Asia-Pacific
Economic Cooperation

Report on APEC Digital Innovation to Implement SMEs' Low-Carbon Transformation

APEC Small and Medium Enterprise Working Group

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Produced by
Small and Medium Enterprise and Startup Administration
Ministry of Economic Affairs
Email: ischung@sme.gov.tw
Tel: (886) 2 2366 2237 Fax: (886)2 2367 7484

For
Asia-Pacific Economic Cooperation Secretariat
35 Heng Mui Keng Terrace
Singapore 119616
Tel: (65) 68919 600
Fax: (65) 68919 690
Email: info@apec.org
Website: www.apec.org

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Introduction

Introduction

I. Development Trends of Low-Carbon Transformation within the APEC Region

Over the past decade, global focus on carbon reduction and sustainability has grown significantly, with green initiatives and net-zero emission targets gaining prominence on the international stage. The 2021 United Nations Framework Convention on Climate Change (UNFCCC) formalized the goal of achieving net-zero emissions by 2050, prompting many economies to integrate carbon reduction strategies into their development plans. This shift toward sustainability has driven not only policy changes but also the transformation of industrial strategies, particularly in supply chain decarbonization and the adoption of circular economy models. Companies along the supply chain, from large corporations to SMEs, are facing increasing pressure to undertake green transformation.

At the same time, mechanisms like the European Union's Carbon Border Adjustment Mechanism (CBAM) have highlighted the impact of regulatory measures on global trade, increasing the pressure on SMEs to transition toward more sustainable practices. With carbon reduction requirements affecting every stage of the supply chain, the imperative for SMEs to adapt and contribute to the green economy is now more critical than ever.

APEC has taken a leading role in advocating policies and promoting development in the Asia-Pacific region. In 2020, the adoption of the Putrajaya Vision 2040 as well as its implementation guidelines-Aotearoa Plan of Action set the aim for an open, dynamic, resilient, and peaceful Asia-Pacific community. Building on this vision, APEC leaders

endorsed the Bangkok Goals on Bio-Circular-Green (BCG) Economy in 2022. This approach emphasizes inclusivity, empowering MSMEs through ESG (Environmental, Social, and Governance) initiatives, BCG measures, and other strategies to enhance their capabilities. These efforts aim to drive sustainability and foster the development of a green global supply chain.

This year, the 2024 APEC Small and Medium Enterprises Ministerial Meeting Statement reiterates the importance of advancing the implementation of the Bangkok Goals on BCG Economy by building the capabilities of MSMEs in sustainability and inclusion practices. The statement provides guidance for the green and digital transformation of SMEs. Similarly, at the 2024 APEC Energy Ministerial Meeting, the need to enhance investments in sustainable infrastructure development and to promote and take advantage of technological innovation across the entire energy system was emphasized, highlighting the critical role of digital technologies in driving the energy transformation.

Considering the growing global demand for carbon reduction, low-carbon transformation has become a critical issue for MSMEs to participate in global supply chains and promote sustainable development. In 2024, SMEs' sustainable development has garnered significant attention within the APEC forum. For instance, Australia executed the initiative "A Project to Enhance MSMEs' ESG Performance in APEC Economies," which aims at helping policy-makers and key stakeholders assist MSMEs in complying with ESG regulations that are impacting international supply chains as the global economy continues. Initiated in the Policy Partnership on Science, Technology and Innovation (PPSTI), the "Green Synergy Solutions to Net-Zero Emissions Based on Bioenergy Technologies for Resilience and Sustainability" aims to advance net-zero emissions through bioenergy with innovation and entrepreneurship.

Distinct from the above initiatives, Chinese Taipei emphasizes capacities to use innovative digital tools to reduce carbon emission by implementing the "APEC Digital Innovation to Implement SMEs' Low-Carbon Transformation Initiative—Developing

Digital Solution of Low-Carbon Business Models." Through hands-on workshops, this project has enhanced MSMEs' digital and green capabilities, helping them address global net-zero emission trends, and in turn strengthen their green competitiveness.

II. Challenges for APEC Economies to Conduct Low-Carbon Transformation

In recent years, APEC economies have been actively working toward ambitious transformation goals. By 2035, APEC aims to improve energy intensity by 45% compared to 2005 levels, while doubling the share of modern renewable energy in the total energy supply by 2030. The proportion of modern renewable energy has increased by over 50% from 2019 to 2024, demonstrating significant progress in renewable energy adoption.[1] However, the realization of these goals is accompanied by complex energy consumption patterns. In 2021, APEC's total energy supply increased by 5.7%, while renewable energy grew by 7.3%, and the consumption of coal, natural gas, and oil also had significant increases.[2]

As policies gradually align with green energy and low-carbon transformation, MSMEs face considerable challenges due to their limited resources and technical capacities. They are often unable to effectively respond to government policies or supply chain adjustments. Without a fair transition framework or guidance from the government on the path toward green energy and industrial transformation, SMEs will face significant pressure and uncertainty.[3]

While notable advancements have been made in promoting green energy and sustainability goals at the economy and corporate levels, MSMEs still need government support to tackle the following challenges.

❶ Technology and Tools

According to a survey conducted by the SME Climate HUB in 2023, 58% of SMEs reported that the lack of appropriate skills and knowledge is the main reason they cannot effectively take action against climate change. Additionally, 61% of SMEs believe that the most urgent task is to equip themselves with tools for measuring and monitoring emissions to take effective climate action.

❷ Funding

Financial incentives have decisive influence on whether to begin the journey toward a low-carbon transformation for SMEs. Given the circumstance of limited funding, government support, such as providing carbon emission tracking tools and a transparent reporting framework, becomes even more crucial.

