料或化肥的初級產品。預計未來德國鋼鐵產業將有每年 2000 萬噸的二氧化碳排放量，也就是德國製造業和工業每年產生的二氧化碳排放量的 10% 可以利用。而該項目預計於 2025 年前將獲得超過 1 億歐元的資金投入。

5. 捷克

目前捷克沒有針對氫技術的具體投資機制，但已經有一些支持此類計劃的合作案例。例如在 2019 年，烏斯季和拉貝姆地區政府以及 UNPETROL, a.s.（PKN Orlen 集團公司）召集了 17 個公共和私營機構簽署了關於開發和使用氫能的合作備忘錄，該倡議的目標為支持在當地工業中使用氫能。

6. 義大利

SNAM S.p.A（SNAM）於 2019 年啟動 SNAMTEC 計畫，旨在提高能源效率、減少污染氣體排放和策進能源領域技術的創新。SNAMTEC 計畫的項目包含在坎帕尼亞地區展開為期一個月的試驗，該試驗在能源組合中引入了 5% 的氫能配額，並證明即使在能源組合中引入一小部分氫能也可以大幅減少二氧化碳之排放。

氫能汽車市場投資

目前世界各地的組織和公司正努力尋求資金挹注汽車產業的氫能技術。已知歐盟資助兩個研究項目（H2ME1 和 H2ME2），旨在到 2022 年在歐盟內增加 49 個加氫站和超過 1400 輛汽車、貨車和卡車使用氫燃料。這兩個項目的預算分別為 7000 萬歐元和 1 億歐元，「歐盟展望 2020 計劃」在這兩個項目中總共投入了 6700 萬歐元，分別持續到 2020 年 5 月和 2022 年 6 月。這些研究項目包含來自 9 個國家以及涉及交通、氫能和能源行業的 40 多個合作夥伴，包括 Audi、BMW、Engie、H2 MOBILITY、Hyundai、Michelin、OMV 和 Renault。

液空集團和道達爾能源合作於諾曼第工業區發展低碳氫能生產

Air Liquide

氫氣、# 能源轉型、# 碳捕捉與封存（CCS）、# 低碳航空、# 低碳交通、# 淨零排放、# 碳中和

氫能是能源轉型和潔淨交通革命的核心。作為氫能轉型的先驅，液空集團持續利用其現有的工業設施、技術和專業知識，與富有遠見的夥伴們合作，在全球各地開發低碳氫能的生產和應用，特別是在運輸領域。本文展示了碳捕捉與封存（CCS）的開創性專案，以及幾個在航空業的實際氫能應用案例，幫助機場為即將到來的氫能時代做好準備。

減少碳排放

根據一項長期合約協議，液空集團將接管並運作諾曼第道達爾基地的每日 255 噸氫能生產裝置。將該裝置連接到液空集團的氫能網路，使其能夠優化性能，並最終開發出全球首個低碳氫能網路。自 2015 年以來，該網路已經包含一個位於熱羅姆港的氫能生產設施，該設施配備液空集團的 CryocapTM 碳捕捉解決方案。液空集團正在考慮增加一個大型裝置，透過電解技術生產可再生氫能。

此外，兩家公司將啟動研發團隊，部署一個碳捕捉和封存（CCS）專案，以在諾曼第基地上對該裝置生產的氫氣進行脫碳。液空集團將安裝其 Cryocap™ 製程來進行碳捕捉，而道達爾將處理捕捉的二氧化碳運輸和儲存，特別是透過正在北海開發的北極光（挪威）和阿拉米斯（荷蘭）CCS 專案。

長期看來，到 2030 年，建置這些專案將使該裝置的氫能生產製程，每年減少約 65 萬噸的二氧化碳排放。

氫能啟動航空業新紀元

航空業佔整體二氧化碳排放的 2%，是生態問題的核心。對於飛機和機場來說，到 2050 年，氫氣可協助減少 50% 的排放。在整個氫能價值鏈中，液空集團正在利用其在氫氣方面的技術和工業專長，協助航空業

實現從地面到空中的脫碳。

氫氣可用於機場內和機場周邊眾多應用

低碳氫氣是以氣體形式生產，特別是透過利用可再生能源進行水電解，液空集團已在其魁北克 Bécancour 的工廠開始此一製程。液空集團安裝的眾多管線很快就能大量運輸到每個機場附近的液化設備。憑藉在航空航太工業和極端低溫領域超過 50 年的專業經驗，液空集團可以運用其在液態氫方面的經驗，為機場生態系統提供服務。一旦完成液化，就會被轉移到儲存容器中。之後可為卡車油箱加滿油進行後勤工作，例如在停機坪上加油。

機場生態系統

一旦可應用在機場，液化氫氣就可被用於許多用途，如地面物流：行李拖拉車、堆高車、吊艙、超級拖船、接駁車等。例如在首爾的仁川國際機場，液空集團為機場車隊提供了加油時間不到 5 分鐘的充電站。這些車輛使用氫氣作為動力，大幅減少了對環境的影響。最後，由於高性能卡車能夠儲存高達 300 公升的液態氫，因而能在數分鐘內在停機坪上直接加油。該集團的其中一個專案是贏得了 AMI「H2 Hub Airport」（氫能樞紐機場）競賽，更協助了機場氫能產業的發展。

飛機上的應用

在飛機上，氫能可為駕駛艙內的所有飛行和通訊系統供電，並透過為照明、暖氣和包括餐飲及製冷在內的所有機上服務供電，確保乘客的舒適度。未來它還能用於推進系統——透過直接燃燒或為燃料電池供電。當用於燃料電池時，氫氣與空氣中的氧氣結合產生電力，副產品只有水。空中巴士公司日前已宣佈，其首架氫動力商用飛機將於 2035 年問世。為了更好地為其到來做好準備，並為法國創新和策略性產業的崛起做出貢獻，液空集團已於 2021 年 6 月與空中巴士 ADP 集團建立了合作關係。

液空集團已經在許多商業領域展現深厚實力，在行動應用間發揮協作效應方面，已佔據理想位置。這在很大程度上歸功於服務於整個機場基礎設施的基礎建設，包括：計程車站、公共交通總站和用於本地或長途運輸的火車站。這些基礎設施用途的互補性，是讓低碳氫能更加普及的主要推動因素。

液空集團、空中巴士和 ADP 集團合作，為巴黎機場做好迎接氫能時代的準備

液空集團、空中巴士和巴黎機場集團（Groupe ADP）已展開合作，預備在 2035 年將氫能引進機場，作為氫氣動力商用飛機開發的一部分。合作夥伴將利用各自的專業知識，支持航空業脫碳，並確定氫能可為航空業帶來的具體需求和機會。這一夥伴關係反映了三個合作夥伴的共同目標，即促使法國出現一個創新的策略領域，致力於在全球實現氣候中和（climate-neutral）的航空產業。

為了迎接 2035 年首架氫動力商用飛機的到來，需要適度調整機場的軟硬體，特別需要將液態氫供應的特殊性納入考量。這項合作夥伴的宣佈重點在於發展此一基礎設施的可行性研究。

第一步將啟動一項由全球約 30 個機場組成的代表性小組研究，以評估液態氫生產、供應和分配的潛在配置。然後將為巴黎兩個主要機場：巴黎戴高樂機場和巴黎奧利機場制定詳細的方案和計劃。這些方案對於確定所需的基礎設施，包括範圍和位置，以及確定和納入與工業和航空安全標準的相關限制，至關重要。

這一合作將使夥伴們的專業知識得以互補，結合各自支持機場轉型的目標，為新時代永續航空旅行展現了新的發展前景。

案例研究：仁川國際機場的氫能應用

仁川機場 T2 加氫站由液空集團、現代汽車公司和氫能網路（Hydrogen Energy Network，HyNet）共同投資，配備了液空集團的技術，於 2021 年竣工。這是一個關鍵里程碑，因為它是韓國 68 個站點中，第 100 個投入使用的加氫站。

針對機場 T2 加氫站，液空集團提供了大容量的加氫站設備。根據一份長期合約，該集團還將成為氫氣的供應商。現代汽車將提供新的氫能巴士和售後服務。HyNet 將負責加氫站的運作，主要為氫能公車服務，但也將用於燃料電池客用車，這將能配合韓國政府大幅增加加氫站網路的計劃。

這個加氫站每天可輸送 1 噸氫氣，比目前韓國市場上現有的加氫站至少多出 4 倍。平均每天可為 40 輛公車或 180 輛客車提供服務。利用液空集團的最新技術，它能讓兩輛公車同時加氣，並允許客用車在有限的等待時間內連續加氣，以達成高效率的尖峰時間管理。

加氫站的導入符合仁川國際機場的公司策略，該公司希望成為東北亞航空物流樞紐，並以生態友好型國際機場作為宣傳主軸。因此，仁川國際機場公司也將逐步將其現有的接駁車隊升級為氫能巴士。

案例研究：液空集團、空中巴士、仁川機場和大韓航空合作，為韓國航空業脫碳中使用氫能做準備

液空集團、空中巴士、大韓航空和仁川國際機場公司

展開合作，探索在仁川國際機場使用氫能的可行性。這項合作還將把研究韓國機場基礎設施的發展，支持氫動力商用飛機的部署擴展到全球領域。此一合作反映出夥伴們對於推動創新航空產業的共同願景，並致力於支持韓國政府到 2050 年實現碳中和的目標。

四個合作夥伴將制定一份發展藍圖，首先在仁川機場及其周邊地區開發氫能的應用，並建立可串接到其他韓國機場的氫能生態系統部署方案。第二步則是合作關係中側重於開展相關研究，旨在確定和發展仁川機場所需的液態基礎設施，為第一架氫動力飛機的到來做準備。

每個合作夥伴都將利用其互補的專業知識，協助確定氫能可提供的潛在商機，並支持航空業的脫碳。液空集團將帶來其在整個氫能價值鏈（生產、液化、封存和運銷）方面的廣泛專業知識，特別是液態氫的供應。空中巴士將提供氫動力飛機地面營運的特點、飛機特性和機隊能源使用情況，而大韓航空將提供地面飛機營運，以及航空管理和營運方面的專業知識。最後，仁川國際機場公司將提供機場發展規劃展望，以及空中交通特點和航廈的分佈，而首先即從全球最大和最繁忙的機場之一：仁川國際機場開始。

透過此次合作，液空集團將利用其在當地的強大影響力，加快韓國的氫能解決方案部署

作者

液空集團為全球領導的工業氣體公司，業務遍及全球 75 個國家，擁有約 66,400 名員工，服務超過 380 萬的客戶及患者。液空集團自 1987 年起便以合資公司亞東工業氣體扎根台灣，在全台擁有 40 多個生產設施和服務據點，透過創新和獨特的產品、設備和服務組合，為不同產業的客戶提供支持。在台灣員工超過 700 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。

液空集團和道達爾能源宣佈，將於法國諾曼第的道達爾能源進行脫碳氫氣生產。該專案將依託於液空集團在諾曼第的氫氣網路和大規模碳捕捉與封存（CCS）解決方案的建置，讓液空集團得以即時向道達爾能源供應低碳氫能。根據兩家公司在 2050 年達到碳中和的目標，這個規模宏大的專案是永續發展策略的一部分，在 CCS 和電解等技術的穩定支持下，將在「Axe Seine ／諾曼第」開發一個低碳氫能生態系統。

博世致力成為永續發展的燈塔

科技

BOSCH
Invented for life

以科技回應社會和環境問題，是博世（Bosch）的策略要務。早在 2020 年，博世即成為第一家達到全球據點碳中和的跨國工業企業，更進一步投入價值鏈減碳。為此，博世正積極推動氫能經濟、推動交通轉型，並提升工業科技效率，以永續為核心，重塑其產品組合。

博世致力成為永續發展的燈塔

對於博世集團來說，肩負永續、環境和社會責任的行動，是我們成功的基礎。此價值形塑了博世集團的公司治理方針，並反映在各個層面的行動中：博世希望成為氣候行動的先驅，並將其理念貫徹於永續發展的願景中。作為一家科技公司，以科技回應社會和環境問題，是博世的策略要務。這就是博世的信念「科技成就生活之美」，為此，我們正在投入開發更多科技和應用以實現理想。

博世：氣候行動先鋒

氣候變遷是人類面臨的最大挑戰之一：防止氣候變遷已然成為人類社會的使命。博世很早就展開氣候行動，並已立下重要里程碑。自 2020 年 2 月以來，包含台灣博世在內的全球 400 多個博世據點已經達成碳中和（範疇 1 和 2）。這項成就讓博世成為第一家達成此一崇高目標的全球工業企業。博世在氣候行動領域的成就，也獲得外部機構的認可：非營利組織碳披露專案（Carbon Disclosure Project，CDP）在 2021 年將博世列入氣候變遷評比的最高等級「A」級企業。

對博世而言，達到全球據點碳中和是策略規劃及系統化行動的必然結果。在減少碳排放的過程中，博世從四方面著手：提高能源效率、擴大可再生能源供應、採購綠色電力，以及抵換不可避免的碳排放。我們認為，長期而言，前兩項舉措將是提升碳中和品質的關鍵，將能使電力消耗和碳抵換的占比逐漸減少。呼應博世集團的全球策略，台灣博世採用節能 LED 燈泡取代傳統燈泡以減少排放，同時抵消不可避免的碳足跡。

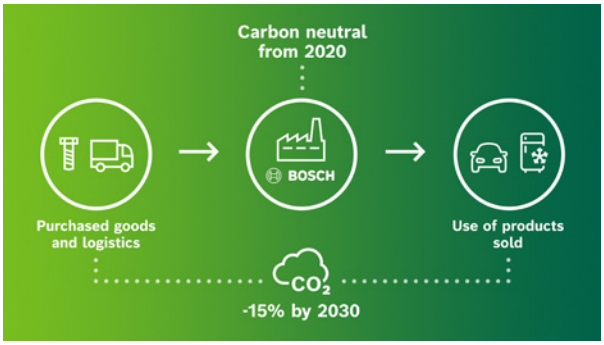


圖 1：博世正致力於 2030 年前達成價值鏈減碳 15%

下一個里程碑

儘管我們以達成全球據點碳中和自豪，但我們並不將其視為博世氣候行動的終點。在繼續優化減碳行動的同時，博世正擴大自身影響力，投入減少範疇 3 碳排放：在 2030 年前，將價值鏈上、下游，以及產品生命週期中所產生的排放量減少 15%，相當於 6,700 萬噸碳排放。如此極其野心的目標，已於 2020 年獲得科學基礎減量目標倡議（Science Based Targets Initiative，SBTi）認證，使博世成為全球第一家在 SBTi 中達到「已設定目標」的汽車零件供應商。為此，我們聚焦於範疇 3 中排碳量最高的三項活動：貨物及服務採購、上下游運輸和物流，以及產品使用。

我們和全球供應商密切合作，以進一步減少因貨物及服務採購產生的碳足跡。博世已於 2020 年識別採購量最大、碳排放量最高的供應商，並直接與其聯繫，取得確切的碳排放資料。為此，我們採用 CDP 提供的平台，並輔以自身盤查的機制。此外，我們在 2021 年的博世全球供應商獎中新增「永續發展」類別，以鼓勵減緩氣候變遷的行動。同時，在博世授予採購合約時，二氧化碳排放量亦是遴選標準之一。

物流串連價值鏈上的所有節點，因此，博世特別著眼於物流運輸減碳，專注於產品製造和大量生產過程中

的採購流程最佳化，並且盡可能避免空運。我們以總體擁有成本（Total Cost of Ownership，TCO）方法，綜合考量運費或關稅等關鍵成本。例如潛在供應商的位置是否鄰近博世據點，也是一項重要的遴選標準。透過上述方式，我們正逐步最佳化運輸數量及利用率，盡可能降低碳排。

為協助緩解全球暖化，博世的產品設計以節能為導向。2020 年，我們進一步專注在能減少產品使用碳足跡的三個面向：能源轉型、擴充產品組合，以及提高能源效率。

圖 2：博世正推動氫能經濟，並投入大量的前期投資

能源轉型：氫能經濟先鋒

在邁向氣候中和的道路上，博世致力於讓能源密集型產業轉而擁抱可再生能源。因此，博世正積極投入氫能經濟，並為其發展投入大量的前期投資。博世正為不同產業提供氫能應用的必要科技，包含車用燃料電池、定置式燃料電池、配備壓縮機的加氫站，以及博世工廠自產的氫氣。2022 年 5 月，博世更宣佈進軍電解槽元件業務。博世正在帶領氫能科技走出實驗室，落實到交通和工業應用。

博世是車用動力系統的領導供應商，而燃料電池使其產品組合更加豐富。燃料電池科技的成熟度現已達到可廣泛使用的水準，是重型卡車的長途運輸最受歡迎的選擇。若燃料電池動力系統由可再生能源生產的綠氫驅動，車輛在行駛過程則可實現零碳排，進而達成氣候中和。博世正在為車用燃料電池組和燃料電池系統的量產做好準備。博世於 2021 年到 2024 年間，將對車用燃料電池領域投資十億歐元。2021 年 4 月，博世與中國商用車製造商慶鈴汽車共同成立合資企業，在中國生產燃料電池系統。此外，我們也獲得戴姆勒卡車（Daimler Truck）和富豪汽車（Volvo）的合資企業 cellcentric 訂單 ，為其供應整合電力電子系統的電動空氣壓縮機（electric air compressors，EACs），預計從自 2025 年起用於 cellcentric 的燃料電池系統。
在能源轉型的過程中，電池總體效率超過 85% 的固態氧化物燃料電池（solid-oxide fuel cell，SOFC），將可望扮演關鍵角色。SOFC 應用靈活、精確滿足用電需求，可做為分散式聯網電廠，應用於城市、工廠、數據中心及船舶等場域。博世預估，分佈式發電市場規模將於 2030 年達 200 億歐元。博世計劃於

圖 3：博世已於 2021 年在班堡（Bamberg）的中央公車站設置固態氧化物燃料電池 (SOFC) 的微型發電廠

2024 年正式量產定置式燃料電池，並為其研發和商轉活動投資逾五億歐元。目前，博世已在其德國據點推動數個前導專案。事實上，博世去年攜手德國班堡（Bamberg）市政單位共同開發，在班堡市中心的公車站設置首座商轉燃料電池微型電廠。

綠氫將是氣候行動中的重要推手。受能源多樣化、放棄化石燃料以及減少碳排放趨勢鼓舞，鋼鐵、化工和重型貨運等能源密集型產業，以及私有房地產領域的綠氫需求正迅速成長。為此，博世不僅著手發展氫能應用，更計劃自行生產氫氣：博世正在開發電解槽零組件，用電解法將水分解為氫和氧。博世正與多個合作夥伴攜手，開發整合電解槽與控制元件、電力電子設備與各類感測器的智慧模組。此模組輕巧、組合彈性，適用於容量達十瓩的小機組，亦可用於在陸上或海上環境中的百萬瓩額定功率設施。

圖 4：博世具有極廣泛的電動交通產品

擴充產品組合：致力協助交通轉型

我們堅信未來交通不應對全球暖化產生負面影響，同時它也應該讓多數人負擔得起。博世廣泛的產品組合不僅對交通轉型貢獻重大，也持續尋求更全方位的解決方案。博世目前每年在電氣化方面的投資超過八億歐元，2021 年其電動交通相關業務營收逾十億歐元，成長幅度為整體市場的兩倍。預計到 2025 年，其營收將成長五倍。憑藉此業務領域的成功，博世將為節能和氣候行

動做出更多貢獻，同時朝其碳減排目標更進一步。

博世在電動交通產品組合豐富、無出其右：橫跨電動自行車系統、工廠生產設備、碳化矽晶片，乃至 eAxle 電動軸模組。博世作為高效驅動系統供應商，提供 eAxle 電動軸模組，並且優化混合動力系統和電動動力系統的熱能管理，是電動交通相關科技的決定性推手。此外，博世自 2021 年底開始製造的碳化矽（SiC）功率半導體元件，將可讓電動汽車的續航力延長達 6%。

為了讓日常生活中的電動汽車充電更便利，博世開發全新的輕巧智慧充電線，整合控制和安全科技，以及 Type 2 和家用插頭轉接器。即使在 230 伏特的插座上充電，也無須配備傳統的電纜內控制盒（充電盒），相較帶有充電盒的傳統纜線，重量減少約 40%。在行動充電方面，博世的雲端充電網絡串聯歐洲 20 多萬個充電站，有效擴展電動車的充電基礎設施。

圖 5：博世相信工業將成為環保轉型的原動力，並全力促進工業 4.0 轉型

提高能源效率：更高效的工業應用

工業領域的二氧化碳排放量約占全球總量的五分之一；在台灣，工業領域的溫室氣體排放量更達全台總量半數。因此，博世相信工業將成為環保轉型的原動力，並貢獻自身科技和製造業專業，以促進工業 4.0 轉型。工業 4.0 連接人、機器和數據，可望將工業製造的效能極大化。根據德國數位協會 Bitkom 資料顯示，若加速德國製造業的數位化，將可於 2030 年前減少高達 6,100 萬噸的二氧化碳。

智慧聯網科技串連機械和流程，再進一步運用資訊和通訊科技，將為節能生產奠定基礎。製造業自硬體轉移至軟體的例子日增。以數位孿生（digital twins）為例，我們能在不中斷正常運作的前提下，在真實工廠中實體資產的虛擬副本上，直接模擬並讓工作流程和製程最佳化。在未來工廠中，只需按下按鈕即可進行諸多調整。也就是說，工廠中除了地板、天花板和牆壁，其他一切都將是動態且可變動的，機器會根據手上的工作，不斷地重新排列其群集和改變它們的配置。因此，廠房和設備的使用壽命會更長，用於生產新硬體的原料將減少。工業製造效率提高，更有助於節省寶貴的資源。

另一個例子則是 ctrlX Automation 開放平台，該平台為完整的自動化提供必要架構，且不受傳統控制器結構的限制。使用該平台後，自動化元件的數量平均減少達 50%。驅動器的重量最多更可減輕三分之一。硬體越輕，所需的驅動功率和能量就越少。硬體設施而言，博世亦正在投入創新的液壓科技：工具機、射出成型機和沖床等高能耗機械，通常會採用博世力士樂的 CytroBox 等智慧型液壓動力裝置，以有效降低能源消耗。與傳統驅動相比，整合的變速液壓驅動可降低高達 80% 的能源消耗和電力成本。此外，CytroBox 的負載依賴控制，使其始終處於最佳運行模式，並在沒有使用的時候自動切換到待機模式。

展望未來：博世致力成為永續發展的燈塔

對博世而言，永續發展不僅是我們事業成功的基礎，也是科技創新的動力。我們以身為氣候行動的先驅自豪，也希望透過交通、工業和氫能科技產品和深厚的專業做出更大貢獻。這並不是一條平坦的道路，我們仍有很長的路要走，但我們很高興能為減緩氣候變遷提供解決方案，並致力成為永續發展領域的重要指標。

石安德
台灣博世執行董事

作者

石安德自 2021 年 12 月 1 日起擔任台灣博世（Bosch）執行董事，負責博世集團在台整體企業事務，以其豐富的經驗帶領台灣博世朝蓬勃的未來邁進。

德國 2045 年預計達成氣候中和

Deutsches Institut Taipei
德國在台協會

德國在 2019 年當時總理梅克爾的領導下，協同五位聯邦部長成立了「氣候內閣」，包含環境部、交通部、能源部、建築部與財政部。同年稍晚，該內閣通過了「2030 氣候行動計畫」，訂定了各部門的目標，用以監督、評估與調整各個計畫，減少消費者的財務負擔，以及降低電費中的稅賦。該行動計畫中最重要的部分是在德國境內推行國家碳交易制度，特別針對交通部門與建築部門。

2021 年 8 月 31 日德國聯邦氣候變遷法修正案正式生效。自此，德國聯邦政府加緊了氣候保護的規定並且確立了 2045 年達到溫室氣體中和的目標。與 1990 年相比，德國的排碳量預計在 2030 年減少 65%，2040 年減少 88%。各部門的目標也已調整符合這項雄心勃勃的減碳目標。

這些氣候目標將定期受到監控。自 2022 年起，氣候議題專家委員會每兩年提出一份進度報告。如果預算未達成既定的成效，那麼德國聯邦政府將會立即採取行動。

為了達到氣候保護的目標以及擺脫對化石能源進口的依賴，德國聯邦政府訂定了目標，預計 2030 年將總用電量中的再生能源占比提高至 80%，2035 年提高將近 100%。為了達成這項具有野心的目標，德國聯邦政府刻正採取名為「復活節加速能源轉型方案（Easter Package）」的措施，加速拓展風能與太陽能，擺脫化石燃料以及提升能源效率。

為使能源轉型與氣候保護能成功，使用替代化石燃料的其他能源是必要的。氫氣作為用途廣泛的能源載體，將扮演關鍵性的角色。因此，德國聯邦政府於 2020 年宣布了「國家氫能戰略」。以友善氣候的方式所產生的氫氣將使碳排量顯著減少，特別是在工業與交通部門，其能源效率與直接使用再生能源電力仍然不足。

從化石燃料至再生能源

根據德國聯邦能源與水力產業協會（BDEW）的資料顯示，德國 2021 年再生能源的總發電量已經達到 40.9%，其中風能（20.1%）與太陽能（8.8%）仍是兩項重要的電力來源，接著是生質能（7.5%）、水力（3.4%）與其他來源（1.0%）。

廢除核能是德國自 2011 年以來跨黨派的共識。今日德國聯邦政府仍堅持這項共識：德國將在 2022 年底廢除核能。

除了其他因素之外，核廢料處理與核安問題仍未解決。德國總理蕭茲於 2022 年 1 月 12 日在德國聯邦議院中說道：「由於這個危險，德國決定廢除使用核能發電。」2020 年 7 月，德國聯邦議院與德國聯邦參議院通過了「廢煤法案」。該法案的目標是至 2038 年逐步減少且最終關閉所有德國的燃煤電廠，以提供民眾具有成本效益、效率與氣候兼容的能源供給。廢除燃煤發電將顯著減少德國的排碳量。

透過「復活節加速能源轉型法案」加速拓展再生能源

為了達到氣候保護的目標以及擺脫對化石能源進口的依賴，德國再生能源在總用電量的占比至 2030 年，應提高到至少 80%，2035 年應將近 100%，不過，2021 年再生能源占比卻只有 42.4%。換句話說，在不到十年的時間內，再生能源在總用電量的占比應達到雙倍成長。除此之外，為了符合「氣候變遷法」修正案所修訂的氣候目標，德國必須將現在的排碳率提高將近三倍，才能達到 2030 年減少 80% 碳排的目標（與 1990 年相比）。2022 年 4 月 6 日德國聯邦政府通過了「復活節加速能源轉型方案」，用以加速拓展風能與太陽能，擺脫化石燃料以及提升能源效率。該方案內容包含：再生能源法 2023（EEG 2023）全面性的修正法案，以及許多法規的修改，像是能源產業法、聯邦需求計畫法、加速電網擴張法、離岸風電法與其他能源法規。針對風能產業，德國聯邦政府的目標是利用 2% 的土地面積，促進陸域風電的發展。

德國聯邦政府自 2022 年 6 月起，已經透過能源與氣候基金（未來將改名為氣候轉型基金）資助再生能源的拓展。該基金的資金來源是透過歐洲碳交易所收取的費用，以及針對德國境內供暖與運輸的碳定價之部分費用。至今，德國針對電力消費者所課徵的再生能源稅同樣也資助能源轉型。2022 年 7 月 1 日該項稅收已經廢除，這也造成未來氣候轉型基金裡少了大約 66 億歐元的收入。

提升能源效率

根據能源平衡工作小組（AGEB）的數據，與 2008 年相比，德國在 2019 年的初級能源消耗下降了 11%。

以具能效的方式使用能源，確實能減少二氧化碳的排放並且省錢。這在一般家庭、公司與城市裡亦是如此。目前，能源效率投資的回報高於資本市場的安全投資。

更高的能源效率也能使德國經濟在國際市場上更具競爭力。畢竟，如果使用較少的資源並且排放較少的碳，那麼就有成本優勢。節制地使用能源同樣也能推動新的商業模式，以及促進創新技術與服務，德國公司藉此能成功立足在國際市場上。

德國在「2050 能源效率戰略」中，首次為減少初級能源消耗訂定了 2030 年的中期目標，該戰略採納了適當的措施，並且為了能源效率政策的後續發展，創建了一項廣納利害關係人的流程。德國聯邦政府的目的在使德國擁有全球最具能源效率的經濟，並至 2050 年急遽減少初級能源的消耗。為了達到這個目標，德國聯邦政府於 2019 年 12 月 18 日通過了 2050 能源效率戰略（EffSTAR）。該戰略為德國提升更多能源效率確立了方向，並且在落實德國與歐盟的能源與氣候政策目標上，亦作出了重要貢獻。德國 2050 能源效率戰略基於三個要素：

● 1. 2030 國家能源效率目標

至 2030 年，初級能源消耗應下降 30%（相較於 2008 年）。這相當於減少大約 1200 TWh 的消耗。應著這項目標，德國刻正作出頗具野心的貢獻，以達成歐盟 2030 能效目標。

● 2. 新的能源效率國家行動計畫（NAPE 2.0）

2014 年德國所制定的「能源效率國家行動計畫（NAPE）」是一項全面性的行動計畫，促使德國能竭力發揮其能源效率的潛力。該行動計畫焦點是在能源部門裡拓展可用資訊與諮詢，資助新設備與新建築的創新能源解決方案，以及要求大公司有義務定期執行能源審計作業。

然而，為符合 2030 與 2050 的能源效率目標，迄今所減少的能源消耗必須再提高。有鑑於此，2050 能源效率戰略針對 2021 年至 2030 年間，在新的能源效率國家行動計畫（NAPE 2.0）裡，提出了為數眾多的能源效率措施。NAPE 2.0 與 2030 氣候保護計畫之間的關係非常密切。因為，大部分減少能源消耗的措施也會帶來減少溫室氣體排放的結果。

NAPE 2.0 關注在能源系統的需求面，並且擴充先前的能效政策。自 2020 年初起，針對具能源效率的建築結構翻修所提供的稅收優惠，已經為住宅建築帶來更多的能源效率。此外，隨著 2021 年 1 月所施行的聯邦能效建築補貼，現有建築補貼計畫已含括其中、並且加以強化與簡化。德國聯邦經濟與氣候保護部預計在未來的四年內，每年提供大約 60 億歐元資助能源效率計畫。自 2021 年初起，德國已針對利用化石燃料供暖與化石燃料使用進行課稅，目的在減少未來的能源消耗與溫室氣體排放。NAPE 2.0 的執行成效每年受到監督。

● 3. 2050 能源效率路徑藍圖

德國聯邦經濟與氣候保護部也創建了一項廣納利害關係人的流程，名為「2050 能源效率路徑藍圖」。結合商業界、市民社會、各邦政府以及學界的代表，共同討論出 2050 年減少初級能源消耗之解決方案。在 2020 年 5 月 26 日該路徑藍圖啟動儀式活動中，針對不同主題總共成立了六個工作小組，包含工業、建築、交通、資格 / 專業人士、數位化與系統相關的議題。這些工作小組一年開會兩次，並在能源效率平台上提出討論結果。這個對話過程歷時兩年半，預計在 2022 年 10 月結束。

氫能：能源轉型的關鍵要素

德國企業已經準備好在氫能產業裡大展身手，像是利用燃料電池與電解法產生綠氫。為了樹立在氫能技術裡領先全球的角色，德國聯邦政府提出了一份「國家氫能戰略」，包含一份持續發展的行動計畫。2020 年 6 月 10 日德國聯邦政府通過了「國家氫能戰略」，並且成立了氫能委員會，該委員會也已在 2020 年 7 月 9 日首次開會。

該戰略追求以下主要目標：

- 以友善氣候的方式生產氫氣，尤其是利用再生能源生產氫氣，其用途廣泛是能源轉型的關鍵因素。
- 為國內市場生產與使用氫氣創造一個監管框架。該焦點在具獲利潛力的領域，或者仍無法使用其他方式去碳化的領域，像是一些工業與運輸部門（航空、船舶與長途運輸）
- 為了打開全球市場，減少氫能技術的執行費用。
- 利用促進研發量能與出口以氫能為基礎的新技術，強化德國企業的競爭力。
- 開創與確保國內未來綠氫的供給。除了促進國家生產潛力，為了生產與運輸氫氣，必須定義可信任的國際夥伴（焦點於歐盟），或建立適當的合作與進口結構。這也是拓展歐盟內部能源市場的一個機會，並且和具備良好再生能源資源的開發中國家合作，創造氫能合作夥伴關係。只要潔淨的氫氣量有限且成本高昂，那麼，在歐洲市場中提升氫能經濟，能提供低碳藍氫和藍綠氫的歐洲市場就能發揮過渡的角色。

澳洲氫能政策和資金情報更新

K&L GATES

本文對澳洲氫能產業的政策和資金發展進行了高層次的綜合概述。這些發展是在聯盟和州級層面進行，突顯了當前政府促進澳洲新興氫能產業，以及將澳洲定位為全球氫能領導者的願景。本文是對《The H2 Handbook》澳洲章節的補充，詳情可在此處查閱。

澳洲政策更新

● 新南威爾斯州

新南威爾斯州淨零工業和創新計劃

2021 年 3 月，新南威爾斯州 (NSW) 政府發佈了新南威爾斯州淨零產業和創新計劃，這是新南威爾斯州淨零計劃的第一階段的一部份：在 2020-2030 年，該計劃旨在實現比 2005 年減少 35% 排放量。到 2030 年，該計劃將投資 7.5 億澳元，以協助達到此一目標。該計劃專注於三大領域：潔淨技術創新、新興低碳產業基礎和高排放產業。儘管這是技術中立的計劃，但它促進了氫能產業的發展，因為它所提供的資金可適用於氫能專案。

作為該計劃目標的一部分，新南威爾斯州政府承諾提供 7,000 萬澳元資金，以支持在獵人谷和臥龍崗地區建立氫能中心。氫能中心還獲得了潛在的 40 億澳元產業投資。

新南威爾斯州的氫能策略

2021 年 10 月，新南威爾斯州政府發佈了以綠色氫能為重點的「新南威爾斯州氫能策略』(簡稱新南威爾斯州策略)。新南威爾斯州策略建立在三個策略支柱上——促進產業發展、奠定產業基礎、而後迅速推動氫能生產規模。藉由這三大支柱，新南威爾斯州策略的主要目標包括：

- 達成至 2030 年每年生產 11 萬噸綠色氫能和 700 兆瓦電解槽能力的延伸目標；
- 在今後 10 年，將綠色氫能的每公斤成本降低 5.8 澳元，到 2030 年降至每公斤 2.8 澳元以下；以及
- 推動運輸、工業和能源產業的脫碳，協助其在 2050 年之前達成淨零排放。

為了將氧能供應鏈商業化，新南威爾斯州策略提供高達 30 億澳元的獎勵措施，其中包括：

- 在符合某些條件的情況下，到 2030 年之前，對連接到部份電力網路備用容量的電解槽，提供 90% 網路系統使用費用豁免，為期 12 年；
- 免除氫氣生產商的環境和電力計劃捐款，為期 12 年，並可就 2031 年以後安裝的新產能進行延長 (有待審核)；
- 擴大新南威爾斯州能源安全保障措施，以支援氫能的市場化計劃，為綠色氫能生產提供財政獎勵；以及
- 在策略性的貨運走廊沿線，為重型車輛建立氫氣加氣站網路。

● 北領地

再生氫能策略

2020 年底，北領地 (NT) 政府公佈了再生氫能策略 (NT Strategy)。NT 的目標是到 2050 年實現淨零排放，在達到此一目標過程中，預計氫能將發揮關鍵作用。NT 的策略概述了五項重點計劃，是向再生氫能轉換的基礎：

1. 發展地方工業，以推動採用氫能的產業。
2. 資源管理，最佳化領土的資源和基礎設施，以促進氫能產業的發展。
3. 擴大和利用對氫能的需求，最大限度地提升國內使用和國際出口機會。
4. 支持創新和新興的再生氫能技術。
5. 實施可順應形勢發展的法律和法規。

再生氫能的總體規劃

2021 年 10 月，NT 政府發佈了再生氫能總體計劃 (Masterplan)，該計劃以 NT 策略為基礎，協助創建其氫能產業，並預計可成長 37 億澳元，側重於基礎活動，以促進民間投資，並建立當地和出口產業。總體規劃將分別以兩個平行部分進行：

1. 奠定基礎——確定需要進一步發展的領域，以強化政府和民間投資，加快再生氫能產業的發展。
2. 擴大出口——全面評估國際氫能市場和供應鏈，以擴大出口規模。

2022 年 6 月 21 日，台灣政府宣佈，將在四年內投資 500 萬澳元，以支持這項總體計劃。

● 維多利亞州

2021 年 2 月，維多利亞州政府公佈了再生氫能產業發展計劃。該計劃規範了維多利亞州將如何發展其再生氫能產業。

該計劃明確了三個重點領域的 18 項成果，運用從研發

到出口的各種方式，來發展維多利亞州的氫能產業，關鍵的重點領域及其各自的一些成果包括：

再生氫能基礎

- 透過研究和開發氫能技術加快創新。
- 持續制定明確的法規、標準和守則，以確保氫能適合於其應用目標。

與經濟鏈接

- 利用現有的天然氣網路作為再生氫能的潛在配送管道。
- 推動氫能在運輸領域的整合，以支持脫碳。

帶頭前進

- 透過政府的支持，推動氫能展開試點、專案和示範。
- 維多利亞州政府將與企業合作，推動維多利亞州成為全球貿易和投資標的。

● 西澳州

再生氫能發展藍圖

2020 年 11 月，西澳大利亞州 (WA) 推出了再生氫能發展藍圖 (Roadmap)。該藍圖確立了西澳州政府為實現其 2019 年氫能策略而正在進行的 26 項倡議。這些措施包括開發再生氫能供應鏈模型、進行法律框架審查、開發 Oakajee 策略工業區，以及對枯竭氣田和油田的儲氫潛力進行建模。

氫能策略更新

西澳州政府於 2021 年 1 月更新了氫能策略 (WA Strategy)。主要的更新是將最初設定的 2040 年目標提前到 2030 年。這些目標包括：

- 西澳州的全球氫氣出口市場占有率將追上目前在液化天然氣的市占率。
- 西澳州的天然氣管道和網路將含有高達 10% 的再生氫氣混合物。
- 在採礦運輸車輛中廣泛使用再生氫能。
- 使用再生氫能作為區域運輸的重要燃料來源。

澳洲政府

2020 年 9 月，公佈了第一個低排放技術聲明 (Technology Statement)，是技術投資藍圖的首個重大里程碑。

該技術聲明闡述了新興的低排放技術如何在經濟上與當前的高排放技術競爭，並取而代之。

潔淨氫能和碳捕獲與封存 (CCS) 被確立為優先的低排放技術。

針對潔淨氫能，關鍵目標是將其價格降低到每公斤 2 澳元，以便在氨的生產、作為運輸燃料，以及穩定電力等應用方面更具競爭力。

技術聲明預計，CCS 將是藍氫等新興低排放產業的發展關鍵。因此，當務之急是二氧化碳的壓縮，中心運輸和 CCS 封存的定價低於每噸 20 澳元。澳洲政府認為，這將使 CCS 在與其他形式的減排相比時，更具有長期競爭力。

澳洲最新立法現況

新南威爾斯州

2021 年 11 月 29 日，《2021 年能源立法修正案法案》(新南威爾斯州) 生效，旨在促進新南威爾斯州策略中提出的氫能產業發展。修正案包括：

- 允許部長根據 1995 年《電力供應法》(新南威爾斯州)，對用於生產綠色氫能的電力給予能源節約計劃的豁免；
- 豁免生產綠色氫能而產生之電力負荷對氣候變遷基金的捐款；以及
- 允許導入法規，以防止網路服務供應商向購買電力以生產綠色氫能的業者收回配電費和傳輸費。

● 南澳州

2021 年 2 月，氫被宣佈為 " 受管制物質 "，因而受到《2000 年石油和地熱能源法》(南澳州，PGE 法) 的管制。

2021 年 8 月 25 日，提出了《2021 年石油和地熱能 (能源) 修正案》，該法案提議擴大《PGE 法》的範圍，包括使用《PGE 法》尚不允許的方式來生產氫氣，包括電解水在內。其目的是透過在 PGE 法案中引入氫能許可證，為所有氫氣生產業者提供與目前提供給石油業一樣的單一政府窗口制度。根據 PGE 法案，現有的環境審核、合規和報告義務將擴大到根據 PGE 法案許可的氫能專案。該法案尚未獲得通過。