❸ Policies and Regulations

Effective promotion of low-carbon transformation is hindered by inconsistent regulatory frameworks and policies across different regions. While some economies have made significant progress in renewable energy policies and corporate transitions, others still face regulatory uncertainty and lack an integral domestic strategy. Coordinating between government departments, private sectors, and international organizations to formulate clear and effective policies that support sustainable energy projects remains a significant challenge.

Addressing these challenges requires coordinated actions across multiple levels, including government support, investments from the private sector, technological innovation, and SMEs' awareness and action.

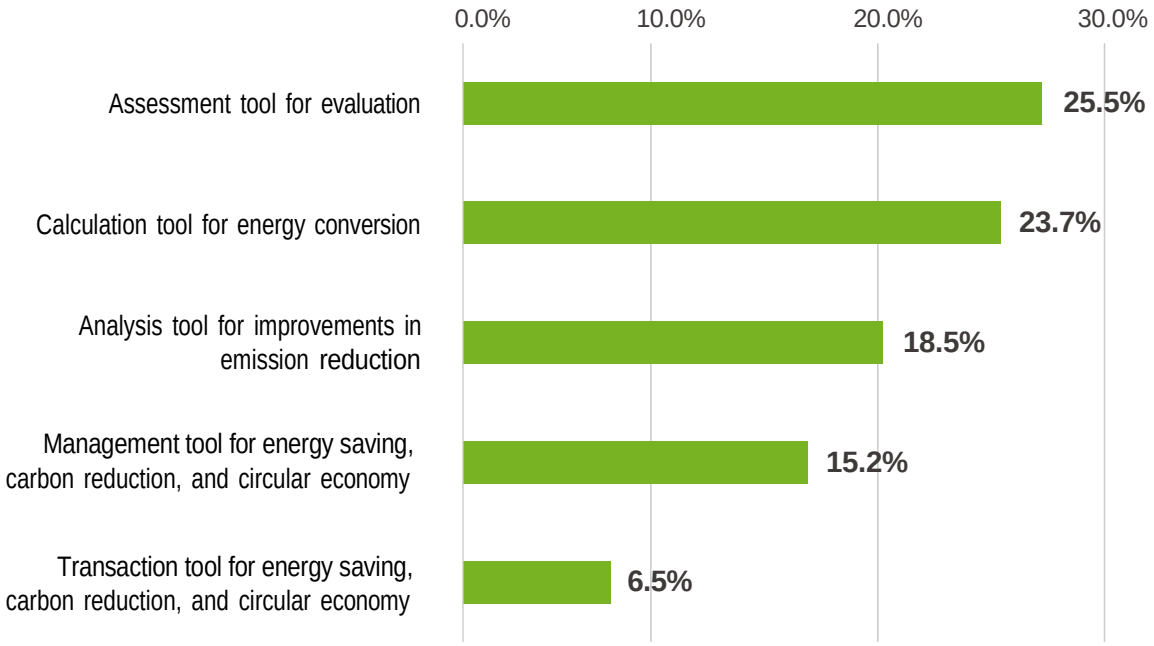
1.APEC Sustainable Energy Center, APEC Urban Energy Report. 2023, June 2024.

2.APEC, APEC ENERGY OVERVIEW 2024, Aug,2024.

3. USPECC, Opportunities for Supply Chain Decarbonization in APEC Economies, Oct 2022.

III.Utilizing Digital Tools to Accelerate SMEs' Low-Carbon Transformation

APEC economies have recognized that digital tools are essential for improving economic efficiency, fostering innovation in an increasingly data-driven world.[4] SMEs in the Asia-Pacific region face increasing pressure to undergo digital transformation in order to remain competitive. At this point, utilizing digital tools in operations and low-carbon transformation has become a critical strategy for business survival and growth, rather than just an optional action.[5]



Source: PwC 2022 SME Digital Transformation Survey https://www.pwc.tw/zh/publications/topic-report/sme-digitalisation-survey-2022.html

Figure 1. Net-zero Emission Tools Currently Used by Companies

According to a survey conducted by PwC, titled "Survey on the Current Situation and Needs of SMEs Transformation in 2022," it was found that 17.1% of Chinese Taipe's SMEs have attempted carbon reduction initiatives. Among the tools currently being used by SMEs, "carbon verification tools for assessment" gains the highest adoption rate, 25.5%, followed by "Assessment survey tools," adopted by 23.7% of

SMEs.[6] The survey findings reflect that the adoption of assessment tools and energy conversion calculation tools are SMEs' priorities on the road to carbon reduction.

The use of digital tools to assist companies in conducting Carbon Footprint Verification (CFV) and emissions calculations has become a key task in their low-carbon transformation. To address the aforementioned challenges and respond to SMEs' priorities in carbon emission management, digital tools are being provided by the public sector or institutions to support SMEs that lack resources or are unsure of how to begin their low-carbon transformation journey. The following are examples offered by APEC member economies to facilitate this transformation.

1 ECOVISEA (INA)

Established through a collaboration between the Indonesian Chamber of Commerce and Industry (Kadin), venture capital firm East Ventures, and the World Resources Institute (WRI) Indonesia, the digital tool utilizes Climatiq's globally standardized emission factor data to ensure that the output data complies with global greenhouse gas agreements and relevant certification standards, assisting enterprises with estimating carbon emissions and measuring their environmental impact. Users can apply for registration on the platform using their corporate email. Through platform tools, the calculation process for emissions is simplified, allowing for the compilation of data on direct emissions, indirect emissions from external energy sources, and other indirect emissions in the supply chain. Additionally, the platform offers visualization templates for enhanced presentation of data.

4. APEC Digital Economy Steering Group and Competition Policy and Law Group, Policies and Tools for Improving Digital Economy and Competition in Digital Markets: Current Issues, March 2024.
5. APEC Small and Medium Enterprises Working Group, Digital Transformation to Generate New Business Opportunities, Opening to New Markets in the MSMES and Gender Focused Cooperatives, in Response to the Economic Crisis Caused by COVID-19, July 2023.
6. PwC, Survey on the Current Situation and Needs of SMEs Transformation in 2022.