● 維多利亞州

2021 年 9 月 14 日，《2021 年能源修正案法案》(維多利亞州，VIC) 生效。該法案的主要目的是讓維多利亞州有關能源和天然氣的法律與國家能源法保持一致。該法修訂了《2008 年國家天然氣 (維多利亞) 法案》，讓部長能夠宣佈天然氣可將氣體作為混合物。這將允許氫氣與天然氣混合使用。

● 西澳州

西澳州政府承認，為實施計劃中的氫能開發，以達到目標排放的過程中，有必要對國家天然氣法、國家天然氣規則和其他立法進行改革。其中一項必要的修正案是擴大氣體的定義，將氫氣納入。然而，目前尚未提供這些擬議修正案的明確時間表。

2021 年 11 月 18 日，西澳州根據《1997 年土地管理法》，提出了一種新的保有權形式，稱之為「多樣化租賃』。讓牧場租賃區和閒置的官方土地可用於開發氫能和再生專案。這項提案將於 2022 年下半年提交議會。

● 澳洲政府

國家天然氣改革

2021 年 8 月，能源部長責成託澳洲能源市場委員會 (AEMC) 審查國家天然氣規則和國家能源零售規則，以制定將監管框架擴大到包含低濃度氫氣混合物和再生氣體的初步規則。立法報告草案訂於 2022 年年中就緒。

認證計劃

2021 年 6 月，澳洲政府發表了關於澳洲氫氣原產地保證計劃的討論文件。該文件概述了運用電解、採用 CSS 的煤氣化和採用 CSS 蒸汽甲烷，確保潔淨氫能來源的方法。有人提議，潔淨能源監管機構將負責該計劃的運作。

試驗於 2021 年底開始，測試與文件概述的相關排放核算方法相關的準確性、行政負擔和核查機制。然而，該試驗並未包含證書的發放和移交，因為這些部分還需要立法。

其他—民間機構認證計劃

2020 年 12 月，智慧能源理事會建立了氫氣認證計劃——零碳認證。這項由業界主導的計劃可評估生產的氫氣中所包含的碳。2022 年 2 月 4 日，該機構宣佈，ActewAGL 在坎培拉的氫氣加氣站已經通過 100% 再生能源生產的再生氫氣認證，其碳排放為零。

澳洲的資金情報更新

● 澳洲首都地區

澳洲首都地區將向其再生能源創新基金投資 1,200 萬澳元，並有可能支持與氫能相關的研發

● 新南威爾斯州

除了作為新南威爾斯州淨零排放產業和創新計劃的一部分所公佈的資金細節外，1987 年的《能源和公用事業管理法》(新南威爾斯州) 也在 2020 年底進行了修訂，明確規定了根據該法案設立的氣候變遷基金中，有 5,000 萬澳元將用於在 2021 年至 2030 年期間發展綠色氫能產業。這將包括利用再生能源生產氫能，以及綠色氫能的供應、使用和出口。

作為新南威爾斯州 2022-23 年預算的一部分，當地政府目前投資包括：

- 10 年內提供 3 億澳元，支持潔淨製造產業，使用包括綠色氫能在內的新興潔淨技術；
- 作為新南威爾斯州策略的一部分，向再生燃料計劃提供 310 萬澳元 (4 年內 610 萬澳元的經常性開支)；以及
- 來自氣候變遷基金的 4.657 億澳元。

● 北領地

在 2022-2023 年北領地預算中，北領地政府承諾撥款 141.3 萬澳元，用於新的加速氫氣產業發展計劃，並承諾撥款 212.8 萬澳元，用於包括氫氣試驗在內的遠端再生電力計劃。

● 昆士蘭

2020 年 12 月，昆士蘭 (QLD) 政府承諾在未來四年內，對其氫能產業發展基金 (HIDF) 再提供 1,000 萬澳元，該基金是昆士蘭氫能產業策略的一部分。自該策略首次宣佈以來，昆士蘭政府已承諾為 HIDF 提供總計 3,500 萬澳元的資金。

2021 年 6 月，昆士蘭政府承諾向昆士蘭和再生能源就業基金 (QREJF) 額外提供 15 億澳元，總額達到了 20 億澳元。QREJF 將允許政府企業購買或參與商業和私人再生能源和氫能專案，這些專案將有助於實現昆士蘭的再生能源目標，具有商業價值，同時可創造新的和持續的就業機會。

● 南澳州

2021 年 4 月，澳洲政府和南澳州政府簽署了一項 10.8 億澳元的州能源和減排協議 (Deal)，旨在為澳洲提供可靠和可負擔的能源，並幫助減少排放。根據協議，聯邦政府將出資 6.6 億澳元，南澳州政府將出資 4.22 億澳元。雖然這筆交易的重點是天然氣，但聯盟資金中的 4 億澳元將用於投資優先領域，包括 CCS、電動車、氫能和其他減排專案。

作為 2022-23 年南澳州預算的一部分，南澳州政府已宣佈了一項氫能就業計劃，其中包括：

- 在 4 年內提供 5.93 億澳元，用於建設一個包括電解槽在內的新氫能設施；
- 在懷阿拉 (Whyalla) 地區的混合發電站和氫能儲存能力；
- 在 4 年內提供 830 萬澳元，以支持氫能計劃的實施；以及
- 投入 3,000 萬澳元，用於博尼森港 (Port Bonython) 的潔淨氫能中心。

● 塔斯馬尼亞州

2022 年 3 月，塔斯馬尼亞州政府提供 1,230 萬澳元，用於綠色氫能公車的試驗，以及針對卡車運輸和海運

船隻進行綠色氫能應用調查。

● 維多利亞州

加速維多利亞州的氫能產業計劃
作為該計劃的一部分，維多利亞州政府宣佈再撥款 1,000 萬澳元，用於加速維多利亞州的氫能產業計劃，主要用於政策、研究和產業發展。該計劃中討論的主要資金包括：

- 660 萬澳元，用於氫能試點、試驗和示範方面的 6 項專案。
- 100 萬澳元，用於產業用戶，以支持商業案例、補助和教育。
- 50 萬澳元，用於澳洲氫能中心的天然氣混合可行性研究。

維多利亞州氫能中心

2021 年 2 月，維多利亞州政府為斯威本理工大學 (Swinburne University of Technology) 提供 1,000 萬澳元，與澳洲聯邦科學和工業研究組織合作，開發維多利亞州氫氣中心 (VH2)。

● 西澳州

再生氫能基金 2.0

再生氫能基金是根據西澳州的再生氫能策略，支持該州的再生氫能產業發展。第一輪融資始於 2019 年，提供了 1,000 萬澳元，第二輪融資在 2022 年，提供了 500 萬澳元。

西澳州 (WA) 預算

在西澳州 2021-22 年預算中，西澳州政府承諾：

- 投入 5000 萬澳元基金支持再生氫能產業發展，包括用於氫能燃料運輸方案的 1,000 萬澳元資金，以促進氫能燃料運輸的普及。這些資金將提供給採購和營運氫能或綠色氨燃料運輸，以及安裝一個或多個加氣站的專案；
- 提供 750 萬澳元，用於將 Oakajee 策略工業區發展為再生氫能中心；以及
- 提供 400 萬澳元，用於強化再生氫能裝置。

西澳州 2022-23 年預算包括：

- 1.175 億澳元，用於皮爾布拉和中西部的兩個氫能中心；以及
- 30 萬澳元，用於研究西澳州地區網路中，為列車提供綠色氫能的高階可行性研究。

● 澳洲政府

2021-2022 聯邦預算

2021 年 4 月，澳洲政府宣佈，將對潔淨氫能和碳捕獲技術方面進行新投資，這是其 2021-2022 年預算的一部分。這項預算將投資 5.392 億澳元，用於新的潔淨氫能、碳捕獲、使用和儲存 (CCS/CCUS) 專案，包括：

- 在 5 年內投資 2.755 億澳元，用於在澳洲地區開發四個新的潔淨氫能中心，並實施潔淨氫能認證計劃。
- 在 10 年內提供 2.637 億澳元，用於發展 CCS/CCUS 專案和中心。

2022-2023 聯邦預算

新當選的艾班尼斯 (Albanese) 政府將於今年 10 月提出 2022-2023 年預算。

碳捕獲、使用和封存發展基金

5,000 萬澳元的碳捕獲、使用和封存發展基金 (CCUS)，將為企業和政府機構提供 50 萬澳元至 2,500 萬澳元的補助，用於碳捕獲、使用和封存技術的試點專案或預商業化專案。

CCUS 基金並非專門針對氫能，不過還是包括下列目標：

- 減少能源生產、天然氣或氫氣生產以及重工業的排放。
- 扶植現有、試點或預商業化的碳捕獲、使用和封存設施，這些設施可能成為未來此類設施的區域中心的一部分。

ARENA 再生氫能部署投資輪

2021 年 5 月，ARENA 宣佈將在再生氫能發展投資輪下，向三個大型氫能專案提供總計 1.033 億澳元的資金。所選擇的三個專案 (Engie Renewables、ATCO Australia 和 Australian Gas Networks) 均發展良好，計劃大規模生產氫氣 (10MW 以上的電解槽容量)，可用於各種終端應用，將於西澳州和維多利亞州進行。

氫能中心

澳洲政府為，區域中心是氫能產業創建需求中心，以及集中氫能基礎設施的最佳方式，因而透過潔淨氫能工業中心補助計劃，投資了超過 4.64 億澳元。

其他

2021 年 2 月，澳洲國家能源資源部門宣佈了一個由 13 個區域氫氣技術集群組成的網路，總投資額 185 萬澳元。這些區域集群是環繞關鍵的氫能專案和技術供應鏈而建立，包括維多利亞州的四個集群，西澳大利亞州的三個集群，以及其他州和地區的一個集群。

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Kelly Davies 專注於能源專案的開發、收購和融資，以及大型企業的能源採購和可持續發展策略。她與客戶就所有能源業務領域密切合作，並針對能源產業的國際和國內能源交易提供建議。
她為電力產業各個層面的客戶提供諮詢，包括發電機、發電廠、輸配電網路營運業者、零售業者、監管機構和消費者，並就澳洲和全球氫能領域的專案開發、能源轉換、運輸、使用和認證以及交易框架等，為客戶提供更多的建議。她在能源市場擁有豐富經驗，曾在全球多個司法管轄區工作，包括英國、非洲、歐洲、中東、亞洲和澳洲。她最近的工作包括為澳洲的多個再生能源專案提供諮詢。

凱利經常介紹有關氫能的發展，包括 K&L Gates 的 Podcast 系列《氫能崛起》(www.klgates.com/Hydrogen-Rising) 和最近的《H2 Handbook》手冊 (www.klgates.com/epubs/h2-handbook)。

關於高蓋茨法律事務所 (K&L Gates) 台北辦事處

高蓋茨法律事務所 (K&L Gates) 是全球最大最完整的律師事務所之一，擁有近 2,000 名律師，其中包括 100 多名專注於能源和再生能源的律師，在我們遍佈五大洲的 46 個辦事處完美無暇地開展業務。我們在全球廣泛的平台，讓我們能夠指導客戶在不斷變化的國際格局中，解決固有的法律挑戰。我們的辦事處彼此之間完全整合，所有案件均能完美銜接執行，並為跨境案件中可能出現的任何問題提供直接的聯絡點。我們為已開發國家和發展中國家的幾乎所有再生能源和潔淨技術領域客戶提供服務。我們的客戶經營太陽能、風能、生物質能、水電、地熱，以及包括儲能、智慧電網和輸電等配套產業。此外，我們的全球監管和公共政策業務，也協助客戶克服監管障礙，並對再生能源領域的立法和政策發展發揮影響力。我們的台北辦事處是一家公認為在台灣具有領先地位的全方位服務律師事務所，提供進入關鍵台灣市場以及在該地區和其他地區的大量跨境機會，並定期為在台灣開展業務的跨國公司提供有關重大基礎設施、能源、再生能源和發電廠專案、專案融資以及企業 / 併購、合資企業、投資、資本市場、私募股權、糾紛和商業訴訟 / 仲裁的建議。K&L Gates 被 Law 360 評為全球 20 大律師事務所之一，並獲《美國新聞》(US News)「最佳律師事務所」授予公司法領域的「年度最佳律師事務所」，同時也是得到最多「一線」認可的十大律師事務所之一。K&L Gates 台灣被「法律 500 強」(The Legal 500) 評為公司和併購領域的「一級」律師事務所，以及資本市場和爭議解決領域的「二級」律師事務所。

如果您有任何問題，請隨時聯絡我們台北辦事處的合夥人 / 資深法律顧問 Owen Chio，電話：+886.2.2326.5120，電子郵件：owen.chio@klgates.com。

台灣如何達成淨零的展望

再生能源、基礎設施

Renewables Consulting Group
an ERM Group company

台灣擁有多種再生能源的巨大潛力，政府、產業和金融部門應該共同努力，實現多元化發展以及電網基礎設施的升級。淨零排放不可能透過單一措施來達成，能源轉型需要能源基礎設施、社會和金融理念的全面轉型。

台灣在開放能源市場管制的同時，低碳能源轉型的壓力也越來越顯著。這必然是整個能源基礎設施和社會的轉型，難以只透過單一或簡單的措施來達成這些目標。RCG 最新的全球離岸風能年度報告顯示，台灣不但是全球前五大離岸風能市場之一，更展現出對浮動式離岸風電有極大的興趣。政府需要有效地利用國營公共事業——如台灣電力公司 (TPC) 的優勢，並與此獨特的經濟體性中的產業合作，加快實現淨零排放 (NZE) 的所有必要條件。國家發展委員會 (NDC) 日前宣佈的 NZE 發展藍圖就是一個很好的例子。長遠來看，這些產業可以期待台灣適應以綠色能源為基礎的能源體系，但在大規模的轉型中，有許多因素需要所有產業的更多規劃和參與。

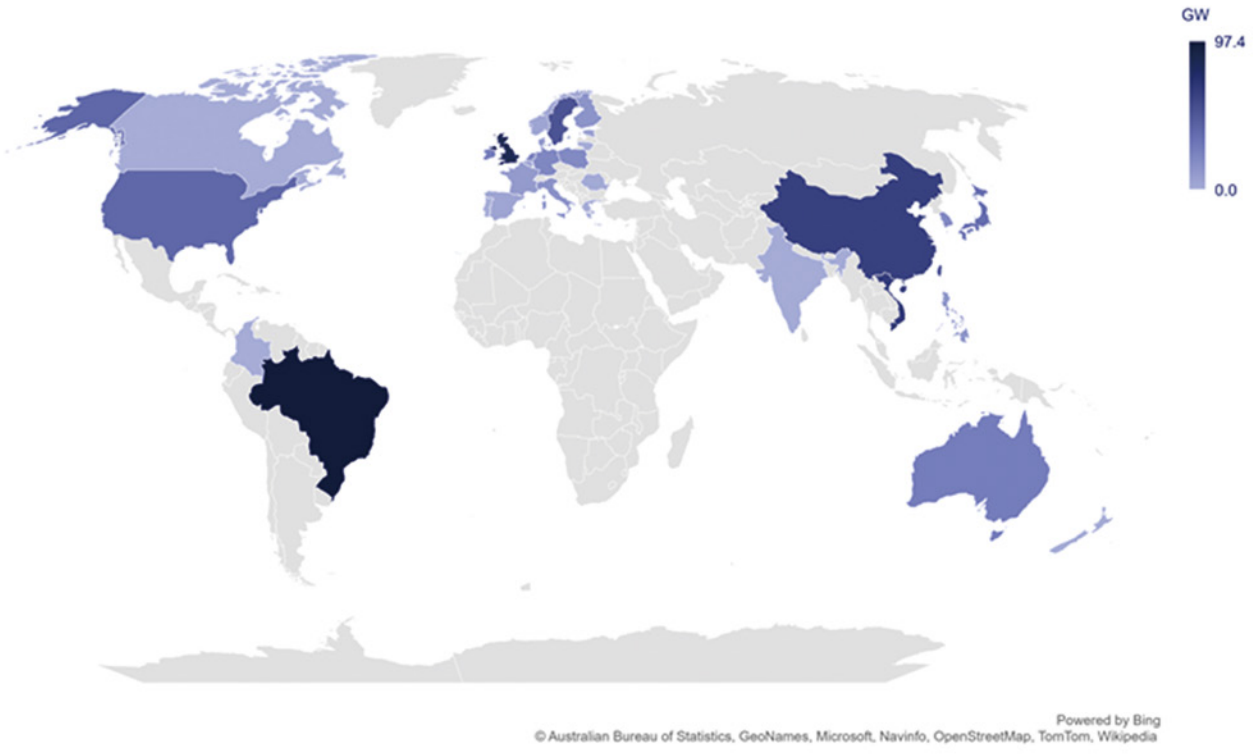

圖 1：全球離岸風電發展概況
來源：RCG GRID 2021 年全球離岸風電年度報告

再生能源的多元可能性

NZE 面臨的最大挑戰，是減少能源使用時產生的溫室氣體排放。因而當務之急是全力發展再生能源，如離岸風電、陸域風電、太陽能、地熱、儲能等。儘管台灣擁有豐富的再生資源，但仍須面對台灣是一個島國，無法與鄰國電網連接的限制。各種研究評估了台灣再生能源的自然潛力和限制因素，其中大多數研究都顯示出支持 NZE 能源轉型的巨大價值。在此政策下，睿思再生能源 (RCG) 推估台灣未來再生能源發展路徑 (圖 2)，而 NZE 目標是可實現的。然而，化石燃料向再生能源的轉型、發展歷程和框架必須有重大變化。

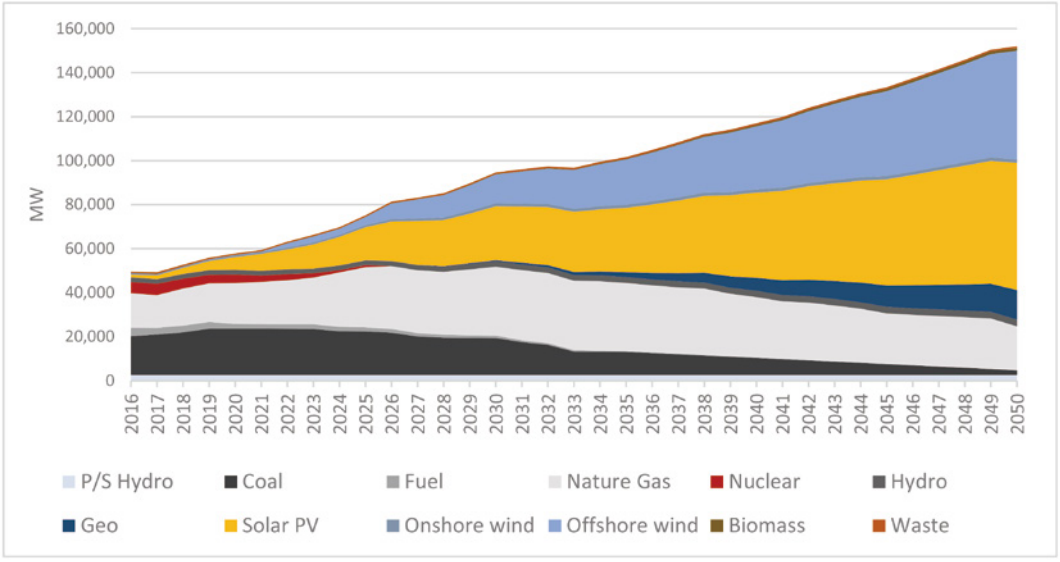

圖 2：能源產能開發設想 (RCG)　來源：RCG 預估

除了大自然的潛能外，開發的可行性也是關鍵。RCG 在其全球再生基礎設施專案資料庫 (GRIP) 中，收集了離岸風電場的市場情報和公開資訊，並支持不同市場陸域風電和太陽能專案的開發和盡職調查。要實現再生能源目標，必須考慮各種可行性，包括技術、政策和監管、資金和市場準備情況。這些因素都相互依存，可行的技術可能不具有財務可行性，地方法規可能會限制某些技術的可行性。政府必須減少限制，並透過正確的政策和法規提供支持，以降低這場競賽中的障礙。開發商應持續研發，為不同的技術創造空間，並與利害關係人和產業界合作，提升多面向的能力，以尋求最佳商業機會，為氣候行動帶來更積極的影響。

台灣政府為能源轉換設定了「風電和太陽能雙引擎」基調，並著眼於地熱、小型水力發電和海洋能源。由於不同類型的技術具有不同特性，因而建議發揮再生能源的最大潛力，讓能源系統穩定、平衡。沒有一種單一類型的再生能源，能夠成為未來電力供應的超級英雄 (或傳統供電規劃中之基載概念)。然而，政府應該考慮到，各種不同技術能為零排放能源體系做出貢獻的潛力，過度依賴某些技術可能會導致系統不穩定，並對相關環境造成過度壓力。結合所有具有潛力的再生能源，才能實現平穩過渡和永續發展。

來源：RCG

技術	優勢	發電模式
太陽能	▪ 可以從小規模到大規模發展 ▪ 發電尖峰與中午時段的負載高峰一致 ▪ 鄰避效應 (NIMBY) 較小	每天定期發電，在上午 10 點至下午 2 點可有充足供電能力
離岸風電	▪ 可發展規模經濟 ▪ 全天都有良好的容量係數	季節性明顯，冬季發電能力非常好
陸域風電	▪ 資本支出低於離岸風電 ▪ 更容易擁有 MW 級容量	類似於海上風能，但受場地條件的影響
地熱	▪ 穩定發電 ▪ 與火力發電廠相比，鄰避效應較小 ▪ 可將發電與其他燃燒源結合	始終穩定發電
小型水力發電	▪ 相對較低的資本支出 ▪ 可控制發電量，可結合小型蓄水設施	可能受到季節性水資源的限制，但在夏季應具有穩定的發電
海洋能源	▪ 相對穩定的發電量 ▪ 鄰避效應較小	可能會有季節性模式，取決於地點和技術

輔助服務和支持性基礎設施

能源轉型不僅代表著我們所使用的能源轉變，也代表著我們所採用的系統和行為的變化。當太陽能和風電的滲透率很高時，代表供需管理和電力調度會和今天有很大差異。如上所述，再生能源的發電模式不同於燃煤與天然氣機組，它需要台電、產業和社會發生根本性的改變。能源轉型不僅是開發商和台電的責任，還需要更多企業提供更多相關的新服務和基礎設施。

人們迫切想擁有 100% 的再生能源，但如果沒有配套的服務和儲能設施，這點是不可能實現的。國發會計劃達成 40-80GW 的太陽能裝置容量，以及 50GW 的離岸風電裝置容量，但電網系統必須能承載與消化來自太陽能的峰值發電。舉例來說，假設在 60GW 太陽能達 40%、 50GW 離岸風電達 50% 發電係數，即可以提供 49GW 的電力供應，但 2021 年 7 月份的的高峰負載約為 38.6GW，亦即在某些特定時期，再生能源的發電量可能會超過負載。儘管我們可預期未來的負載會持續成長，但再生能源的高發電量可能會導致再生能源的需要降載的風險。另一方面，晚上太陽能的突然減少也是穩定電力供應的棘手問題。此外，RCG 模型還顯示在冬季和春季風較大的週日，由於國內用電負載較低，離岸風電降載風險的可能性也很大。舉例來說，50GW 離岸風電發電量的 60%，可能超過週末的負載。屆時，台電調度中心必須降載部分的再生能源發電量，導致再生能源案場所有者的損失，並浪費發電量——這對開發商來說並不是一個正面訊息。我們認為整體能源系統必須更智慧、更靈活。需量反應計劃將扮演重要角色，但並不是唯一的措施。台電已經建立了能源交易平台，而輔助服務的需求將是巨大而迫切。需量反應能力應與太陽能和風電總容量維持一定比例的匹配。此外，台灣需要很大的儲能容量來吸收中午的太陽能高峰，並抵消晚上的第二個高峰負載。有了更多的儲能和輔助服務能力，台電才能讓燃煤發電安然退場。

另外，國家電網系統也需要升級，以容納更多分散式發電的再生能源容量。未來將有大量的太陽能需要在分散的地點接入電網，而風電需要靠近海岸的適當併接點。電網必須提高適應能力，以避免來自野生動物和自然災害的威脅，但也必須更加靈活，進行更好的評估和規劃。在近年來幾次全國停電後，台電宣佈投資超過 1,000 億新台幣進行電網升級。然而，升級不應該只是新的電纜和變電站，而是更智慧、更靈活的系統。

整合的方案將有助於創新管理。舉例來說，廣受歡迎的機車交換電池系統具有為電網提供儲能容量的可觀潛力，但換電站的高峰需求往往發生在晚上，因為用戶通常在回家的路上更換電池。這種模式可能會惡化晚間高峰負載的供電。電力輔助服務以及儲能發展對許多產業來說都有著新商機的發展可能，例如交換電池、電動汽車、水庫和氫氣設施。能源基礎設施和框架的轉變是可預期的。如果沒有更好的輔助服務和配套設施，離岸風電場可能無法對系統做出最好的貢獻。

為能源轉型提供金融資助

如果缺乏金融領域的支持，所有的專案開發都無法完成。綠色金融、責任投資和 ESG 投資是當前的熱門話題，越來越多的機構投資者將資金投入到再生能源和相關開發專案中。然而，金融界和投資者也需要學會識別綠色專案的風險和機會。不同的技術可能會產生完全不同的結果，這取決於條件和市場。儘管有些專案乍看之下很有前途，但仔細看細節將發現一個完全不同的故事。此外，快速變化的市場和新技術也為投資者帶來了挑戰。我們見證了離岸風電機組規模的快速發展，台灣在 2017 年安裝第一台 4MW 離岸風力發電機組，2025 年將可能安裝 14MW 風力發電機組。我們預期，資本是技術研發和專案開發的驅動力，但金融產業需要盡職調查和市場情報，以正確投資於永續的未來。

我們知道沒有投資是毫無風險的，風險和收益之間的平衡是金融圈參與綠色轉型的關鍵。伴隨台灣能源市場管制開放，政府也預期企業購電協議 (CPPA) 將取代躉購 (FIT)，成為再生能源專案的主要收入來源。然而，金融界要將 CPPA 作為未來收益的保障仍然有難度。我們必須相信能源市場將會發生典範轉移。所有商業條款和條件都將得到仔細的討論和審查。我們已經發現，在台積電與沃旭能源簽署第一份 CPPA 後的兩年內，CPPA 的討論在台灣變得白熱化。而關於淨零碳排的目標，若沒有大量的 CPPA 更是無法達成的，金融部門和投資者必須接受再生能源專案融資的新典範。

結論：不能遺漏任何人，也須將納入各種因素考量

我們必須借用永續發展的老口號來說明淨零碳排轉型：不能遺漏任何人 (leave no one behind)。這是一項極具挑戰性的任務。因此，利害關係人必須需要採取綜合措施與努力來實現這個目標。綠色能源轉型不能脫隊，但必須將所有的微小因素和新興技術都納入考慮，任何人都不能被忽視。應對氣候變遷是基礎設施和人類行為的格局變遷。政策制定者、開發商、供應鏈、融資和投資者，都應該從各種角度做出貢獻。商機非常巨大，行動非常緊迫；策略和全面規劃是在轉型中取得最佳成績的關鍵。

作者

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黃敬文
睿思再生能源 (RCG) 台灣副總監

以歐洲油氣工業經驗獻策 台灣中油公司淨零發展策略

基於歐洲的綠色新政及石油天然氣工業的淨零發展經驗，本文探究並推薦台灣中油淨零發展策略，包括系統化的淨零路徑及脫碳策略、開發氫能價值鏈及碳捕捉技術、推動天然氣管線混氫及輸氫、鼓勵油氣企業從加油站轉型為加氫站、最後建立可靠的追碳預警管理機制，逐步實現 2025 年低碳、2050 年淨零碳排的永續目標。

油氣企業的淨零路徑及脫碳策略

在歐盟 2021 年的綠色新政及 2050 年碳中和目標下，石油天然氣集團如 Shell、BP、E.ON、Total、ENI 等企業都積極推出淨零目標及發展路徑。同樣的，我國政府於 2022 年 3 月 30 日公佈淨零排放路徑及策略之後，台灣中油公司也積極規劃因應作為，包括 2025 年、2030 年碳排放量及減量的中期目標及 2050 年的長期目標。基於歐洲油氣企業的策略及經驗，建議台灣中油可在「節能減碳」、「發展並使用再生能源」及「推動 CCUS」的三大路徑基礎上，系統化融合「優油、減碳及潔能」三大主軸，整合出更具體的路徑策略，並藉由減碳 (carbon reduction)、脫碳 (Decarbonlization) 至碳中和 (carbon neutral) 的階段性方法逐步實現淨零碳排目標。

近日歐盟已宣布於 2035 年不再銷售燃油車，亦即大幅減產車輛燃油，這值得台灣深思脫碳的決心，因此可仿效國際能源總署 IEA 針對全球總能源供應趨勢，所提出的化石燃料減量策略，並參考歐洲潔淨氫聯盟「氫和脫碳氣體計畫」的低碳燃料概念，釐訂台灣中油生產化石燃料減量及「優油、潔能」增量的逐年目標。
歐 美 Total、Shell、BP、Chevron、ExxonMobil 等石油天然氣集團的淨零發展策略都包括在近期推動大規模的綠能開發或投資計畫。因此鼓勵中油展現 CPC (Clean Power Company) 潔能決心，具體規劃或投資離岸風電、其他綠能及電解槽系統等興建計畫，才有機會應用德國 Power-to-X 概念，使用剩餘綠電生產綠氫，再運用先進觸媒技術與脫碳技術轉換成低碳燃料或再生化學品，並結合政府的碳循環經濟政策及措施，達成台灣中油的碳中和目標。

開發氫能價值鏈及碳捕捉技術

在淨零碳排發展策略中，氫能價值鏈及碳捕捉與再利用扮演相當重要的脫碳角色。由於台灣中油的業務幾乎涵蓋整個氫能價值鏈 (如圖 1 所示)，因此可進一步在製氫、儲氫、運氫、輸氫及終端化工用氫上構思更多的發展優勢與轉型契機。

在製氫及儲氫方面，製氫產量是氫能發展的關鍵挑戰，而傳統的灰氫模式將不再被接受，因此過渡期必須將製氫融合碳捕捉而形成藍氫。目前台灣中油與中鋼公司合作的鋼化聯產計畫即為一例。典型的煉鋼廠 CCS 製程捕捉高爐氣 (BFG) 與轉爐氣 (LDG) 所產生之 CO/CO_2，再利用水煤氣變換反應系統，透過蒸汽與一氧化碳轉化為二氧化碳和氫氣，並導入選擇性吸附酸性物質特性的固體吸附材料吸附二氧化碳及碳酸，達到碳捕捉及製氫的目的。目前歐盟所開發之新穎藍氫製程，其優勢為結合傳統製程中碳捕捉與產氫兩步驟，在二氧化碳產生的同時進行吸附，並產生氫氣。因此可降低水煤氣變換的逆反應速率，進而減少蒸汽用量。相較於傳統的碳捕捉製程可減少三分之二蒸汽用量，在瑞典煉鋼廠的成功案例中已降低 25% 的成本，並可應用在其他工業製程上，因此台灣中油可參考此技術做為借鏡。

工業製程的碳捕捉技術包括燃燒前補集、富氧燃燒補集、燃燒後補集等三大類 (如 ISO/TR 27912 所述)，在歐洲不斷發展許多嶄新技術和專利產品，可節省設備空間、建造時間及成本，並可增加碳補捉效率、可靠度及安全性，因此推薦台灣中油可透過國際商會平台多與歐洲的高端成熟技術廠商交流合作，導入最適化解決方案。
第三方認證在 CCUS 與氫能價值鏈領域扮演關鍵角色。在 CCUS 方面，可依據 ISO 27919-1 與 ISO 27919-2 驗證性能測試，運用 ISO 27915 認證 CCUS 的碳減量。在氫能價值鏈的碳足跡方面，TÜV Rheinland H2.21 標準的綠氫及藍氫認證與安全驗證能夠確保碳中和的成效與安全，這些歐盟成功認證經驗都值得台灣中油仿效。

天然氣管線混氫及輸氫

在管線輸氫方面，歐洲 GET H2 計劃的七家重工業公司共同建立綠氫的跨境長輸管線網路，從德國林根市的 RWE 公司電解廠產生的綠氫利用既有的天然氣管網輸送荷蘭，再送至德國蓋爾森基興市的 BP 煉油廠。預

估至 2030 年本計畫煉油廠、鋼鐵廠和其他工廠的管線輸送綠氫能夠減少 1600 萬噸的 CO_2 排放。此外，德國的天然氣城市採用混氫輸送的混氫比已增至 20%。因此推薦台灣中油在混氫輸送的可行性及管材安全適用性驗證下，可適度發展以達到減碳效果。

油氣企業從加油站轉型為加氫站

為推動加氫站在國內的商業化，可參考德國國家氫能戰略的「氫能夥伴關係」作法，鼓勵台灣中油與上游製氫業者及下游燃料電池車輛業者組成策略聯盟，加速加氫站普及，並建議盡早規劃大型的定置式加氫站，甚至考慮自行開發或興建加氫站設備，以達到 2025 年台灣中油的中期減碳目標。

基於歐美日對加氫站的公共安全嚴苛要求，從加氫站設計階段的安全風險評估、加氫站主要設備及部件的製造檢驗、設備現場安裝驗證及性能測試、氫氣品質試驗、加氫機與燃料電池車輛的加氫協定測試等都必須依照各項國際標準 (如 ISO 19880 系列、SAE J2601 等) 實施嚴格第三方驗證，落實安全是加氫站推動過程中的第一原則。

追碳預警管理

自 2020 年全球新冠疫情、2022 年烏俄戰爭導致能源市場混亂等因素，許多國家、跨國組織及工業大廠已經意識到淨零發展出現偏離計畫的狀況。德國政府 2022 年 4 月已經開始加嚴碳管理戰略，企業組織也陸續採取動態碳管理措施，並使用第三方認證的碳追蹤平台來進行智能化 ESG 管理。因此推薦台灣中油訂定更具體的減碳工作績效指標及碳足跡預警機制，縮短檢討週期，並考慮設置追碳管理戰情中心實施動態管理及大數據分析預測，驗證 ESG 永續管理系統的有效性及達標能力，逐步實現 2025 年低碳目標及 2050 年的淨零目標。

作者

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高鴻鈞
總經理
台灣德國萊因技術監護
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以離岸風電及再生氫能邁向淨零及能源自主

離岸風電、再生氫能

在歐洲大陸發生的烏俄戰爭加深了我們對於能源依賴的反思。俄羅斯將天然氣作為其戰爭策略與地緣政治的槓桿，使得歐洲更加意識到，對俄羅斯能源的長期依賴必須趕快結束，而且，不是改成依賴其他國家的化石燃料——若持續仰賴其他國家來供應能源，同樣會面對受制於他人的風險。

這個道理也適用於台灣。台灣的能源近 98% 依賴進口，而且在減少燃煤發電佔比的能源轉型過程中，天然氣正在成為再生能源極大化前的橋接角色。今天台灣已經踏上邁向淨零轉型的起跑點，而同時我們也需要思考自身能源系統的韌性，追求一個更加自主的長期目標。

在沃旭最新發表的 "Need for Speed" 白皮書中，我們提出以離岸風電為主力的再生能源，加上再生氫能及合成綠色燃料的 Power to X(P2X) 模式，建構一條同時邁向淨零，亦能強化能源韌性及自主的路徑。實現這條路徑的重點在於 4A，也就是 Accelerate deployment — 加速建置、Allocate the space —分配空間、Activate the industry — 催化產業、Appoint a clear role for renewable hydrogen and e-fuels —確認再生氫能及合成燃料的明確角色。我希望以此拋磚引玉，供台灣政府及各界先進參考。

第一，我們期待政府與產業攜手建置更大規模的再生能源項目。我們除了須加快目前正在規劃中的再生能源招標作業，並應考慮優先啟動更大規模複合式的能源項目。例如，丹麥政府啟動的能源島計畫，將可以做為 10 GW 離岸風場的基地，並結合儲能及再生氫能電解槽。在台灣，我們應該更專注於建置 750 MW 至 1 GW 以上更大規模的離岸風場，除了滿足市場上對於大量、可負擔綠電的需求，且能讓離岸風電專案更有能力整合再生氫能及 P2X 設施。

與此同時，離岸風電開發業者必須針對風場專案和項目組件，持續推動標準化和一致性的設計規範，以進一步提高供應鏈的效率。而且，開發商也應負起責任，盡可能讓供應鏈看到長期的採購需求，與供應鏈共同承擔額外的風險，減少市場不確定性。在 900 MW 大彰化東南及西南第一階段離岸風場中，沃旭展現市場領導力，與西門子歌美颯（Siemens Gamesa）達成協議，將其歐洲以外、亞太第一座機艙組裝廠設置於台灣，就是超前政府規劃、提前落實離岸風電生態系建立的最佳例證。

第二，在分配空間面向上，我們期待海洋空間規劃能容納更多離岸風場發展，以加速能源系統轉型。台灣政府在淨零路徑中，提出將鬆綁離岸風電僅能設置於領海內的限制，這就是一個有意義的開始。最有效的規劃是，海域空間只需要經過初步的篩選，便由開發商去選定風場，並承擔開發的風險。同時，應避免同一塊海域有不同的開發商做重複開發工作，減少整體經濟及人力資源的浪費。當市場可以更有效率的運作，我們就越能找到利用台灣海域及風能的最佳技術和商業模式。而在陸地上，我們則應把電網及 PX2 基礎設施納入國土空間布局的長期規劃中。

當然，在重構海域及陸域等國土空間的過程中，我們不該付出比過去更多的環境和社會代價來推進再生能源建置 —— 這也就是為什麼沃旭能源設定了最遲在 2030 年所有沃旭建置的再生能源專案都需帶來生物多樣性的淨值正面效益。不過，我們也需要平衡的對話以促進了解，避免讓片面或錯誤的理解而限縮再生能源的發展。這一點仰賴更基於科學及負責任的環境規劃、環境影響評估、審查和追蹤監測，以及更透明及公正的利害關係人溝通機制。唯有這樣做，我們才能夠打造一個基於信任和證據的堅實基礎，以此來實現碳中和的未來。

第三，我們期待整個離岸風電產業更進一步進化，不僅提供更低成本的電力價格，同時也能創造社會價值。現在我們正面對全球鋼鐵和銅的商品價格上漲，供應鏈成本增加，然而台灣主管機關仍限制離岸風場專案在 500 至 600MW 區間，這將導致本地離岸風電產業無法掌握規模經濟。使得我們擔心，相較於過去經由技術創新促進的成本下降，未來我們產業面對的，是否會是削減成本的惡性循環、削弱整個產業可以為社會做出的重大貢獻？著眼於此問題，未來的離岸風場競標制度應該調整風場規模限制，確保建置容量達到經濟規模，以此確保離岸風電價格的可負擔性；同時，也要思考如何激勵離岸風電去創造高社會價值，避免惡性削價競爭。有許多重要的社會價值值得產業去追求，包括：能夠如期如質完工以符合國家減碳目標、生物多樣性的維護和經營、與地方社區合作追求永續發展、是否以最佳方式整合多元能源系統及電網等等，而這些都應該成為評價離岸風場專案的標準。

此外，在政府主導的招標制度之外，建議同時考慮讓持續增長和專業化的市場力量來驅動離岸風場專案發展。開發商可以自主去開發海域，投入資本建置風場，甚至是整合性的設施。例如，將綠電及再生氫能生產結合起來，來回應客戶的多元需求。

第四，我們認為應該為再生氫能及合成燃料 (e-fuel) 的角色應更加明確。為難以電氣化的產業或社會部門，以再生氫能以及合成燃料等 P2X 模式鋪設邁向淨零的最後一哩路。為了鋪設這一條終極去碳化的道路，需要加速為大規模的 P2X 項目建立政策與法規。亞太地區的其他市場，包括韓國、日本、澳大利亞，已經在定義再生氫能在從工業、運輸和到發電等各個領域的角色。