❷ Carbon Footprint Calculator (JPN)

The Carbon Footprint Calculator is established by the Tokyo Convention & Visitors Bureau (TCVB). It primarily serves organizers of business exhibitions and events held in Tokyo. Users can input information regarding direct energy consumption, accommodation, transportation, dining, and other relevant data during the event period. The system then calculates the event's carbon emissions, allowing enterprises to better understand and manage the carbon footprint of their commercial activities. Additionally, the system provides carbon reduction suggestions for different aspects of the event. Users can access the calculator without registration, and there are no restrictions for user identity.

❸ Circularity Calculator (PE)

The Circular Calculator established by the Coalition for a Circular Manufacturing Economy in Peru (Coalición por una Economía Circular Manufacturera en Perú), led by the Ministry of Production, is a self-diagnostic tool for enterprises. It allows Spanish-speaking companies to assess their development status by answering questions and understanding their progress in the circular field through the scores and explanations provided by the system. Additionally, the tool offers suggestions for the company's future business activities. To use this tool, registration with the Peruvian Tax Administration (SUNAT) is required, using the Tax Identification Number (Registro Único de Contribuyente).

❹ Carbon Service (Line@) (CT)

Carbon Service is established by the Small and Medium Enterprise and Startup Administration (SMESA), Ministry of Economic Affairs. It integrates resources from various departments to provide SMEs with one-stop carbon reduction resource services, including carbon reduction knowledge, carbon emission estimation tools, energy-saving management, carbon reduction diagnosis services, and carbon reduction subsidies. For carbon emission estimation, the platform assists companies with preliminary calculations and examination of carbon emissions through statistics

on emissions from different scopes. In terms of industry categories, the platform is further divided into manufacturing and service industries. Manufacturing companies need to register with the public sector and provide a Business ID number and Factory's Registered Number to access the estimation system. For service providers, there are no registration-related restrictions. Regarding carbon reduction diagnosis services, companies can analyze their current carbon reduction stage through the use of the aforementioned tools. The platform then suggests using suitable public sector resources to continue carbon reduction efforts.

❺ Carbon Calculation Tool (CT)

Established by the Industrial Technology Research Institute (ITRI), this tool facilitates quick calculation of greenhouse gas emissions by allowing enterprises to easily input information such as electricity usage, natural gas consumption, and vehicle mileage. It serves as one of the preliminary tools for companies to gain an understanding of their carbon emissions. Additionally, there are no restrictions on the identity of registrants for this tool.

❻ Green SME Index (THA)

Established by the Office of SMEs Promotion (OSMEP) of Thailand, this program enables SMEs to use an electronic form-based scoring sheet to conduct self-assessments of their green business concepts and operational conditions. The indicators are divided into four major areas: sustainability management, value chains, governance, and innovation. Enterprises can use this scoring sheet to understand their current status in developing green operations. Additionally, public sector entities can use the platform's registration information to match financing for enterprises that meet green standards and provide business advisory services.

Chapter 2
Best Practices

Best Practices

I. Merck (DE)

Merck is a global science and technology company, with a focus on healthcare, life sciences, and electronics. It is committed to advancing scientific innovation to address global challenges. With a strong presence in pharmaceutical development, high-tech materials, and life science solutions, Merck plays a significant role in shaping the future of these industries. As the world moves towards sustainability, Merck is taking bold steps to integrate digital and green transformations, enhancing its competitive edge and ensuring long-term sustainable growth.

Driving Sustainable Innovation: Merck recognizes the need for continuous innovation, especially in creating sustainable solutions that not only reduce environmental impact but also open new market opportunities and strengthen its position in the industry.

In view of this, Merck is taking action through three key areas:

- **Design for Sustainability Ambition & Product Life Cycle**

  Using Life Cycle Assessment (LCA) to evaluate environmental impact, and collaborating with local companies.

- **Creating a Sustainable Value Chain**

  Promoting sustainability culture among internal and external partners through training and activities.

- **Reducing Ecological Footprint**

  Modifying packaging to increase recyclability and reduce carbon footprint.

In addition, Merck is also utilizing two digital tools, **DOZN** and **SYNTHIA**, to help achieve its goals for digital green transformation.