短期內，我們可以採用示範計畫的形式，結合市場上的不同利害關係人—包括開發商、用戶、政府，共同來形塑政策框架和路徑。在 P2X 的市場以及投融資機制成熟前，我們也可以考慮透過政府科研補助或透過公共預算支出為專案提供支持。

以長期來說，我們則需要為綠氫及合成燃料的生產、銷售和應用，打造一個有效的市場，而這個市場需要靠明確的需求來拉動。為了達成工業、航空、重運輸等部門的去碳化，僅有綠電是不夠的。我們除了可以透過政策鼓勵不同部門投入綠氫及合成燃料採購的規劃，至關重要的更是提高綠氫應用的規模和效率，這是未來十數年需跨越生產和消費端、跨越商業和科研機構、以及跨越政府和民間企業，一起努力的工作。

同時，我們建議應將氫氣基礎建設及傳輸骨幹，納入國家基礎建設的思維和計畫裡面。政府可以考慮優先在工業或重運輸聚落，先行改造或升級現有的供氣網絡，成為新的氫氣傳輸骨幹，來支持再生氫能的取得和應用。

我們相信，本土的 P2X 系統越密集，越具規模，台灣能源系統就越有韌性。這個韌性來自於兩個面向。第一，未來再生氫能將是國際競逐的資源，依靠從單一或少數國家進口綠氫，將複製上個世代過度對外依賴化石能源的問題。所以，我們需要確保國內擁有一定的再生氫能產能。第二，綠電轉換成再生氫能或合成燃料，可以視為一種儲能的形式，為具有間歇特色的再生能源電力帶來補充和平穩的效果。

台灣真的有能力自主供應再生氫能嗎？我們的答案是肯定的。這是環環相扣的議題。透過上述加快、擴大建置再生能源專案、積極分配空間以及促進離岸風電產業的價值進化等策略，台灣將會擁有更多、平價的綠電，為本土再生氫能創造發展的基礎。在邁向 2050 年淨零轉型的過程裡，以及過往數個世代至今對能源自主的追求中，我們已預見離岸風電和再生氫能將是非常關鍵。沃旭能源將持續提供可行、可負擔、具永續性的，從離岸風電到 P2X 的解決方案，協助台灣及全球社會實現淨零轉型和能源自主的理想。我們將持續專心致力與來自不同國家、不同社區的夥伴，共同打造一個完全以綠能運作的世界。

汪欣潔
沃旭能源台灣總經理

作者

汪欣潔為沃旭能源台灣總經理，負責沃旭在台灣的各項業務及活動，帶領並拓展沃旭台灣團隊及相關部門，確保各項業務運作順暢，協助推動台灣以及其他發展中的亞太市場，在離岸風場 開發建造以及業務活動皆能獲取成功。

台灣中油淨零轉型具體做法介紹
淨零路徑

台灣中油股份有限公司
CPC Corporation, Taiwan

台灣中油因應 2050 淨零排放之策略規劃

在第 26 屆聯合國氣候變遷大會 (COP26)，將全球 2050 年達成淨零排放目標納入格拉斯哥氣候協議後，碳中和及淨零排放議題成為全球企業關注的顯學，我國國家發展委員會亦於 2022 年 3 月 30 日公布淨零排放路徑及策略，並指出 2030 年後，需更多淨零新科技與新能源技術發展及導入。為研擬及推動因應淨零排放相關策略及方案，台灣中油於 2021 年成立氣候變遷因應工作小組 (如圖 1)，由董事長擔任召集人，並於小組下分設低碳發展中心、製程節能中心，橫跨總公司、各事業部及各研究所，分別就轉型經營策略、氫能、碳捕捉封存再利用、低碳及零碳能源研發、離岸風電、低碳及零碳產品供應、煉化轉型及製程節能減碳等八個領域進行相關業務研討，期能於淨零趨勢下，達成抑碳展綠、材料創新，建構多元能源系統的新 CPC(Clean Power Company)。

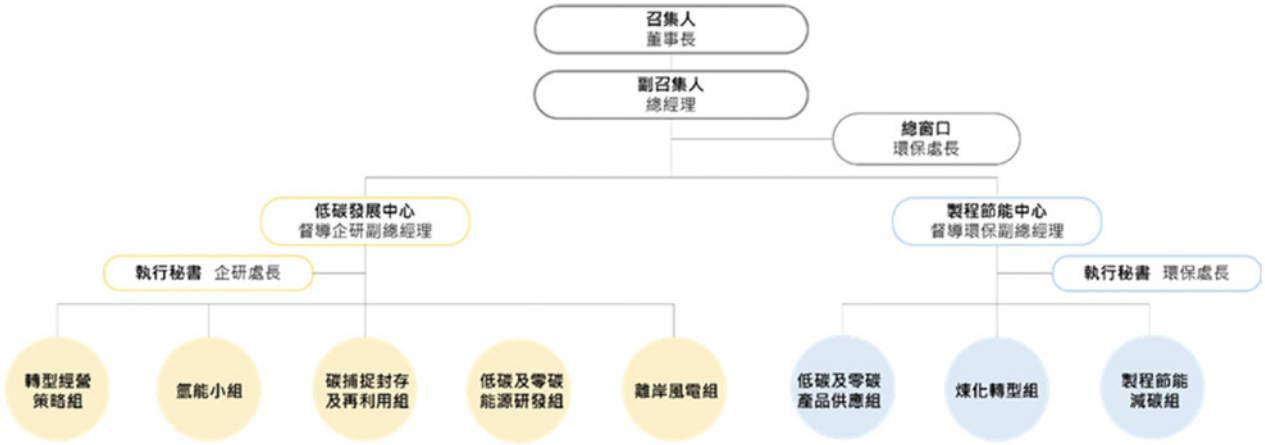

圖 1 中油公司氣候變遷因應工作小組組織架構

台灣中油溫室氣體減量成效

台灣中油為國營企業，橫跨能源與石化兩大產業，多年來落實政府節能減碳政策，持續推動溫室氣體減量，已具成效。自 2005 年起，推行全公司溫室氣體排放量盤查及查證，推動工場節能計畫，並配合經濟部進行產業溫室氣體自願減量工作。為強化減碳力道，於 2019 年 4 月成立節能減碳工作小組，邀請外部專家學者至廠區進行節能減碳診斷及輔導。經第三方查證，全公司溫室氣體排放量由 2005 年之 1,158 萬噸，至 2020 年減為 711 萬噸，減量達 38.6%，優於國家減量幅度。

台灣中油溫室氣體減量目標及路徑

為因應國際淨零排放趨勢，我國溫室氣體減量及管理法於 2021 年公布修正草案，研擬將我國長期減量目標由 2050 年降為 2005 年 50% 以下，修訂為 2050 年達到淨零排放。配合我國 2050 年減量目標，台灣中油已訂定 2025 年、2030 年排放量分別較 2005 年減量減量 40.6%、49.5% 之中期目標 (如圖 2)，並滾動檢討，持續依技術成熟度發展並導入再生能源、氫能、碳捕捉封存再利用等負碳技術，以 2050 年達成淨零排放為長期努力目標，主要路徑說明如下：

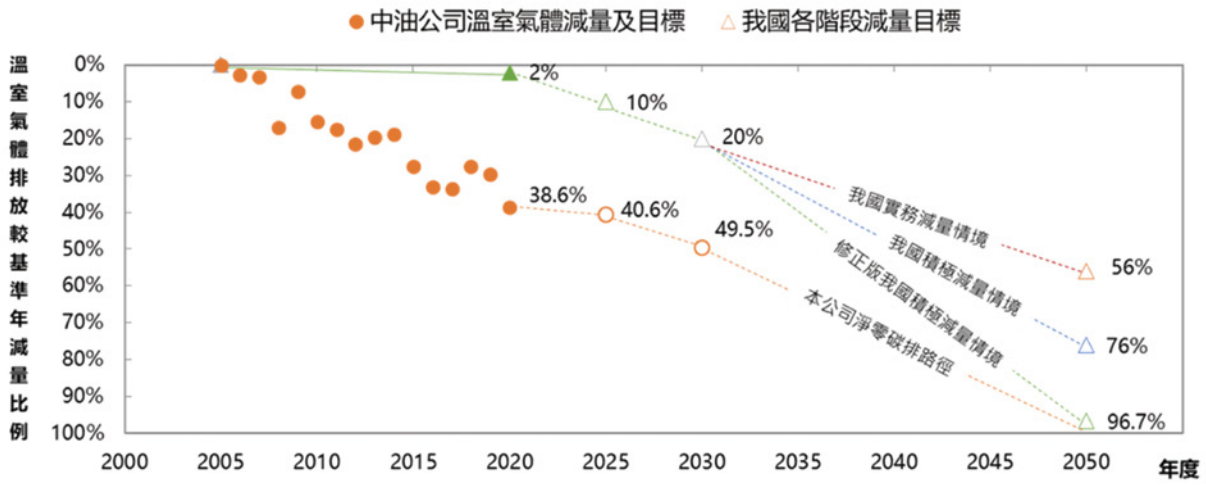

圖 2 中油公司歷年溫室氣體排放較基準年減量之比例及目標

持續推動節能減碳計畫並訂定煉化廠每年能源效率提升 1.7% 之目標

• 1. 提高能源效率

更新製程、擴大產能及導入先進節能技術，訂定能耗標準並加強檢測與維護，進行製程及公用系統改善與汰舊換新。

• 2. 加強能源管理

加強製程、加熱爐、鍋爐相關能源管理之整合，廢油氣、粗氫氣及中低壓蒸氣之回收利用，以提高能源之使用效率。

• 3. 區域能源互補整合：

例如大林廠使用中鋼蒸氣，推動廢熱、冷能回收利用，降低能源使用。

• 4. 使用低碳燃料：

使用天然氣、冷能利用或其他低碳能源。

發展並使用再生能源

• 1. 太陽光電系統

因應綠能發展及再生能源發展條例，規劃利用太陽光電維運系統整合管理中油分散各地之案場，並進行相關數據分析，規劃至 2036 年設置發電裝置容量達 26MW，2045 年達 35MW。

• 2. 開發國內地熱能

於宜蘭土場地區持續鑽探及產能測試並建置地熱發電廠；另為擴大地熱能發電規模，評估東部、大屯山地熱及全國深層型地熱，規劃地熱發電裝置容量設置目標，至 2023 年達 4MW、2030 年達 23.6MW、2050 年達 127MW。

推動碳捕捉、再利用及封存 (CCUS)

1. 進行碳捕捉與轉化試驗系統之規劃、評估及建置，引進商業化製程，規劃於 2030 年碳捕捉量能達每年 100 萬噸，

其中碳再利用量能達每年 25 萬噸；2040 年碳捕捉量能提升至 200 萬噸，2050 年碳捕捉量能達每年 300 萬噸。

2. 短期將進行碳封存場址之篩選評估、監測計畫與風險評估、概念性設計及民眾意向調查等，完成後由封存場先導試驗逐步發展至商轉，規劃年封存量於 2025 年達 10 萬噸、2030 年達 75 萬噸、2040 年達 500 萬噸、2050 年達 1,000 萬噸。

台灣中油身為國營事業及能源產業龍頭，在持續穩定供應國內所需油氣，維持油品與服務品質，善盡企業社會責任的同時，將配合政府 2050 淨零排放路徑，以「優油」、「減碳」、「潔能」三大主軸全面規劃轉型，並與國內外企業攜手合作，發展零碳能源相關技術及布局，希望蛻變成為「帶動台灣永續發展的新動能」，為加速台灣達成淨零目標而努力。

楊漢宗
處長
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作者

楊漢宗處長，目前擔任台灣中油公司環境保護及生態保育處處長，迄今已有 5 年以上資歷，負責台灣中油公司空氣、水資源、廢棄物與土壤及地下水之污染防治與整治及環境影響評估、溫室氣體管理、環境教育與生態保育之規劃與推動。

台灣中油淨零轉型具體做法介紹策略主軸及行動方案

台灣中油為因應降低溫室氣體排放及國內油品需求減少等趨勢對公司營運之衝擊，以「優油」、「減碳」、「潔能」為主軸策略，並以研發為帶動企業轉型的驅力，開發相關前瞻技術及產品，相關行動方案說明如次：

台灣中油為因應降低溫室氣體排放及國內油品需求減少等趨勢對公司營運之衝擊，以「優油」、「減碳」、「潔能」為主軸策略，並以研發為帶動企業轉型的驅力，開發相關前瞻技術及產品，相關行動方案說明如次：

減碳策略

● 1. 推動製程節能減碳

訂定煉化廠每年能源效率提升 1.7% 之目標，持續推動減碳計畫與耗能設備汰舊更新，強化區域能資源整合與能源管理，提高整體能源效率。

● 2. 供應碳中和產品

與國際能源公司合作採購經第三方認證之碳中和原油及天然氣供應國內用戶，深化綠色共榮理念。

● 3. 碳足跡盤查

推動溫室氣體之盤查與查證工作並通過第三方查證，以落實低碳之永續環境。另著手研議內部產品碳定價 (ICP) 機制。

● 4. 開發負碳排技術

(1) 碳捕捉及封存 (CCS)

研提「二氧化碳技術發展研究計畫」，持續於本公司煉化廠鄰近區域進行碳封存場址調查與震測作業，評估適合場址、封存潛能與安全性，持續提升 CCS 量能。

(2) 碳捕捉及再利用 (CCU)

初期規劃於大林煉油廠建置碳捕捉並合成甲醇之示範設備，並同時開發氫化合成觸媒系統，將捕捉之二氧化碳轉往石化衍生物發展，以建構完整循環經濟產業鏈。此外，和中鋼進行鋼化聯產合作計畫，將中鋼轉爐氣轉化為甲醇、甲烷。

5. 開發生質油料與生物可分解塑膠品

將導入生質原料開發生產脂肪酸酯、聚乳酸 (PLA) 與羥甲基糖醛 (HMF) 等項目，替代部分石化原料需求以減少碳排放。

優油策略

● 1. 發展漸進式原油製石化品 (COTC) 技術

將透過調整原油種類、變換操作模式及投資關鍵設備等方式，以「減產燃料、增產石化品」及「石化品向下發展新材料」為目標，逐步提升石化品轉化率。

● 2. 開發石化高值材料及投入碳循環應用領域

與產、學、研各界合作發展高值、創新及綠色環保材料，重點項目包括：

(1) 雙環戊二烯 (DCPD)：
提升自有材料附加價值，將裂解汽油透過碳五提純裝置產製高純度 DCPD，可作為 5G 高頻基板、風力發電葉片及光學鏡片之樹脂材料，並支援國內半導體產業所需之關鍵材料。

(2) 電池儲能材料：
配合政府綠色能源產業政策之推動，將低價重質油開發為具快充壽命長、放電強及容量高等特性之軟碳 (Soft Carbon) 電池材料；另開發安全性高、壽命長及耐高 / 低溫環境等特性之鈦酸鋰 (LTO)，適用於大型儲能或電動巴士之電池關鍵材料。

(3) 生質多重孔洞碳材：
採用自行開發之多孔洞碳材搭配商用儲能材料，提高電池能量密度，應用於電容脫鹽、超級電容等領域。

(4) 推動鋼化聯產：
與中鋼公司攜手建置示範產線，由煉鋼製程所產生之 CO 與 CO2，透過化工廠製程及氫化觸媒將之合成為化學品。

(5) 高模數碳纖維：
透過精製瀝青開發高模數碳纖維複合材料與泛用碳纖維，具輕質、高負載、低變形等特性，可應用於動車材料、風機葉片與航太設備等高強度產品。

(6) 聚合技術與乙烯高值材料：
開發乙烯高值衍生物並建立聚合技術，項目包含線性低密度聚乙烯、聚烯烴彈性體、超高分子量聚乙烯及線性 α- 烯烴等。

3. 拓展智慧綠能加油站

因應未來市場趨勢，持續選擇合適站點建置具創能、儲能及用 (智) 能等面向之智慧綠能加油站，並以太陽光電系統、天然氣燃料電池與小型風力發電設備等作為複合電力來源，打造智能、零碳、多元 (油 / 電 / 氫) 之能源供應站。

● 4. 建置電動 (機) 車充換電設施

依據行政院核定「智慧電動機車能源補充設施普及計畫」及工業局分年補助預算編列數，2022 年底前將完成千座電動機車充換電站之建置；另亦將逐步選擇合適加油站站點建置電動車充電設施。

潔能策略

● 1. 建置太陽光電系統

台灣中油自 2010 年起於加油站屋頂設置太陽能發電系統，並配合「一定契約容量以上之電力用戶應設置再生能源設備管理辦法」(俗稱「用電大戶」條款) 積極找尋合適案場，擴大太陽光電系統量能。

● 2. 開發國內地熱能

已於宜蘭仁澤、土場完成地熱井鑽探與潛能測試，預計於土場建置地熱示範發電廠，持續評估東部、大屯山地熱及全國深層行地熱。

● 3. 跨入氫能初級領域

國際氫能應用技術尚屬精進階段，台灣中油將從示範運行階段開始試行，規劃建置移動式示範加氫站，未來則配合政府法規及各產業未來對氫能需求，規劃與建置氫能設施。

湯守立處長
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作者

擔任台灣中油公司企研處處長，迄今已有 5 年以上資歷，負責台灣中油公司策略規劃、績效管理、投資規劃、研究發展及永續規劃等相關業務。

台灣中油淨零轉型具體做法介紹 碳捕捉再利用及封存 (CCUS)

台灣中油股份有限公司
CPC Corporation, Taiwan

碳捕捉、再利用及封存 (Carbon Capture，Utilization and Storage，以下簡稱 CCUS)，係將工廠 (如：發電廠、鋼鐵廠、煉油廠、石化廠與水泥廠等) 所排放的二氧化碳，透過設備捕捉與純化後 (稱為捕捉)，部分可再製為其他產品 (如：轉成化學品、建築材料或食品添加物等，稱為再利用)，或以高壓將二氧化碳注入地表下 (至少 800 公尺深) 的多孔隙儲層中進行永久封存 (稱為封存)。CCUS 為目前減碳效果最好的技術之一，亦被國際能源總署 (International Energy Agency, IEA) 列為實現淨零排放不可或缺之關鍵技術。因應淨零碳排之國際趨勢，行政院國家發展委員會於 2022 年 3 月 30 日提出我國「2050 淨零排放路徑與策略」，亦將推動 CCUS 負碳技術應用列入淨零轉型之十二項關鍵戰略之一。2022 年 4 月 21 日行政院亦通過環保署擬具的「溫室氣體減量及管理法」(下稱溫管法) 修正草案，將送請立法院審議。本次修正後法案名稱為「氣候變遷因應法」，除了徵收碳費專款專用外，也納入 CCUS 條款。

台灣中油為加速 CCUS 業務推動與提升技術研發進度，採取如下具體作法：

設立專責小組

2021 年年初成立 CCUS 工作小組，整合煉製、石化與探採等部門之專業與資源，共同推動 CCUS 業務與從事技術研發，大致分工為：煉製研究所、煉製事業部與石化事業部負責碳捕捉與再利用 (CCU)；探採研究所與探採事業部負責碳封存 (CCS)。

整合國內資源，落實技術在地化

CCUS 關鍵技術可分為捕捉、再利用、運輸與封存等面向，將透過合作、委託研究或策略聯盟方式進行關鍵技術開發與試驗場域設立，發揮彼此的專長以提升研發效率，如與中鋼合作進行鋼化聯產、與工研院合作發展碳封存監測技術等。

汲取國際商業化 CCUS 計畫實務經驗 適時引進必要技術

目前國際上營運中的商業化 CCUS 計畫計有 27 個，其中，碳捕捉來源包括發電廠、水泥廠、鋼鐵廠、氫氣製造廠、石化廠、肥料廠與天然氣處理廠等；封存的類型則可分為鹽水層與強化採油 (Enhanced Oil Recovery, EOR) 等二類，惟台灣並無適合進行 EOR 之油田，目前目標以發展鹽水層封存為主。

為參考國際相關場域設置與營運之實務經驗，以利國內場域之推動，台灣中油刻正與前述計畫之主導單位或相關技術服務公司交流，洽詢可能的合作機會， 如 與 ExxonMobil、INPEX、TotalEnergies、Schlumberger 等公司舉辦交流會議、洽談合作意向及簽訂意向書等，以掌握技術發展動態與導入必要技術，縮短研發時程。

進行公眾宣導與民眾溝通

依據國外大型碳封存計畫之經驗，民眾接受度係影響計畫成敗的關鍵因素之一，民眾抗爭與反對造成部分計畫之延宕或停止，此亦為台灣中油過往碳封存先導計畫中止之主因，儘早布局與調查，以瞭解一般社會大眾對此技術之認知與疑慮，有其必要性。台灣中油規劃與地方政府、大專院校、研究機構及環保團體合作，透過民眾意向調查，以瞭解其對於 CCUS 之基本認知、接受度及疑慮，並據此研擬適當的宣導素材，以傳遞正確碳封存知識，並作為後續公眾溝通策略和參與方案研擬之依據。

積極參與 CCS 碳捕存跨部會試驗計畫 協助政府完善法規

鑑於國內目前尚缺乏碳封存相關法規，欲投入之業者無所依循，我國政府規劃透過碳捕存跨部會試驗計畫建立本土 CCS 試驗實證場域，以研究計畫先行排除相關法規限制，驗證封存安全性，取得監測數據，作為未來「氣候變遷因應法」子法修訂依據。台灣中油將

配合政府規劃，參與 CCS 碳捕存跨部會試驗計畫，除藉此發展 CCS 關鍵技術外，亦將提供所取得的各項數據協助政府完善相關法規。

擬定時程

● 碳捕捉及再利用

規劃於 2025 年前完成碳捕捉與轉化試驗系統建置，進行技術驗證、觸媒開發及製程最適化研究；進行 CCUS 商業化製程評估。初期規劃在 2030 年前建置每年 100 萬噸的碳捕捉工場 (Carbon Capture)，其中碳再利用 (Utilization) 為每年 25 萬噸、碳封存 (Storage) 為每年 75 萬噸註。

● 碳封存

除積極參與 CCS 碳捕存跨部會試驗計畫外，目前規劃於 2024 年前完成台灣西部碳封存場址調查，並根據調查結果進行建立碳封存先導試驗場設計、規劃與施工，初期規劃於 2030 年完成每年 75 萬噸碳封存場址建置註，並配合公司減碳需求及發展碳封存技術服務，逐步提升碳封存場量能。

註：碳捕捉再利用及封存目標將視實際發展狀況滾動式調整。

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王志文與黃乙倫擔任台灣中油公司探採研究所「二氧化碳封存技術研究」計畫主持人，並在公司氣候變遷因應小組下設 CCUS 組進行業務整合，推動 CCUS 成為邁向 2050 淨零技術之一。

台灣中油氫能推動規劃與成果

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蔡英文總統於 2016 年 3 月「氫能城市論壇」中公開指出，氫能將是台灣未來能源轉型，建立永續能源系統及實現非核家園的戰略選項之一。政府 2022 年 3 月 30 日正式公布之「臺灣 2050 淨零排放路徑及策略總說明」中提及，2050 年淨零排放初步藍圖中總電力配比，再生能源占比達 60~70%，並搭配 9~12% 的氫能發電，同時配合國內氫能供需情形 (來源、應用場域)，規劃建設氫能輸儲基礎設施 (接收站、儲槽、管線)，並制定國內相關法規、標準，完善氫能管理制度。

在此之前，經濟部於 2021 年即已提出「台灣中油公司應將轉型為氫能供應商，初期以灰氫為主，待技術成熟、法令完善、市場確立後，將逐步往藍氫甚至綠氫為目標」，因此，台灣中油將肩負起國內氫能供應者之角色，提供安全、可靠的氫氣為使命，也將進一步布局於氫能之應用開發，並整合國內相關氫能廠商之研發能量，構築國內技術自主的氫能產業鏈。

台灣中油參考國際技術發展及因應我國政策情況，規劃三階段的氫能發展策略：第一階段為「建立技術、示範先行」，進行示範加氫站實證計畫以確立氫能市場發展可行性等技術建立工作；第二階段為「配合應用、建立商模」，台灣中油將朝向結合碳捕捉、封存及再利用技術之氫氣來源開發，藉由回收因製造氫氣所產生之二氧化碳，供應低碳排放之「藍氫」燃料，並配合市場需求，逐步提升氫氣供應能力及建立商業模式；第三階段為「氫能接收、氫淨家園」，台灣中油將投入液態氫接收站可行性評估及建置，並由再生能源豐沛之國家進口綠氫燃料，協助我國邁向「氫淨家園」。台灣中油第一階段氫能推動規劃與成果，有關加氫站建置與分散式燃料電池發電系統之說明如下：

加氫站建置

「臺灣 2050 淨零排放路徑及策略總說明」提及氫能在無碳燃料運輸中具有潛力，因為氫燃料電池車具備行駛時不排放二氧化碳，且補給氫燃料速度與汽柴油車相較具有相當優勢。但全面普及氫燃料電池車之先決條件在於加氫站的廣泛設立，即加氫站係實現氫燃料電池車商業化的重要基礎設施。台灣中油為國營事業，配合國家政策將投入加氫站實際示範，此亦為台灣中油業務轉型的重要方向。

有關加氫站建置規劃 (如圖 1)，將分成加氫站建置評估、加氫站設備採購與建置、示範運行計畫實施與效益評估等三階段，規劃導入 H35/H70 可移動式加氫站技術，可提供氫能巴士 (350bar) 與小型車 (700bar) 加氫使用。

初步進行加氫站設置地點評估與國際加氫站資料收集，透過國際已制定之加氫站標準與加氫協定，引進符合國際標準之加氫站設備，配合國內氫能發展之需求，進行示範計畫之推廣，並透過計畫之執行累積加氫站設置與維運經驗。台灣中油亦將規劃利用現有加油站通路優勢，逐步將加油站轉型成可同時供應氫氣之能源供應站，提供消費者安全、可靠的供氫環境。

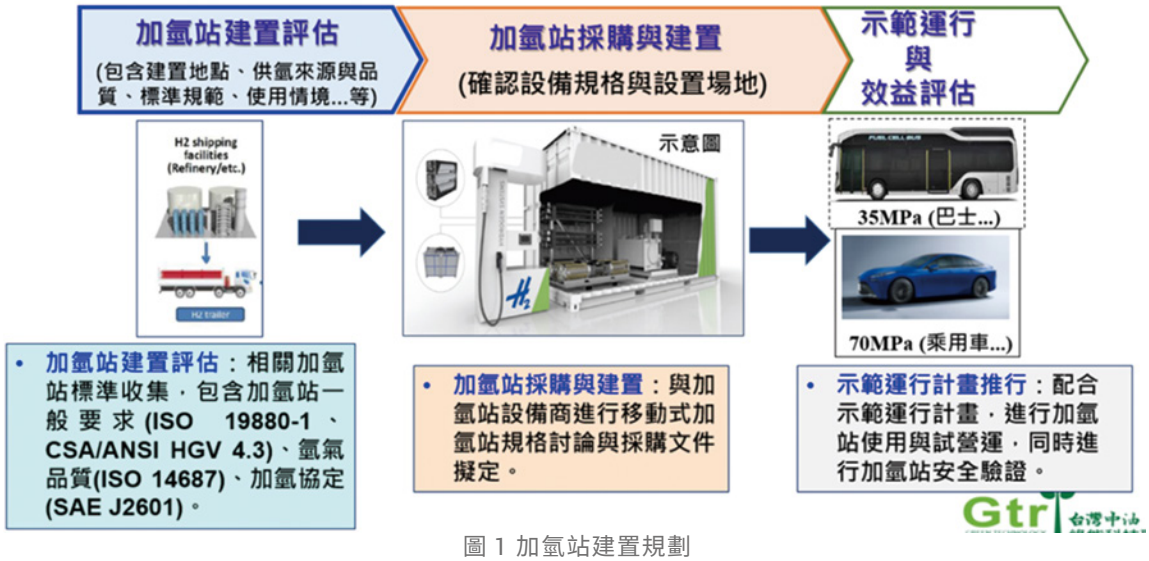

圖 1 加氫站建置規劃

分散式燃料電池發電系統

台灣中油自 2016 年起著手研究分散式燃料電池發電系統 (如圖 2)，基於過去在天然氣重組器關鍵元件有部分成果與開發經驗，透過觸媒篩選、反應器設計、反應參數最適化與控制、系統熱管理等，開發出適用於 5 kW 級固態氧化物燃料電池的天然氣重組器，並搭配國內研究單位進行合作開發，同時建置天然氣管道氣與硫份分析檢測技術，以進行發電系統長期運轉測試。

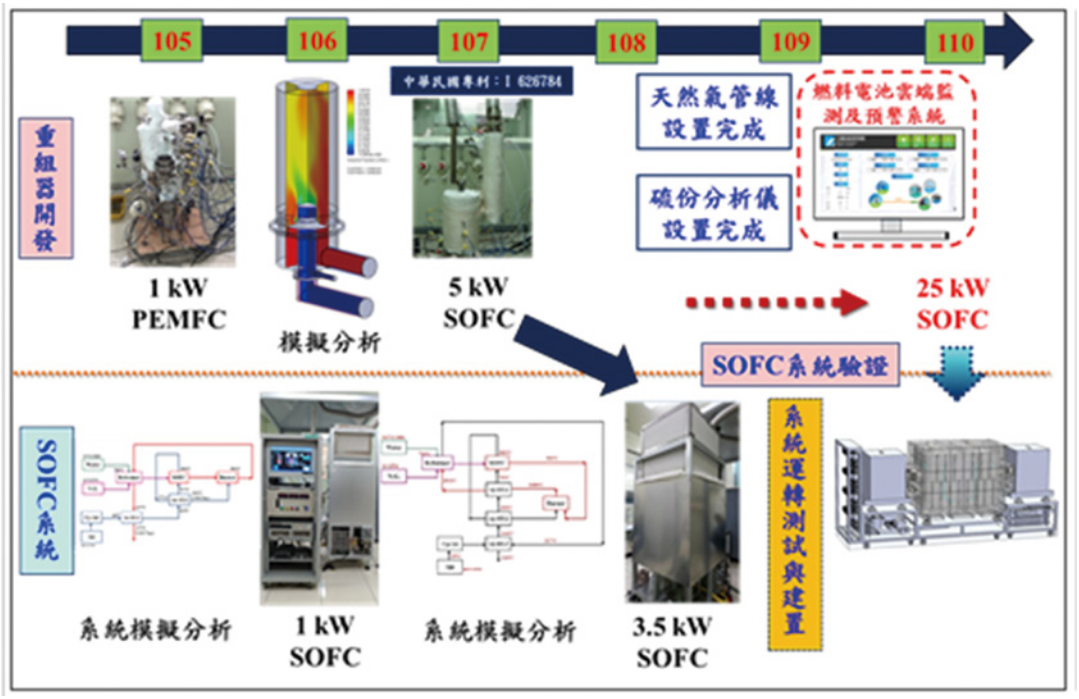

圖 2 台灣中油燃料電池發電系統研發歷程

自 2019 年逐年導入燃料電池發電系統實證計畫，包含於台南前鋒路智慧綠能加油站設置 2 台日本 Panasonic 低溫型燃料電池系統 (0.7 kW)，並與其能源管理系統 (EMS) 整合應用驗證；另外也與國內研究單位合作，進行 5 kW~25kW「固態氧化物燃料電池」 (SOFC) 發電系統實證計畫。近期則投入燃料電池監測預警系統與大數據資料庫之建置；中長期規劃目標則是與合作單位或廠商共同開發出一套 SOFC 商業原型機，導入遠端監控、大數據資料庫、AI 分析等技術，建立 SOFC 系統之維運模式，進而帶動國內分散式氫能發電之產業發展。

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氫能技術發展演進

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全球如能進一步提升再生能源使用比例，將有助於淨零排放。常見的再生能源利用方式，是將可循環再使用的自然能量 (如陽光、風等) 透過發電設備將能量轉換為電能，將再生能源轉換為電能後，大部分是以即發即用的方式，使用所生產的電能，原因是再生能源不穩定且電力儲存不易，因此再生能源轉換及儲存應用是未來發展的重要課題。

目前全球氫氣約 55% 用於生產氨氣，約 25% 用於原油煉製，約 10% 用於生產甲醇，均屬於煉油及其他工業應用範疇，尚未廣泛應用於能源領域。氫氣可作為再生能源餘電的能源載體，並可有效被轉換為電能與動能，已逐漸被應用在交通、工業及各種領域。氫能應用的範圍廣泛，能作為燃料電池的燃料來源，也能直接運用於工業部門或交通運輸的動力設備燃料，導入氫燃料電池車可減少傳統車輛對於環境的污染，也是國內發展氫能應用的方案之一。

氫能與燃料電池應用已逐漸進入早期市場，但仍有生產、輸儲、轉換、安全及成本等問題待克服與改進，有關氫能各項技術關鍵議題發展概況說明如下：

產氫技術

目前氫氣來源 95% 以上以煤炭、天然氣或石油為原料生產，其中以天然氣蒸氣重組技術生產氫氣占一半以上，其成本主要視天然氣價格而定。重組技術並不局限於使用天然氣，富含有氫元素的化合物都可以用重組技術生產氫氣；另外，約有 4% 則是透過電解製氫，施加直流電把水電解成氫氣和氧氣，不同類型的電解槽可以按電解質和電荷載體的不同，分成鹼性電解法 (AEL)、質子交換膜電解法 (PEM) 及固體氧化物電解法 (SOEC) 等，惟成本需再進一步降低以符合效益。

氫氣的輸儲

氫燃料的輸送主要有三種方式：高壓氣瓶、液化罐輸送及管道輸送。氫氣的運輸方式選擇，需考量固定成本與變動成本，目前國內主要以壓縮氫氣瓶方式運輸，成本低但運輸容量小，變動成本相對較高；反之，以管道輸送氫氣，投資固定成本高，但也降低了變動成本。

氫能的普及應用，需依賴完善的氫燃料供需基礎設施，來保障氫能的高效運用。以交通運輸而言，加氫站是燃料電池車燃料供應鏈重要的一環，加氫站的普及是滿足消費者跨入氫能利用的先決條件，目前加氫站燃料供應以兩種方式提供，由產氫工廠運輸壓縮氫氣到加氫站供應，或是由加氫站進行小規模重組天然氣產氫。不論氫燃料使用目的為何，運輸氫氣應考量氫氣的需求量及運輸的距離，才能評估利用何種方式運輸氫燃料，以符合經濟效益。

氫燃料電池

氫燃料電池是透過氫氣為燃料與氧化劑反應產生電能，依據電解質和電荷載體的種類不同分為幾種類型：鹼性燃料電池 (AFC)、質子交換膜燃料電池 (PEMFC)、磷酸型燃料電池 (PAFC) 及固態氧化物燃料電池 (SOFC) 等。其中，質子交換膜燃料電池因操作溫度低 (約 80°C) 且效率高，適合做為車輛動力來源；固體氧化物燃料電池操作溫度高 (可達 600°C)，可適用於熱電共生系統。燃料電池的選用須依使用環境條件而定，氫燃料電池雖然高效能且環保，但成本高是目前一大課題，未來若可提高效能及配合氫能基礎設施提升，將有助於燃料電池之應用。

台灣氫能相關廠商多屬中小企業 (如表 1)，但技術能量早已獲得國際肯定，如中興電工的燃料電池備用系統 (質子交換膜燃料電池，PEMFC) 已輸出至南非、印度與東南亞等國家；保來得、高力、康舒、宏進等則是國際大廠 Bloom Energy 燃料電池系統供應商 (固態氧化物燃料電池：SOFC) 最重要的組件供應鏈，年產值達數十億台幣。

在 2050 淨零排放架構下，氫能應用是許多國家選擇能源轉型的方式之一，而氫能來源中除了工業餘氫的再利用，綠氫的應用才是能達到減碳目標的主要方式。利用再生能源發電雖可作為環境及能源的解決方案，但再生能源具間歇性，無法提供穩定且可靠的電力來源，藉由將再生能源多餘電力轉化為氫氣儲存，如透過燃料電池轉化為電，或是氫氣直接燃燒利用，可進一步確保能源供應的穩定性；發展低成本且高效率的能源轉換輸儲技術，將是氫能與再生能源結合發展的關鍵。

原材料 (上游)	電池組件 (中游)	系統應用 (下游)		周邊產品	
雙極板	電池組	系統		氫氣供應	系統周邊零組件
亞太	工研院	工研院	高力熱處理	三福氣體	高力熱處理
恩良	中科院	台電	恆昌精密	聯華氣體	康舒
順德	核研所	光騰光電	熠飛綠能	亞東氣體	保來得
禾新	光騰光電	亞太	安華機電	台灣中油	亞太
鼎旭	博研	博研	億鴻系統	甲醇供應	宏進
碳布、碳紙	鼎佳	核研所	協同能源	伊默克	台達電
碳能科技	中興電工	美菲德	碩禾	李長榮公司	漢鐘精機
觸媒	亞太	鼎佳	車測中心	甲醇燃料罐	光洋應用
碧氫科技	新力	中興電工	富堡能源	奇鋐	元寧
重組器	繼茂	光陽	聯合再生	儲氫合金罐	
工研院	順德	群翌	恩柏科技	漢氫科技	
碧氫科技	九豪	新力能源	聯盛數位	博研	
高力熱處理	璞真能源	亞洲氫能		亞太	
中興電工	膜電極組	錫力科技		旭陽科技	
俊鼎	揚志	漢氫科技			
臺禹科機	光騰光電	加百裕			
信通	亞太	能碩			
	律勝科技				

表 1 台灣氫能與燃料電池相關廠商

氫能技術運用情形

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氫氣 (Hydrogen)，被廣泛運用於石油化學、石油煉製、玻璃、食品及半導體等工業，另外氫也能做為燃料電池的燃料來發電或交通運輸工具的能量來源。

石油煉製工業

由於原油含有硫化物，會對製程中的觸媒造成毒害；所生產的油料，會受制於環保法規的要求，限制其硫含量，避免燃燒時產生硫氧化物，導致酸雨破壞環境，故煉油工業常會加入氫氣來去除原油中的硫份，這也是目前氫氣在工業上作為去化製程的極大化利用。

加氫脫硫，是一種廣泛用於脫去天然氣和石油煉製產品 (如汽油、噴氣燃料、煤油、柴油和燃料油) 中硫的催化技術。油料中的硫化物主要有硫化氫 (H2S)、硫醇 (RSH)、有機硫化物 (RSSR) 及環狀硫化物 (Thiophene、poly-cyclic thiophene) 等硫化物，油品沸點低於 430 °F者硫化物以硫醇較多，沸點愈高者環狀硫化物也愈多，這些硫化物存在於油料中會造成環保及煉製設備之腐蝕等問題，需利用加氫脫硫製程脫除，煉油廠之加氫脫硫裝置有：

● 1. 輕油加氫脫硫

降低硫含量至 1 ppm 以下，可作為重組工場進料，生產重組油。

● 2. 輕油裂解汽油加氫脫硫

降低硫含量至 1 ppm 以下，可作為芳香烴萃取工場進料，以生產苯、甲苯、二甲苯。

● 3. 柴油 / 製氣油加氫脫硫

降低硫含量至 50 ppm 以下，以生產高級柴油。

● 4. 真空製氣油加氫脫硫

降低硫含量至 0.3% 以下，可作為媒裂工場進料，以生產觸媒裂解汽油。

● 5. 重油脫硫

降低硫含量至 0.5% 以下，除了可作為低硫燃料油外；另可作為媒裂工場進料，以生產觸媒裂解汽油。

加氫裂解是在高壓和催化劑存在下，通過添加氫氣將石油中的烴分子分解成更簡單的分子 (如汽油或煤油) 的過程。該過程使用氫氣來提高裂解分子中的氫碳比，並獲得更廣泛的最終產品。

石油化學工業

● 1. 氨

可由哈柏法合成 (Haber-Bosch process)，所需之合成氣組成為 N2 ： H2 ＝ 1 ： 3，在溫度約 450 °C及壓力下 250 bar，混合氣通過活化之氧化鐵觸媒產製氨，反應率甚低，約為 10%，因此需大量回收及再利用未反應之合成氣。氨可以用來生產肥料、氨水、尿素、三聚氰胺、尿素酯、硝酸等化學品。