1 DOZN

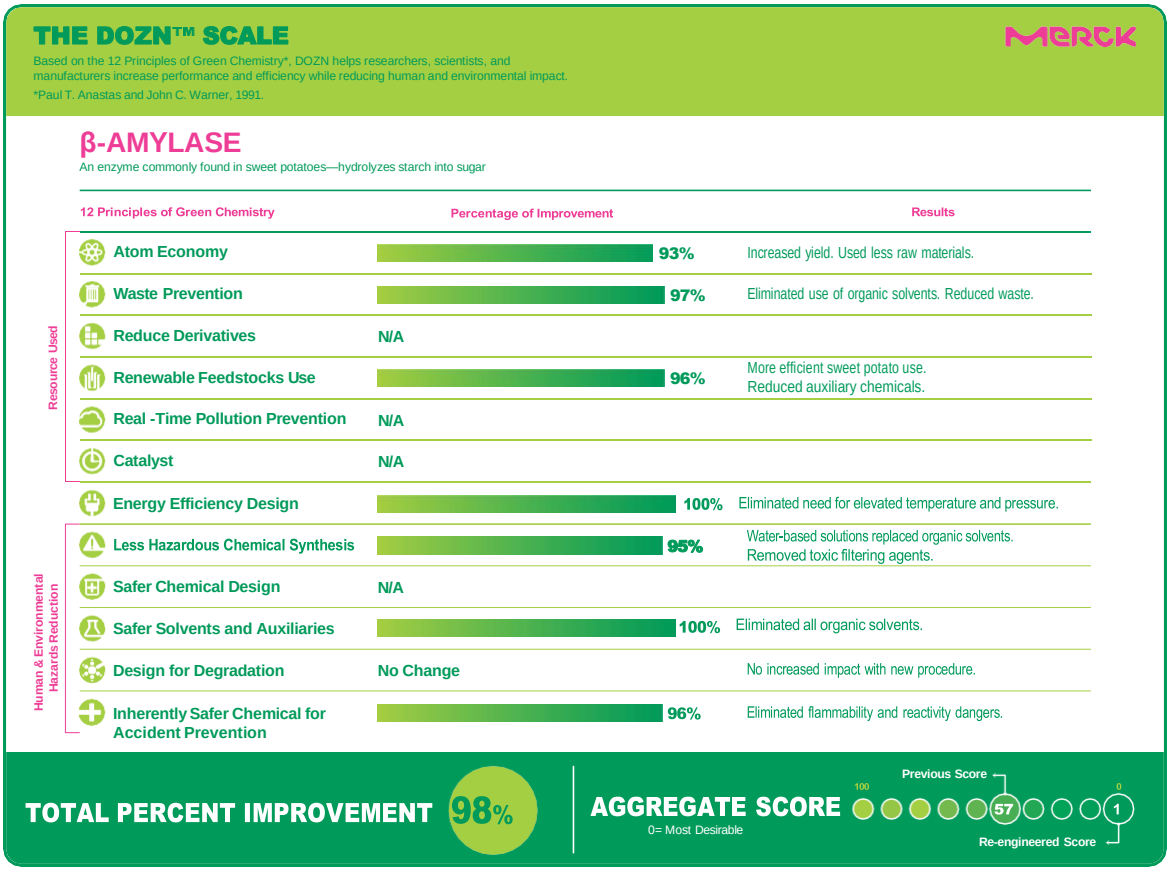
DOZN is a web-based quantitative green chemistry tool developed by Merck to quantify the environmental impact of chemicals and chemical processes. It is based on the 12 Principles of Green Chemistry,[7] allowing users to calculate a “green score" for their products and processes.

12 Principles of Green Chemistry

Prevention	Atom economy	Less hazardous chemical synthesis	Designing safer chemicals
Safer solvents and auxiliaries	Design for energy efficiency	Use of renewable feedstocks	Reduce derivatives
Catalysis	Design for degradation	Real time analysis for pollution prevention	Inherently safer chemistry for accident prevention

Take the enzyme β-amylase, commonly found in sweet potatoes that hydrolyzes starch into sugar, for example (Refer to the figure below for reading). The chemical process of the use of β-amylase has made progress in the principle "Atom economy," which means it maximizes the incorporation of materials used in the process into final products, and the principle "Energy efficiency design" by eliminating the need for elevated temperature and pressure. In the end, the overall improvement reached 98%, and scored 1(from 0 to 100, 0 is the most desirable).

7. https://www.acs.org/greenchemistry/principles/12-principles-of-green-chemistry.html



Source: DOZN Quantitative Green Chemistry Evaluator: ß-AMYLASE
https://www.sigmaaldrich.com/deepweb/assets/sigmaaldrich/marketing/global/documents/384/415/beta-amylase-dozn-mk.pdf

Figure2. Merck's DOZN scale to quantify chemical process' greenness

This system helps researchers and industries identify opportunities to improve sustainability, such as enhancing resource use, increasing energy efficiency, and reducing environmental hazards. By providing actionable data, DOZN enables more informed, eco-friendly decisions in product development and chemical processes.

② SYNTHIA

SYNTHIA is an AI-powered retrosynthesis tool developed by Merck that aids chemists in designing efficient chemical synthesis routes. By utilizing over 100,000 encoded reaction rules, SYNTHIA helps reduce the complexity and time needed for drug development. It identifies the most sustainable synthesis pathways, minimizing

waste, energy consumption, and environmental hazards. SYNTHIA optimizes synthesis routes, increasing the yield to 57% with only 3 steps, compared to the traditional method of 7 steps that results in just 19.2%, significantly improving efficiency and reducing the number of steps. This tool supports Merck's green transformation efforts by streamlining chemical processes, making them more resource-efficient and environmentally friendly. Ultimately, SYNTHIA accelerates innovation in drug discovery while contributing to sustainability goals.

With these initiatives, Merck demonstrates its commitment to being a leader in sustainability and innovation. By integrating digital tools like DOZN and SYNTHIA, the company not only enhances the efficiency and sustainability of its processes but also sets new standards for green chemistry and pharmaceutical development.

II. Victor Taichung Machinery Works Co., Ltd. (CT)

Victor Taichung Machinery Works Co., Ltd. is one of the leading companies in the machine tool industry. Its main motivation for driving low-carbon transition stems from global climate change trends and international market demands. The company faces several key needs accordingly: (1) establishing a comprehensive carbon emission data system to comply with future carbon-reduction policies; (2) integrating upstream and downstream supply chains to jointly promote carbon reduction actions; and (3) enhancing the green competitiveness of its products to meet customers' demand for low-carbon products.

During its journey of carbon reduction, the company encounters several challenges, including: (1) the high difficulty of collecting and integrating carbon emission data, especially when involving the entire supply chain; (2) the lack of resources and knowledge among small and medium-sized suppliers to conduct carbon inventory and

reduction; and (3) balancing economic benefits with environmental investments.

To address these issues, the company has introduced carbon reduction strategies that cover three main aspects: Building Green Factories, Developing Green Machinery, and Setting Green Goals, all engaging digital tools or models.