● 2. 甲醇

一氧化碳與氫氣在 5-10 MPa(50-100 atm) 和 250 °C 的條件下，經催化劑反應，可催化一氧化碳與氫氣產生甲醇。甲醇可以用來生產甲醛、乙酸、甲酸甲酯、乙二醇、MTO 及 MTP 等化學品。

玻璃工業

氫氣和氮氣的混合物用於防止製造玻璃過程中的缺陷和氧化。

食品工業

氫氣可將不飽和脂肪氫化成飽和脂肪，提升油脂的穩定性。

半導體工業

● 1. 氫氣作為一種高效的還原劑和蝕刻劑，可用於製造半導體、發光二極體、顯示器、光伏部件等其他電子產品。

● 2. 退火 (Annealing)：

矽晶圓製備需加熱超過 1,000° C，以利晶格重組或退

火，氫氣可使熱能均勻加熱矽棒，以利矽棒晶格重組並移除氧元素。

- **3. 磊晶 (Epitaxy)：**

氫氣用於處理緩衝層表面，以避免緩衝層受侵蝕，並可清除緩衝層表面的雜質，以利磊晶層的形成。

- **4. 沉積 (Decomposition)：**

氫可以直接滲入薄膜中，以降低結晶度，使該層絕緣性質提升。

- **5. 穩定 (Stabilizing)：**

添加氫氣可以延長重要電子化學品的保質期，例如乙硼烷 (B2H6) 和二鍺烷 (Ge2H6)，否則它們會緩慢分解。

- **6. 光刻 (lithography)：**

光刻是使用光將半導體芯片的圖案從稱為光罩的母版轉移到矽晶片的過程。在極紫外線 (EUV) 生產過程中，錫滴被雷射激發出紫外線，導致光收集器中不必要的錫屑沉積，需要定期清潔腔室，使用大量氫氣與沉積的錫反應形成氫化錫 (SnH4)，再利用真空泵去除。

氫燃料電池

氫燃料電池是以氫氣和氧氣做為進料，產物為水及熱，不會排放二氧化碳造成溫室效應，對環境造成的負擔較低。氫做為燃料，在陽極氧化，氧氣做為還原劑，在陰極進行還原反應，電子由陽極傳至陰極產生直流電，形成完整的電路，所產生的電力可併入電網或供家庭用戶使用。交通工具亦可搭載氫燃料電池做為能量來源，來驅動交通工具移動。

氫能技術研發願景與限制

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近年來，因應並解決氣候變遷問題成為全球共識，2021 年第 26 屆聯合國氣候變化大會 (COP 26) 召開的首要任務除了討論如何實現淨零排放目標，也高度重視能源轉型，其中氫能源可推動再生能源的加速部署與電力系統靈活性，同時扮演在用能端實現綠色低碳轉型的重要載體。目前已有 20 多個國家發布或制定氫能戰略，透過氫能源，也成為台灣 2050 年淨零排放路徑的手段之一。依據氫能源委員會在 2020 年 1 月發布的資料，隨著可再生能源和氫能源成本的下降，到 2030 年廣泛的氫能源應用將具有競爭力。

目前世界各國在氫能發展上皆是以國家的高度來擬定出整體戰略規劃。台灣環境又與日本較為相似，皆為島國，土地與天然資源有限，無法像歐洲可以發展充裕的再生能源；台灣如欲發展氫能經濟，應可參考日本的發展經驗與策略規劃，以發展碳捕捉技術之化石能源產氫 (藍氫) 為優先，長期目標則為零碳排之綠氫，同時須兼顧氫氣生產成本、技術成熟度，以利於產業之推動。以下分別就氫氣生產、輸儲與應用之研發願景與限制加以說明。

氫氣生產技術

目前主流的產氫方式是天然氣蒸汽重組法 (SMR)，但因採用化石燃料的天然氣為原料，製程中也會產生二氧化碳；為降低碳排放可以搭配使用碳捕獲技術捕捉產生的二氧化碳而不排放到大氣中，因此蒸汽重組法搭配碳捕獲技術產出的氫氣被稱為「藍氫」，為可投入研發並擴大生產之技術。然而目前最大的瓶頸是捕捉後之二氧化碳該如何封存，台灣是否有適合之封存場域還須進一步評估與驗證。

利用再生能源電力並發展水電解產氫技術已被歐盟視為未來氫能戰略的發展主軸，產生的氫氣又稱為「綠氫」。水電解方法主要包括鹼性電解法、質子交換膜電解法及固態氧化物電解法等，目前商業化主軸為鹼性電解法，但其轉換效率低 (65-82%)；而固態氧化物電解法則是近期極受關注的產氫技術，主要是轉換效率最高 (85-90%)，且固態氧化物電解設備逐漸進入產業成長期，設備成本預期可大幅下降。然而綠氫生產成本要下降必須使用過剩的綠電才具經濟效益，短期內台灣再生能源占比仍不高，須等到大量的離岸風機建置完備，以及其他再生能源 (地熱、海洋能等) 的投入，才有機會創造在地並具經濟效益之自產綠氫。

氫氣輸儲技術

氫能供給體系最大的瓶頸是儲存與運輸，其中又以提高氫氣長途輸送之效率與安全性為開發重點。目前高壓氫氣 (>700bar) 應用最為廣泛且技術成熟度最高，已實際應用於氫能載具與加氫站，但仍存在運輸效率低與安全性的疑慮；而進口液態氫氣則須在極低溫下 (零下 253°C) 才能達成，技術門檻高，仍屬研發階段，目前僅有日本川崎重工發展液態氫氣供應鏈技術 (HySTRA)，並在神戶港建置液態氫氣接收示範站，2022 年初也完成首次澳洲與日本兩地長途海上運輸實證。台灣能源供應體系與日本相近，待液態氫氣運輸等技術商業化後，將可規劃設置大型氫氣進口接收站。然而未來仍須與民眾對話溝通，以克服進行接收站建置及長途陸上氫氣管線建置等評估時可能遭遇的居民抗爭限制。

氫氣應用

● 1. 發電應用

氫氣使用可透過氫氣或天然氣摻氫發電，也可透過燃料電池進行高效率區域發電，前者台電公司已規劃相關驗證計畫進行測試；後者已有國內廠商投入低溫質子交換膜燃料電池 (PEMFC) 發電系統開發，PEMFC 具有快速啟動的特性，近來多以移動型載具 (例如汽車、巴士、無人機) 為主要應用市場，而在定置型發電應用上則受限於發電效率較低，故僅以中小型家用熱電共生系統與偏遠地區的備用電力為其主要市場。台灣中油則是投入固態氧化物燃料電池 (SOFC) 發電系統技術開發，SOFC 擁有高發電效率、料源多元、可直接使用天然氣的優點，較適合定置型發電應用，因此在中大型的產業用發電裝置或小型的家用熱電共生裝置方面，都有穩定的成長。

● 2. 運輸應用

目前氫能交通載具主要在乘用車與大型及重型車領域，其中乘用車市場相較於電動車，目前尚無明顯優勢，而在商用大型及重型車市場 (如巴士、物流車、卡車) 仍有機會。然台灣尚無完整之氫能法規與標準，氫能載具上路與加氫站建置均為短期須克服的項目。目前台灣中油已積極投入可移動式加氫站建置規劃，並尋求合作單位進行氫能載具示範計畫之推廣，期能加速國內氫能交通載具之應用發展。

● 3. 工業應用

除了滿足原有工業氫氣使用需求，許多新穎淨零碳排技術也被導入到工業技術開發，例如 : 鋼鐵業以氫氣煉鋼、碳捕捉及再利用 (CCU) 也需要導入氫氣產製合成燃料或化學品等，相關工業應用之氫能技術也正蓬勃發展中。

台灣約二十年前即已啟動氫能相關研發，目前仍有部分廠商持續經營中，但尚未大規模產業化，主要係受限於缺少國家氫能政策的支持，以及民眾對氫能使用的接受性。2022 年 3 月公布之我國「2050 淨零排放路徑」已將氫能納入重要減碳策略之一，並將訂定氫能管理專法，同時也將營造氫能應用情境，向社會大眾說明與溝通，再加上產、官、學、研投入資源開發氫能產業鏈關鍵技術，將有助於台灣氫能產業的發展。目前台灣中油已在台南前鋒路加油站導入分散式燃料電池發電系統，並成為環教場所，推廣綠能與氫能之公民教育；未來將完成可移動式加氫站建置及推動氫能載具示範計畫，由國營事業以身作則，以大帶小的合作模式，加速國內氫能技術與產業之發展茁壯。

下一個 20 年 - 港口物流的轉型與碳中和 台北港智慧車輛產業園區

東立物流股份有限公司 Tonglit Logistics Co., Ltd.

東立身為物流業者，有榮幸與眾多優秀的國際性企業合作，藉以在朝向碳中和、淨零碳排的發展上，能夠跟得上世界的腳步，看得更遠；對於未來的路徑，有更清晰的思維及清楚的目標規劃。

東立物流主要在臺北港，進行車輛進出口的相關物流服務。自 2002 年成立，2004 年開始正式營運的近 20 年里程中，看到國內的車輛銷售使用趨勢，進口車從 2004 年的 13% 成長到 2021 年的 48.9%，這些商品車輛所衍生出的物流活動，也隨之活躍。但物流活動所產生的碳排放量，卻也是這些經濟活動下必然的產物。

無論是因應公約等法律規章的強制性要求，還是各經濟體的互相要求牽制，甚至是企業永續意識的覺醒，整個供應鏈都紛紛對減碳有相關作為。製造商生產低碳排的商品：透過東立進口的純電車相較於其他車輛的占比，已經從 2011 年的 0.1% 成長到 2021 年的 3.7%。2022 年，預估經由東立服務的電動車將會有 14,000 台，佔預估年處理量 207,000 台車的 6.8%，倍增的成長速度更顯示各品牌紛紛加快腳步要跟上 2050 年達到淨零碳排的目標，預估 2025 年後就會達到 10 倍的成長，在此之後，電動車或新能源車輛勢必成為世界的主流。

然而不只是製造商，物流活動中最重要的運載工具：搬運機具、卡車、船舶等都朝向以綠能為動力的導向，積極嘗試各類動能來源，包括使用氫和氨作為船隻及運輸工具的能源，並積極發展這些新能源的運輸載體。同時，許多國家也朝向綠色港口發展，包括設置碼頭岸電，使用電動機具等硬體設施。身為在港口的第一線成員，供應鏈中重要的物流環節，東立物流當然也要承接起延續綠色供應鏈的使命，因此規劃中的「智慧車輛產業 & 跨境物流園區」便是在這樣的背景下蘊育著。

「Go Green & Go Smart」是園區未來 20 年的願景策略，配合政府六大戰略目標的綠能與再生能源策略，園區以綠色建築為基礎，並發展綠能發電場域；建立電動化及智慧化的智慧車輛物流平台，打造亞太區域電商與智慧物流域區域運籌樞紐。

「Go Green」要打造 100% 的碳中和永續園區，利用太陽能及風機發電，以綠電供給園區內的船舶停靠、基礎設施、電動載具智慧車輛接駁行駛和商品電動車輛充電需求。更希望界接業界在氫能源發展的技術，搭配臺北港周遭既有可能為發展氫能的軟硬體等設施及環境資源，協助及促成臺北港區成為氫能示範港口。

「Go Smart」在東立物流汽車物流及港口物流專業穩健的基礎下，發展並統合園區內所有新能源活動，以全方位智慧行控中心及綠能管理系統，掌握園區內能源的生成與循環使用。「汽車物流」搭配車輛的演進將逐漸以電動車整備為主，車用電池管理、充放電系統管理將是必要附加服務，搭配自駕應用使物流作業更自動更智慧化，亦能解決生產力人口逐漸減少，面臨缺工的問題。「港口物流」要以綠色作業為基礎，除綠色建築外，物流商的自動化與智慧化是標準配備，無論是在園區內甚至是運往區外的貨物，目標都以電動運載工具或是 FCV(燃料電池車，fuel cell vehicle) 來避免燃油運具所產生的碳排放。

以綠色物流物流為宗旨，以太陽能、風能發電為基礎，並逐漸導入潔淨能源氫能；搭配儲能及其應用，使園區真的做到「Go Green & Go Smart」。除了自身企業永續外，也支持客戶發展永續為目標，期許為地球盡一份心力。

東立物流計畫於臺北港打造一座 100% 碳中和永續園區

第四章
淨零碳排－眾志成城

如何達到淨零碳排

自第 26 屆聯合國氣候變化大會（簡稱：COP26）各國決議加強檢視階段性減碳目標，來自政府、投資人等各方的期待與壓力，加速企業意識到淨零轉型的迫切性與重要性。然而，根據 2021 年天下雜誌進行的「台灣企業氣候行動大調查」，發現超過 6 成的受訪企業並未定期揭露氣候相關資訊，甚至有高過 5 成的企業沒有進行溫室氣體盤查，並不了解自身營運的排放量，也不清楚如何減量以及達到淨零排放目標。
面對全球淨零大浪來襲，企業亟需制定減量目標，擬定策略與行動方案，確立減碳路徑，落實淨零轉型，將氣候議題與日常營運機制結合。

從企業內部管理策略精進優化著手

若以類比方式更淺白地說明如何達到淨零碳排，採用一般人生活中常見的體重管理做為比喻，是最容易理解的。當我們採行體重管理時，首要任務是了解脂肪、肌肉等成分組成，便於設定合乎自身情況的減重目標；推動淨零碳排也是一樣，企業需要了解公司的溫室氣體排放組成與來源，以設定減量目標。

其次，進行體重管理時，我們也需要了解飲食、運動等生活習慣，擬定管理計畫，逐步調整；相同地，當企業推動淨零碳排時，需要重新盤點內部管理策略，修正過往舊有模式，依據減量目標建立管理方針，推動行動方案。
以下依序說明企業如何優化及精進內部管理策略：導入溫室氣體盤查、設定科學減量目標、建立能源管理系統、推動員工行為改變、實施內部碳有價化。

導入溫室氣體盤查

溫室氣體盤查的目的，是將排放源、排放量加以清點，以確定溫室氣體排放之情形、數量等，協助企業掌握潛在風險，並且將盤查資訊做為設定減碳目標的基礎，協助對症下藥擬定減量措施。

溫室氣體盤查依盤查對象、範疇、用途不同，區分為二類：一是以組織（單一公司、或廠區、或集團）為盤查對象，稱為組織型溫室氣體盤查；另一類是以單一產品為盤查對象，稱為產品碳足跡盤查。

組織型溫室氣體盤查的資訊，是協助企業設定全公司減量目標的主要基礎；而產品碳足跡盤查所獲得的資訊，則協助企業了解特定產品與服務從原料開採到成品出廠（從搖籃到大門）的排放量，進而對單一產品的產製過程擬定減量措施。

類別	組織型溫室氣體盤查	產品碳足跡盤查
特性	■以公司（或廠區、或集團）的視角，檢視營運過程溫室氣體排放量	■以特定單一產品的視角，檢視該產品生命週期的溫室氣體排放量
主要目的	■了解公司營運活動相關的排放源與排放量 ■找出公司營運活動的排放熱點，做為設定全公司減量目標與措施的參考依據	■了解特定產品從原料開採、運輸、製造、分銷等流程的排放量 ■找出特定產品的排放熱點，做為設定特定產品之減碳目標與措施的參考依據

涵蓋範疇	■直接排放：企業所擁有或可控制的排放源（例如：鍋爐、廠內堆高機、冰水主機冷媒、製程使用的溫室氣體等） ■能源間接排放：與企業能源使用相關，但不為企業直接控制的排放源（例如：外購電力、外購蒸汽等） ■其他間接排放：與企業營運相關，但不為企業直接控制的排放源（例如：員工通勤、商務旅行等）	■原料開採：計算製造特定產品所需的原物料在其製造階段所產生的排放量 ■製造階段：計算企業生產特定產品使用能資源所產生的排放量 ■運輸階段：計算特定產品運送出廠至經銷商的運輸過程排放量 ■產品使用階段：計算特定產品在客戶端使用時所產生的排放量 ■產品廢棄階段：計算特定產品在生命終了時廢棄處理所產生的排放量

因組織型溫室氣體盤查涵蓋範圍更為全面，且是企業推動淨零碳排的主要基礎，以下聚焦說明企業導入溫室氣體盤查的九大步驟：

步驟	組織型溫室氣體盤查	產品碳足跡盤查
步驟一	召開跨部門啟始會議	盤查過程涵蓋企業日常營運所有範疇，透過召開跨部門啟始會議，高階主管闡述盤查之目的與承諾，並成立盤查小組，確立各部門對應之負責人，以利後續相關工作順利進行。
步驟二	確立所遵循的盤查規範	依盤查目的，確立所遵循的國際規範（例如：ISO 14064-1:2018）或國內規範（例如：溫室氣體排放量盤查登錄管理辦法）。
步驟三	界定盤查邊界	依據所遵循的盤查規範，確立要納入盤查的事業體、子公司、實體據點等。例如若企業依循金融監督管理委員會之要求進行盤查，則盤查邊界需與財務報表一致。
步驟四	鑑別排放源	檢視盤查邊界內的事業體、子公司、或實體據點，鑑別直接排放源、能源間接排放源、其他間接排放源。
步驟五	收集活動數據	根據排放源所使用的原燃物料或所逸散的溫室氣體，進行使用量、購買量、逸散量的數據收集。
步驟六	選擇排放係數與全球暖化潛勢值	依據排放源、活動數據，選擇相應的排放係數。並依據所遵循的盤查規範，選定合適的全球暖化潛勢值。
步驟七	計算七種溫室氣體的二氧化碳當量	透過活動數據、排放係數計算七種溫室氣體排放量後，以全球暖化潛勢值將各溫室氣體轉換為二氧化碳當量。
步驟八	彙整資訊製作文件化報告	將盤查方法、數據、程序、假設以及估算結果進行綜整記錄，出具溫室氣體排放清冊與溫室氣體盤查報告書。
步驟九	進行第三方查證	依企業自身需求與所遵循的盤查規範，委請第三方查驗機構進行查證，確保盤查資訊的完整性、正確性、一致性。

設定科學減量目標

企業掌握營運相關的溫室氣體排放量之後，參考科學基礎方法，設定溫室氣體減量目標與路徑。所謂的科學基礎方法，是由科學基礎減量目標倡議（science-based target initiative，SBTi）組織所提出，協助企業計算，在依據全球升溫限制在 1.5° C 的情境之下，企業在短、中期（至 2030 年）必須要減少的溫室氣體排放量，以此做為減量目標值，確保企業的減量成果緊扣全球控溫目標。

科學基礎減量目標將溫室氣體減量與全球平均升溫的連結明確化，強化企業行動對全球目標的貢獻。過往實務上企業在設定減量目標時，往往對於如何設定每年的量化指標遭遇困難，源自於企業並不知道每年減量 1 %對全球升溫產生的貢獻程度。SBTi 提供標準化計算方法，協助企業對焦巴黎協定，以升溫 1.5° C 為限值，設定每年減量幅度。

SBTi 所公告的相關指南文件中，明確規範減量目標所涵蓋的範疇必須至少包含直接排放（範疇一）與能源間接排放（範疇二）。若企業的其他間接排放量（範疇三）超過範疇一與範疇二的排放量總和 40% 以上，則必須將範疇三納入減量目標當中。此外，考量各產業之間的差異，SBTi 也針對特定產業制定行業別相關規範，協助企業在制定目標時納入產業特性。經過 SBTi 認證之後，企業的減量目標將於 SBTi 網站揭露，向全球宣告企業的減碳承諾。由於通過認證的企業都採用具一致的方法學，因此各減量目標之間具備可比性與可分析性，也有助於利害關係人追蹤減排進展。

建立能源管理系統

盤查溫室氣體排放量、設定減量目標之後，為了達成目標，下一步即是著手調整舊有管理策略，建立減碳行動方案。一般而言，企業的主要溫室氣體排放來源，多數來自直接、間接能源使用，包含電力使用、鍋爐燃料、外購蒸汽等。如何有效地管理能源以減少溫室氣體排放，是企業能否成功達成淨零減排的重要關鍵。

ISO 50001 能源管理系統提供企業一套標準的系統與流程方法，首先了解來自外部挑戰（例如：產業節能目標、溫室氣體排放管制等）及內部議題（例如：企業永續性考量、節能目標等），確立能源管理的目標及範疇。其次，針對能源議題建立政策與方針，並確立由哪些單位或部門主責管理。若企業內部由多個部門負責能源議題，則需要釐清各單位的角色、權責、和權限，並且明確地文件化，確認相關單位均了解其所肩負的責任。進一步由權責單位領導，開始建立能源基線、蒐集能源相關數據資料、設定能源管理量化目標、建立績效指標，並制定績效評估的監督、量測、內部稽核系統，以及持續改善機制。

能源管理系統協助各部門落實能源管理的工作與職責，並建立監督機制，定期檢視目標達成情形。當企業增進對能源數據的掌握程度，善用數據分析技術，即可找出高耗能設施設備，精準地推動設備汰換或製程改善措施，以有效地減少溫室氣體排放。

企業也可以借助智慧作業系統，導入由軟硬體設備整合而成的能源管理平台（Energy Management System，EMS），透過可視化界面監控能源使用情形，即時發現異常耗能，以自動化控制立即改善。

推動員工行為改變

若企業要成功地推動淨零碳排，更需要將淨零承諾貫穿企業文化，協助內部員工理解並認同淨零轉型對公司日常營運的意涵與影響。唯有員工肯定且支持公司的淨零願景與目標，減排策略與行動方案才可能實質整合於各部門營運當中，也只有在員工認同淨零減排的理念之際，企業內部將產生群策群力之綜效，由員工主動發想創新減排措施與行動，改變原有的慣常做法，加速企業減碳的行動。

企業可以率先透過氣候變遷、淨零減排等相關教育訓練課程，逐步建立員工的環境意識，開始關注氣候變遷相關議題。進一步引領各部門員工腦力激盪，思考在全球淨零趨勢之下，當前所屬產業及企業所提供的產品與服務可以扮演什麼角色，再將範疇縮小至各部門有哪些影響力、可以做出何種改變。

盤點全公司與各部門的影響力與可能採取的減碳措施之後，企業可透過各種機制的設計，例如集點獎勵部門低碳行動、舉辦創新減碳競賽等，促進員工在日常生活與業務層面改變固有行為與思維，讓企業的低碳轉型不再只是「由上而下」的指令布達，而是兼具「由下而上」的共同協作。

實施內部碳有價化

內部碳有價化（或簡稱內部碳定價）是由企業自行對溫室氣體排放量給予明確價格，將排放溫室氣體所產生的外部成本進行內部化，有助企業掌握碳管理的成本，並有利銜接外部碳市場的碳價格。根據不同目的與其當前的減碳進程，企業可自行選擇合適的碳價機制：內部碳費、影子價格、隱含價格。

內部碳費是向每噸溫室氣體排放量設定一個定額價格。各部門試算所排放的溫室氣體排放量後，乘上價格即為需要負擔的費用。所收取的碳費可以為企業內部減碳工作提供專款專用的經費，或是用於獎勵達成減量目標的部門。然而，各部門需繳納的內部碳費恐受限於該部門的功能特性而定，因此如何合理地收取碳費及分配，都需要妥善規劃。

影子價格是以每噸二氧化碳的理論價格為基礎進行計價，實務上以未來氣候相關政策或碳市場發展變化推估企業可能需要為碳排放所支付的成本作為定價參考，是目前多數公司所採取的方式。企業若以影子價格定價，易於連結未來碳相關財務風險，並且預先為外部碳費進行準備。影子價格機制也有助於企業在中長期的投資決策當中考量氣候風險，亦是一種風險管理的措施。

隱含價格是指企業依據過往減少溫室氣體排放所花費的成本，以一噸二氧化碳當量所需要的成本做為內部碳價。由於採用已發生的投資行為進行計算，難以反應實際的碳排放成本，無法為企業風險管理提供前瞻

資訊，也較難在公司內部創造跨部門資金流動機會。因此，雖然隱含價格機制具備容易計算的優點，在實務上較少企業採用此機制。

跨產業 / 企業的技術創新與交流

創新科技是企業減碳的重要關鍵。自工業革命至數位革新，新興技術為人類生活提供各式解方，面對氣候變遷，企業透過積極掌握低碳科技應用與創新研發，並且加速導入商業應用，將氣候風險轉換為商機，扭轉「減碳 = 利益虧損」的錯誤認知，打造「越減碳，越賺錢」的企業體質。

以跨業合作共同開發淨零解決方案，突破企業單打獨鬥面臨資源不足、人才庫過度集中單一技能的限制條件，透過知識與技術共享，不僅可以達到共同減碳的成果，也能開發新的商業機會，打造淨零生態圈。

從產業價值鏈的整合開始推動跨業淨零技術創新與合作模式，有助於企業更有效地推動低碳轉型，並且成果也能實際反映在企業的範疇二、範疇三溫室氣體排放量當中。以企業自身為起點，一方面與上游供應商共同合作研發低碳原料、零組件、淨零能源等，另一方面則與下游客戶攜手開發減少產品與服務在使用、廢棄階段碳排放的商業模式，促成價值鏈的典範轉移，擴大成果與潛力，進一步搶占淨零市場。

與供應商的合作創新

供應商是企業最主要的夥伴，包含原物料生產及相關的運輸物流、能源供應、承攬服務等，若是缺少了這些供應商，企業的營運將遭受嚴重衝擊。如此脣齒相依的關係，也反映在企業的碳排放量上。根據世界經濟論壇出版的《淨零碳排大挑戰：供應鏈的契機》報告，對於食品業而言，透過原料與製程創新、與供應商合作減少毀林可減少約 45% 的排放量；對於電子產業而言，透過與供應商在原料、製程及能源供應的淨零合作，可以達成約 55% 的減量成果。

國際知名輪胎廠商米其林承諾於 2050 年達成所有輪胎產品均是永續輪胎，同時在原料、零件、物流運輸及自身營運達成全面碳中和。為了達成此目標，米其林於 2012 年即開始布局，與法國能源運輸研究單位 IFP Energies nouvelles 及石油化學廠商 Axens 共同合作，在法國能源與環境管理局的支持之下，啟動 Biobutterfly 計畫。

過往輪胎所使用的丁二烯，皆是由石油提煉而來，受限於原料來自於化石燃料，輪胎對於環境的影響一直以來備受討論。Biobutterfly 計畫旨在開發生物質材料（木材、稻稈、玉米、甜菜等）製成合成橡膠，取代原先的石油基原料，目標是讓米其林的輪胎產品全面採用生物質合成橡膠，不僅增加產品的可回收性與永續性，也減少產品原料的碳足跡。

這項 10 年的合作計畫在 2019 年取得重要進展，成功地在生物質材料製成的乙醇當中，提取出合成橡膠重要原料丁二烯。米其林也宣布在 2020 年完成示範生產，每年預計可生產 20 噸至 30 噸的生物質丁二烯，並且在 2021 年取得技術驗證，開始進行商業量產。

除了生物質合成橡膠之外，米其林也與塑膠化學回收廠商 Pyrowave 合作，共同研發如何從廢棄塑膠容器當中提煉再生苯乙烯，用以取代目前輪胎製成的另一項重要原料—苯乙烯。米其林與瑞典輪胎熱解公司 Enviro 共同開發從廢輪胎當中回收碳黑，並將回收的碳黑用於生產新輪胎，藉以減少對於初級原料的使用。米其林透過跨產業的合作，成功開展創新產品。2021 年發布具有 33%-40% 永續原料含量的 MotoETM 產品，並於 2022 年拉高永續原料比例至 40%-46%，成功達成在 2030 年所有產品系列中平均使用 40% 永續原料的中期目標。

與客戶的合作創新

企業提供客戶產品與服務，並不單只是一次性的交易，更多時候我們希望與客戶維持長期緊密的夥伴關係，透過各種溝通與合作，提前發現客戶需求，提供創新服務，協助客戶解決問題。而客戶的問題不僅會發生在使用產品之際，更有可能發生在產品生命終了的廢棄處理階段，若能與客戶共同開發創新解決方案，不僅能夠協助客戶降低成本、減少碳排放，也可能發展出新的低碳商機。

李長榮化工公司為台灣石化原料領域的重要生產者，主要生產塑膠、熱可塑性彈性體、溶劑等，並且供應台灣許多半導體、液晶顯示器企業在清洗製程當中關鍵的異丙醇、丙酮。李長榮化工公司與客戶共同合作，回收電子產業使用過後的異丙醇，將其回收再製，重新製成可以再回到客戶製程使用的同級異丙醇，不僅減少客戶在委外處理廢液時可能因處理廠商程序不當而產生潛在環境衝擊，同時也減少李長榮化工自身在生產異丙醇時的環境影響。

半導體廠商經沖洗製程後留下的異丙醇廢液，含有 90% 的水與 10% 的異丙醇，過往半導體廠商均交由環保公司進行焚化處理，並無任何回收方式。李長榮化工公司發現，焚化處理雖然簡便省事，卻造成不必要的溫室氣體排放與資源浪費。因此主動與客戶推動合作，由李長榮化工公司負責從客戶端載運異丙醇廢液，回到化工公司的製程當中，進行分離過濾，產出純度為 60%-70% 異丙醇，再經過蒸餾純化，成為純度超過 99.9999% 的電子級異丙醇，與一開始提供給客戶的產

品無異，再次回到客戶製程。

透過與客戶的合作，李長榮化工公司成功開發了新的服務，除了減少溫室氣體排放量，更獲得台灣 TCIA 循環經濟貢獻獎，以及半導體客戶所頒發的 Triple R 最佳夥伴獎的肯定。

串聯全價值鏈推動淨零減排

當企業進行溫室氣體盤查與擬定減量策略時，不僅需要清楚自身營運的排放，同時也需要掌握來自上游供應商、運輸物流、下游客戶使用產品時的相關碳排放量，以達成全面減量。但實務操作上，許多企業在釐清上下游廠商的排放量遭遇到困難，除了數據不齊全之外，也可能在計算方式、邊界定義上有著諸多不一致之處，造成企業面對淨零目標依然寸步難行。
為了尋求解決方案，於 2021 年 11 月開始，位在巴西的食品業價值鏈開始進行跨產業合作。由穀物生產商 AMAGGI、業務遍及 117 個國家的食品品牌集團 BRF、巴西最大的鐵路物流服務商 Rumo、生質能源廠商 Raizen、軟體平台服務商 SINAI Technologies 共同發起，成立合作計畫，旨在收集、計算、預測全球食品供應鏈的溫室氣體排放數據，並且相互分享數據資訊，推動產業為減緩氣候變遷採取行動，促成脫碳轉型。

參與合作計畫的企業，將使用軟體平台服務商 SINAI Technologies 的資訊平台，分享從種植、作物生產、交易、運輸物流、畜牧養殖、食品生產、食品配送等從巴西出口到全球的全價值鏈溫室氣體排放數據，彙整到這個數據平台的資料，均經過第三方查證，以確保數據的正確性與完整性。該計畫的目標是，未來這個數據資料庫不僅能夠協助價值鏈夥伴們了解排碳熱點，也可協助購買食品的在地商家找出哪些是低碳產品，成為進貨時的參考依據。

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

前言

歐洲在臺商務協會 (ECCT) 於 2011 年制定低碳倡議行動 (Low Carbon Initiative, LCI)。LCI 的目標，在於針對各種產業，介紹歐盟 (EU) 及全球最佳的低碳方案、政策與規範、提升各界對於永續發展的認知，同時鼓勵各界採用低碳方案，協助台灣減少碳排放量。

背景

● 低碳倡議行動的成立

臺灣 90% 以上的能源需求皆仰賴進口，以石油、煤礦、液化天然氣與核能為主。風力與太陽能發電佔總發電量的比重至 2020 年 5 月僅達 8.06%。2011 年，臺灣政府開始一項遠大的計畫，期望在 2020 年之前將二氧化碳排放量降至 2005 年的水準，並在 2025 年之前將其降至 2000 年的水準。接著，在 2015 年及 2016 年台灣政府陸續制定「溫室氣體減量管理法」及宣示在 2025 年之前再生能源的發電量達到總發電量 20%，2017 年一月通過「電業法」，為台灣邁向低碳環境的行動上加添動能，今 (2022) 年，台灣政府跟進世界各國的腳步，正式宣布「2050 淨零排碳路徑圖」，同時將「溫室氣體減量管理法」改制為「氣候變遷因應法」，以上政策目標若要實現，並達到預期標準，則須在若干領域採取行動。

LCI 將持續在臺推廣低碳解決方案，與政府、企業、學界、非政府組織，與社會大眾共同合作，因應永續性的挑戰，對未來能源費用上漲採取提前因應方案，最終達成臺灣政府所設定的 2050 淨零碳排放目標。

低碳倡議行動 架構圖

架構

低碳倡議行動由 LCI 委員會監督，在 2017 年 LCI 根據台灣政府的 5+2 政策及其會員之核心技術，設立了七項領域：綠色能源、綠色金融、能源效率、綠色交通、智慧城市、智慧製造及循環經濟。接著在 2020 年，針對台灣 2020 年至 2024 的政策方向，LCI 成立了四個工作小組，分別為：「綠色金融、永續經營與企業採購綠電工作小組」、「節能與綠色建築工作小組」、「永續交通及永續物流工作小組」、「永續供應鏈工作小組」，建立在前述七項領域之下。

● 綠色金融、永續經營與企業採購綠電工作小組

此一工作小組的目標是與台灣政府和利益相關者合作，促進台灣推廣環境保護、社會責任以及公司治理 (ESG) 和可持續投資、公平透明的綠電交易。

● 節能與綠色建築工作小組

此一工作小組的目標是通過與政府的高層進行圓桌對談以及與 LCI 會員和合作夥伴組織的活動，推廣台灣在節能和綠色建築的最佳實踐。

● 永續交通及永續物流工作小組

此一工作小組的目標是與台灣政府和利益相關者合作，在台灣推廣替代燃料、電動汽車基礎設施、高效電網和電力調度系統、生態物流。並鼓勵在主要城市開展生態交通和生態物流試點。

● 永續供應鏈工作小組

此一工作小組的目標是與台灣政府和利益相關者合作，促進永續生產和消費。並實地考察台灣在地永續供應鏈的成功案例。

聯繫 LCI

聯絡我們：蘇冬蘭 低碳倡議行動總監
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欲了解更多 LCI 的資訊
請掃描 QRcode

低碳倡議行動 會員

低碳倡議行動得到政府、產業界和學術界的高度認可和支持，與台灣政府及重要企業建立了堅實的夥伴關係。自 2013 年以來，低碳倡議行動的會員公司從 14 個增加到 91 個。2022 年 LCI 會員表列如下（按英文字母順序排列）：

低碳倡議行動 駐台辦事處會員

典範精神 領先國營事業

台灣中油股份有限公司 CPC Corporation, Taiwan

創立與發展歷程

1946 年 6 月 1 日，中油公司創建於上海，原隸屬資源委員會（即今日經濟部國營事業委員會之前身）。

1949 年隨政府播遷來臺，改隸經濟部，總公司設址臺北市。主要業務範圍包括油氣之進口、探勘、開發、煉製、輸儲與銷售，以及石油化學原料之生產供應，業務設施遍布全臺。

2003 年底，為順應世界潮流，配合國際環保趨勢，制定永續經營政策。

2007 年 2 月 9 日董事會通過「中國石油股份有限公司」更名為「台灣中油股份有限公司」。

2016 年 6 月 17 日董事會通過修改公司章程，總公司設籍於高雄市。

中油公司資本額新台幣 1,301 億元，2021 年營業額新台幣 9,089 億元。

永續經營政策

台灣中油公司永續經營政策

- 遵守政府法令，配合國際公約
- 全面清潔生產，維護生態環境
- 資源有效使用，貫徹節水節能
- 重視社會責任，擴大服務範圍
- 建立環境指標，資訊透明公開
- 積極投入研發，開創經營領域

台灣中油公司於 2005 年即成立「永續經營推動委員會」，聚焦永續經營議題的推動與策略規劃及目標設定，並將永續經營行動分成「環境與生態保育」、「社會關懷」、「政策與研發」、「環境會計與資訊」等四大領域。2007 年進一步提升委員會層級，由董事長擔任主任委員親自督導，總經理擔任副主任委員，各副總經理、發言人及五大事業部執行長擔任委員，更於 2008 年開始外聘學者、專家擔任委員。

每年召開三次永續經營推動委員會議，討論前述四大領域之報告及提案，即時掌握社會脈動，推動永續議題並追蹤執行情形。

與利害關係人溝通部分，除了設立全球資訊網、年報等方式外，台灣中油公司自 2007 年即開始發行《永續報告書》，持續就利害關係人關注議題進行說明與揭露，顯示與所有利害關係人進行溝通之決心，並多次獲得外界不同獎項之肯定。未來將以聯合國永續發展目標（SDGs）做為公司永續發展的基準，持續透過「永續經營推動委員會」，聚焦永續經營議題的推動，並藉由社群網絡與永續報告書，揭露永續發展相關資訊，致力創造「環境保護」、「經濟發展」與「社會關懷」三贏局面，與各界攜手打造更美好的未來。

2021 肯定與榮耀

- 連續 21 年蟬聯《讀者文摘》信譽品牌白金獎
- 連續 3 年蟬聯《讀者文摘》信譽品牌潤滑油產品類金獎
- 「2021 年亞洲卓越企業暨永續發展獎」（ACES）榮獲「永續獎 - 亞洲頂級永續倡導公司 (Top Sustainability Advocates in Asia)」及「領導獎 - 個人 - 亞洲傑出領袖獎 (Outstanding Leaders in Asia)」殊榮，為臺灣首位傑出領袖獎獲獎企業
- 「亞洲企業社會責任獎」(AREA) 榮獲「綠色領導獎」及「社會公益發展獎」兩大獎項
- 台灣永續獎 (TCSA) 榮獲得九大獎項肯定，包括「綜合績效獎－台灣 TOP50 永續企業獎」、「企業永續報告類－能源產業白金獎」及七項「卓越案例獎」
- 台灣永續行動獎 (TSAA) 榮獲一金二銀三大獎項，展現國營事業永續發展的最佳模範
- 國家品牌玉山獎榮獲八大獎項，其中「95 無鉛汽油」、「智慧綠能加油站」獲全國首獎肯定

中華紙漿
Chung Hwa Pulp

中華紙漿 - 生物基質纖維材料的創新與傳承

成立於 1968 年，為台灣唯一林、漿、紙一貫式整合的造紙業。同時取得造紙 FSC™、PEFC™ 國際環境認證。設計和製造各種特殊的紙漿和功能性紙材及永續循環材料，包含紙漿、紙板、文化用紙、特殊用紙，並精心研發具高附加價值之終端產品，涵蓋食安、醫療、紡織、3C 等豐富面向，行銷全球 5 大洲。

中華紙漿以更貼近生活之方式引領紙材的新應用，期望開創「垂直整合、綠色環保、技術加值」的造紙業新紀元，持續以「提升材料利用率」、「科技結合傳統」、「產品多元再進化」、「生態復育與教育回饋」等四大面向，做為永續發展的願景。

我們珍惜每一項資源並積極以森林及生質材料邁向「零廢棄、零排放」的循環經濟生活。

Chung Hwa Pulp Corp., the Innovator and Inheritor of Bio-based Cellulosic Materials.

Founded in 1968, CHP is the one and only enterprise in Taiwan's paper industry with the island's most comprehensive, integrated line of forestry, pulp, and paper mills. Our products have been certified by FSCTM and PEFCTM. We are specialized in designing and producing various kinds of pulp, functional papers, and sustainable materials, with the production and sales of pulp, cardboard, printing paper, and specialty papers, as well as value-added products for food safety, health care, textiles, and computer, communication, and consumer electronics.

CHP integrates new applications of paper and pulp into everyday activities, aiming to create a new era of papermaking industry for vertical integration, greenness, and eco-friendliness, continuing to maximize material utilization rate, combine new technology with traditional techniques, diversify product portfolios, rehabilitate the ecosystem, and improve environmental education, etc., to realize our vision of sustainability. We cherish every resource and strive toward the goal of "zero waste and zero emissions" for a circular economy and a sustainable life.

CircuWell

本報告書由中華紙漿 (CHP) 贊助印製
This publication is sponsored by Chung Hwa Pulp Corp. (CHP).

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CircuWell 全紙回收食品容器解決方案
Total Recyclable Food Packaging Solutions

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

台灣中油股份有限公司
CPC Corporation, Taiwan

2050

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