❶ Smart Factory System

Its new headquarter is the first smart factory in the machine tool industry aligning with the Industry 4.0 based architecture concept. This system integrates production management and Enterprise Resource Planning (ERP) systems, enabling real-time monitoring of the production process, optimizing resource use, and reducing waste, thus achieving the goal of carbon reduction.

❷ Smart Energy Management System

The entire factory's electricity and air conditioning adopt digital monitoring and statistical systems to precisely control electricity and air conditioning. Through data analysis, the company has optimized lighting brightness and air conditioning efficiency, significantly improving energy use efficiency and reducing carbon emissions. This intelligent management effectively reduces unnecessary power consumption, making a significant contribution to the annual carbon reduction targets and continuously providing data support to drive future energy-saving and carbon reduction strategies.

❸ Carbon Footprint Audit Tools

The company is promoting low-carbon transformation with ISO 14064 greenhouse gas inventory and ISO 14067 carbon footprint assessments, which helps accurately calculate carbon emissions of products throughout their lifecycle, and provides a data foundation for subsequent carbon reduction actions.

❹ Supply Chain Collaboration Platform and Co-Creation Academy

The company has established a collaboration platform to work with suppliers, sharing knowledge and techniques for carbon reduction. It also launched the Victor Taichung Zero Carbon Transition Academy (Victor DigiZero), which uses a LINE@ interface and CRM platform to link courses with carbon reduction tools. In the future, the academy will add AI virtual advisors to provide a one-stop solution for zero-carbon transformation. This effort not only improves information sharing but also supports carbon reduction across the entire supply chain.

The company's carbon reduction results include: (1) receiving Green Building certification, (2) bold to set annual carbon reduction targets of 5%, aiming for net-zero emissions by 2050, and (3) engaging industry-government-academia-research

Source: Victor Taichung Machinery Works Co., Ltd

Figure3. Victory Taichung Machinery Works' Smart Green Factory.

❶ low emissivity glass; ❷ Permanent Magnet Synchronous Motor ceiling fan;
❸ underground pipe air induction system; ❹ ice storage AC system.

partnerships through the supplier collaboration platform. The company also leads supply chain transformation and shares low-carbon experiences, promoting collective industry progress through the previously mentioned platform.

III. Landseed International Hospital (CT)

Landseed International Hospital recognizes the direct impact of climate change on human health, particularly in the increase of cardiovascular and respiratory diseases. The hospital's key needs for low-carbon transformation include: (1) establishing a comprehensive carbon emission data system to meet future carbon management requirements; (2) improving energy efficiency to reduce operating costs; and (3) fulfilling social responsibility by enhancing the hospital's green image.

Landseed's energy consumption data underscores the urgency of these needs. Electricity accounts for 75.4% of the hospital's total energy consumption, with air conditioning and lighting systems being the two major sources, accounting for 49.6% and 31.7% respectively. Operating rooms are particularly energy-intensive, with their electricity expenses accounting for 25% of the total cost of the entire medical building, approximately USD12,055 per month.

To address high energy usage, the hospital has developed collaborative models that include: (1) A three-phase energy saving plan that provides a replicable pathway from energy auditing to intelligent operations and carbon neutrality; (2) Industry academia partnership with universities and tech companies to introduce advanced energy management technologies and methods; and (3) Cross-departmental collaboration by establishing an ESG and Sustainability Development Center to integrate hospital resources and drive low-carbon transformation.

Building on the measures aforementioned, the hospital has also adopted digital tools and management models to strengthen its energy management capabilities and accelerate progress toward its carbon-reduction goals.

1. **ISO 50001 Energy Management System:** uses digital tools to collect and analyze energy data, helping the hospital identify energy use patterns and energy-saving opportunities.

2. **Energy Management System (EMS):** to be installed in high-energy consumption areas, like operating rooms, for real-time monitoring Through sensors and smart meters, detailed electricity consumption data is collected, allowing energy consumption review in real-time through a central control platform that sets alarm thresholds, and generate detailed energy reports.

3. **Intelligent Energy Operation Model:** Utilizing data collected from the EMS, combined with AI and machine learning algorithms, it optimizes lighting brightness and air conditioning system efficiency. The system automatically adjusts equipment operating parameters based on indoor environmental conditions, personnel activity, and historical data, achieving precise energy management and reaches the carbon reduction goal.

4. **Human Sensing and Environmental Control System:** Developed in collaboration with Misecure, it uses millimeter-wave human sensing equipment and environmental control units. The system can accurately detect personnel activity and integrate data such as temperature, humidity, and CO2 concentration, automatically adjusting lighting and air conditioning to maximize energy-saving and carbon-mitigating effects while ensuring comfort.

5. **Carbon Footprint Inventory Tools:** used to calculate carbon emissions from various hospital departments, integrating energy consumption data and other relevant information to automatically calculate direct and indirect carbon emissions. It generates visual reports to help management develop targeted carbon reduction strategies.

Based on these data and tools, the hospital has developed a phased energy-

saving plan. In the first phase, the hospital focuses on energy optimization in operating rooms, aiming to reduce electricity costs in these areas by 25%. Once achieved, this plan continues to provide valuable experience for implementing similar energy-saving measures in other areas in the future.

Overall, the hospital's low-carbon transition has enhanced its operational efficiency and social responsibility profile, setting a benchmark for sustainability in the healthcare industry. Through the application of digital tools and innovative management schemes, the hospital demonstrates the proactive role healthcare institutions can play in climate actions.

Source: Landseed International Medical Group

Figure 4. Installation of environmental control box in operating rooms

IV. E.SUN BANK (CT)

E.SUN Bank directs funds to areas essential for building a sustainable future, leveraging its financial influence to help SMEs and the society move toward sustainability. E.SUN Bank has launched the Sustainable Transformation Platform to provide comprehensive support for enterprises, particularly SMEs, on their journey

toward a low-carbon future. E.SUN Bank not only offers financial assistance but also supports enterprises through its robust digital technology infrastructure, helping them adopt modern digital tools to optimize their operations.

Banks themselves are not high carbon emitters, but their challenge of reducing carbon emissions mainly comes from indirect emissions generated by their borrowers. In recent years, Sustainability-Linked Loans has gained attention from banks. E.SUN Bank, which has a large SME client base, not only assists its clients in their low-carbon transitions but also reduces the bank's carbon footprint by sustainability-linked lending and investment activities.

The platform integrates advanced digital tools focused on improving operational efficiency, reducing carbon emissions, and aligning enterprises with global sustainability standards. With E.SUN Bank's technological support and the use of AI and IoT technologies, the platform provides real-time data analysis and offers specific strategies for emission reduction and improvement. This not only helps enterprises reduce their environmental footprint but also reinforces E.SUN Bank's pivotal role in driving sustainable development. Below are the key digital tools provided by E.SUN Bank to assist MSMEs in their journey toward low-carbon digital transformation.

E.SUN Bank provides SMEs with Carbon Emission Calculators, which assist enterprises in calculating their carbon footprint with over 80% accuracy. The automation of data collection and analysis enables SMEs to track their emissions more efficiently and make data-driven decisions for carbon reduction.

The implementation of these digital tools through E.SUN's platform has significantly improved SMEs' carbon management. These tools help SMEs integrate smart devices into their low-carbon transformation processes, allowing for the collection of business data. Through automated generation, these tools produce and organize reports that assist in managing diverse business needs. Companies have been able to

enhance their sustainability reporting, align with international standards like SBT and RE100, and receive relevant certifications. Furthermore, E.SUN fosters collaboration between SMEs, large corporations, and government entities, encouraging knowledge-sharing and supporting SMEs in reaching sustainability goals. This public-private partnership model has proven effective in reducing carbon emissions and improving competitiveness in the low-carbon economy.

V. Carbon Addons (INA)

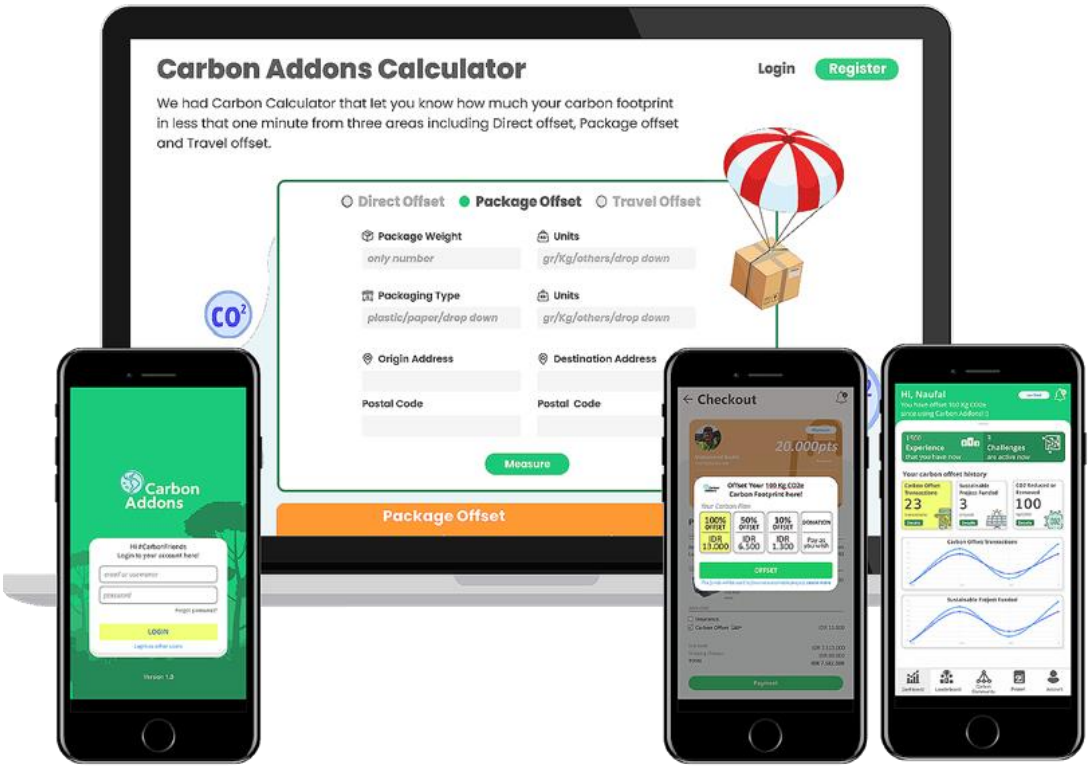
Carbon Addons is an innovative Indonesian company dedicated to assisting SMEs in achieving low-carbon transformation. Driven by its '1000 Low-Carbon Brands Movement' vision, Carbon Addons has developed a series of digital tools and platforms to provide enterprises with accessible carbon management and reduction solutions.

1. **One stop carbon neutrality platform:** to help SMEs conduct carbon emission analysis and set reduction targets. The platform can simplify the carbon assessment process, allowing even non-experts to understand their company's carbon footprint.
2. **Regular capacity-building workshops:** to teach carbon management knowledge and reduction strategies, while also establishing a carbon reduction partner network to facilitate collaboration among enterprises.
3. **Carbon offset financing scheme:** that integrates carbon footprint calculation software into e-commerce platforms, enabling consumers and companies to voluntarily participate in carbon offsets during their transactions, thus increasing public engagement.

Attributable to these innovative tools and models, Carbon Addons has achieved positive results in driving low-carbon transformation. The one-stop carbon neutrality

platform lowers the barriers to carbon management; capacity building workshops and the carbon reduction partner network accelerate industrywide transformation. The Carbon offset financing scheme helps integrate carbon offsetting into consumer behaviors, creating a win-win model for consumers, enterprises, and environmental projects.

In summary, Carbon Addons combines digital technology, educational training, and innovative business models to provide SMEs and consumers with effective ways to engage in low carbon transformation. Its experience not only offers valuable insights for Indonesian companies but also provides a replicable model for low-carbon transition in other APEC economies.



Source: Carbon Addons

Figure 5. Carbon Addon's carbon emission calculator and carbon offset API

VI. Nuvilab (ROK)

Nuvilab is a sustainable food solutions AI startup that addresses greenhouse gas emissions, exacerbated by food waste, from the food industry. Nuvilab believes that reducing food waste can lower carbon emissions and improve resource efficiency.

To achieve this goal, the company focuses on two main needs: (1) accurately quantifying food waste and associated carbon emissions to optimize food service operations; (2) providing customized nutritional advice to promote healthy dietary.

However, Nuvilab faces challenges, including the complexity of collecting and analyzing food waste data, the difficulty of changing user behavior and habits, and balancing waste reduction with maintaining food quality and safety. To address these challenges, Nuvilab has developed a series of AI based innovative solutions.

❶ AI Food Scanner

Utilizing advanced visual AI technology to identify and measure food types and quantities, particularly useful in commercial and institutional cafeterias for precise tracking of food consumption and waste.

❷ NutriVision AI

An intelligent nutrition analysis system that provides personalized dietary recommendations based on food intake.

❸ Data Analysis Platform

This platform integrates data from the AI Food Scanner and NutriVision AI to generate detailed reports, including food waste amounts, carbon emission estimates, and nutritional intake analysis.

4 Smart Menu Planning System

Using collected data, Nuvilab developed a smart menu planning system that optimizes menus based on user preferences and nutritional needs while minimizing food waste.

Nuvilab's innovative tools have brought about positive feedbacks: (1) Food Waste Reduction: Nuvilab's solutions have been applied in over 100 institutional cafeterias worldwide, including schools, kindergartens, and hospitals, effectively reducing food waste; (2) Carbon Emission Reduction: It is claimed that AI food scanning machines help cafeteria managers to reduce food material cost by up to 5%, reduce over-prepared food by 30%, and reduce plate waste by 42%. As a result, the tech has the potential to cut down 9% of the greenhouse gas emissions currently generated from food waste; (3) Health Promotion: By offering personalized nutritional advice, Nuvilab's solutions not only support environmental protection but also enhance user health.

In addition, its promising collaboration models include: (1) Academic Partnerships: collaborations with educational institutions and hospitals increase installation of Nuvilab's technology in their cafeterias, reducing waste and providing better nutritional guidance; (2) Healthcare Partnerships: implementing solutions in hospitals not only reduces food waste but also provides precise nutritional management for patients; (3) Data Sharing Models: Nuvilab's data offers valuable insights into food consumption and waste, aiding government and research institutions in crafting more effective policies and studies

Source: Nuvilab(누비랩)

Figure 6. Nuvilab's AI food tray scanner that measures plate waste and personal intake data.

Chapter 3
Analysis and Findings

Analysis and Findings

I. Patterns of Low-Carbon Transformation

The case studies find that the global trend of net-zero emission, the practice of regulatory measures on global trade, or regulations on climate and greenhouse gas emission management have been well noted by enterprises who have implemented, or will adopt, low carbon transformation. From the standpoint of motivation, saving energy to lower operating cost, and enhancing the market competitiveness of products are the main purposes of reducing carbon emission. The findings also reveal that the intention to strengthen a company's green reputation and shift consumer behaviors toward eco-friendly ones has been propelling the low carbon transformation forward.

A common challenge for enterprises lies in the complexity of gathering carbon emission data, both within individual enterprises and across supply chain partners. Evidently, the shortfall in relevant knowledge and technological resources deters SMEs. Another concern is how to strike a balance between economic benefits and environmental efforts.

Responding to motivations and challenges of low carbon transformation, SMEs take a series of actions, suggested by the case study, such as adopting digital equipment or integrated platforms to monitor energy use, calculate carbon emission, carry out carbon inventory, in turn figuring out tailored carbon reduction solutions or practices. Some enterprises, like Landseed International Hospital, deal with energy saving, a means to reduce carbon emission, by replacing old equipment with eco-friendly ones so as to lower their operating cost. While, others, like Victor Taichung Machinery Works, have managed to achieve international standards, specifically ISO 14064 -1:2018 and ISO 14067, and compile sustainability report for the purposes of being equipped for tougher “green” requests from global supply chains, or, from a

positive perspective, wider business opportunities in the low carbon economy.

Some SMEs are driven by the low carbon trend to innovate. Carbon Addons developed carbon offset financing scheme to support the Low Carbon Brands Movement; Nuvilab, from a healthy dietary and food waste management perspective, created AI food scanning machines that helps reduce food waste with added value of carbon emission reduction. Regarding the goal of reducing carbon emissions within the supply chain, Merck innovated DOZN to evaluate chemicals and chemical process' environmental impact, and SYNTHIA to design efficient chemical synthesis routes, which, along with its efforts on promoting sustainability culture among internal and external partners, has provided guidelines on reducing ecological footprint for its supply chain partners to follow.

Due to different perspectives, the low carbon transformation has brought about diverse achievements, including the building of the industry-government-academia partnership, improved capacity for data collection, processing, and application, and, the most important one, reduced carbon emissions.

II. Comparison of Government Digital Tools and Enterprises' Needs

The free digital tools provided by governments in various economies have played a crucial role in promoting low-carbon transformation for enterprises, especially for SMEs, which often face limitations in resources and technology. These tools offer essential support to SMEs. For instance, Indonesia's ECOVISEA platform simplifies carbon emission calculations and offers data visualization functions to help enterprises estimate and track their carbon emissions, which is particularly important for managing indirect emissions in the supply chain. On the other hand, Chinese Taipei's Carbon Service provides multiple carbon reduction services, including energy efficiency

management and carbon emission diagnostics, along with financial subsidies. This platform is suitable for companies lacking the resources to manage large-scale carbon emission reductions. The main goal of these platforms is to lower the technical barriers, allowing non-expert users to manage their carbon emissions and advance the overall industry's carbon reduction efforts.

Additionally, we can see that large corporations like Merck rely on more specialized digital tools to drive their green transformation. Merck uses DOZN and SYNTHIA, which not only quantify the environmental impact of chemical processes but also provide specific improvement recommendations based on the principles of green chemistry. These tools help optimize resource use, improve energy efficiency, and reduce environmental risks. Such specialized tools cater to specific industries, providing more detailed data analysis and decision support. Similarly, Japan's Carbon Footprint Calculator, originally designed for events and exhibitions, offers professional assistance for specific industries despite its more limited scope.

Victor Taichung Machinery has adopted ISO 14064 and ISO 14067 carbon footprint auditing tools in its journey toward low-carbon transformation. These tools allow the company to accurately calculate the carbon emissions across the entire product lifecycle, helping it to track carbon footprints comprehensively and integrate them into the supply chain. Such in-depth data analysis and tracking capabilities represent a goal that many government-provided tools are working towards achieving in the future.

In conclusion, the digital tools provided by governments are an important first step for SMEs. These tools offer simplified carbon emission calculations and reduction suggestions, helping enterprises to initially understand and manage their environmental impact. Government-provided tools typically focus on accessibility and ease of use, serving as a gateway for SMEs toward transformation. Later, enterprises will have the opportunity to access more specialized, tailor-made digital tools, allowing them to make greater progress in their green transformation and low-carbon development.

III.The Importance of Digital Transformation for Inclusive Green Transition

When it comes to SMEs led by individuals with untapped economic potential, women, MSMEs, Indigenous Peoples, and those from remote and rural communities are often mentioned together. As addressed in the 30th APEC SME Ministerial Meeting Statement, the implementation of the Bangkok Goals on BCG Economy model cannot do without inclusion practices.

Science, technology, engineering, and mathematics (STEM) fields and occupations are crucial to the green transition. Among the STEM expertise, digital skills are basic to develop tech-enabled solutions and to achieve sustainability objectives.

Since digital skills are basic and inevitable, they can pave the way toward the green transition by empowering individuals with untapped economic potential. In this regard, it is important to accelerate digital transformation by providing equal access to information and communication technologies (ICTs), promoting digital connectivity, and enhancing digital literacy and skills development in order to bridge the digital divide. In turn, benefits and potential opportunities associated with the use of digital technologies can increase their participation in the green economy, which would realize the expectation that "MSMEs, including those owned or led by women, can make significant contributions to the green transitions," stated in the Chair's Statement of the 29th APEC SME Ministerial Meeting.

8. https://www.eib.org/en/stories/female-leaders-climate

Chapter 4

Conclusion and Recommendations

Conclusion and Recommendations

From the understanding of digital tools introduced in this article and the case study, it is evident that carbon footprint calculation and energy efficiency management are the two main functions of new digital tools, which, to a significant extent, address SMEs' needs in initial stages of carbon reduction. It is also suggested that collaborations between the public sector, corporations, startups, institutions and business partners along the supply chain are vital to low-carbon related digital innovation and its practices.

When SMEs face challenges during their low-carbon journey, government funding and support measures provide a gateway for SMEs. Digital tools, co-developed or introduced by the public sector, can simplify complex processes of calculating carbon emissions and identify emissions hotspots, where would be the starting point of carbon reduction. As enterprises advance, they can access more specialized tools to drive further progress in their low-carbon efforts.

Companies that have already made progress in low-carbon development are increasingly developing or utilizing more advanced digital tools. For example, Merck’s DOZN tool improves resource efficiency and enhances the environmental sustainability in the supply chain. Victor Taichung Machinery Works Co., Ltd. designs green digital tools for customer use and provides carbon reduction training and communication channels to suppliers. These leading companies, in terms of low carbon actions, not only focus on their own transformation but also actively drive the entire supply chain and stakeholders forward together.

In addition to advancing environmental goals, digital tools also offer opportunities

for the untapped economic potentials. For instance, empowering women with digital skills can effectively bridge the gender digital divide, increasing opportunities for women to participate in the green economy. This enhances capacity for SMEs to grow and play a pivotal role in low-carbon development.

In 2024, the project "APEC Digital Innovation to Implement SMEs' Low-Carbon Transformation Initiative: Developing Digital Solution of Low-Carbon Business Models" has built companies' capacity in conducting digital carbon footprint assessments and helped them to learn how to reduce carbon emissions through digital innovation, serving as a stepping stone for their transformation to low-carbon practices.

Looking ahead, the promotion of digital green practices within the APEC region is expected to increase SMEs' interconnectedness in green supply chains. By fostering key factors that support business continuity in a green digital manner and facilitating information exchange between the public and private sectors of APEC member economies, a level playing field can be created for SMEs. The follow-up project, the APEC Digital Innovation to Enhance SMEs Competitiveness in Green Supply Chains Initiative, aims to help enterprises succeed in an increasingly environmentally conscious global market, and better participate into the global green economy.

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Produced by
Small and Medium Enterprise and Startup Administration,
Ministry of Economic Affairs
Email: ischung@sme.gov.tw
Tel: (886) 2 2366 2237 Fax: (886)2 2367 7484

For
Asia-Pacific Economic Cooperation
35 Heng Mui Keng Terrace, Singapore 119616
Tel: (65) 68919 600 Fax: (65) 68919 690
Email: info@apec.org Website: www.apec.org