APEC Digital Innovation to Enhance SMEs Competitiveness in Green Supply Chains

Research Report

APEC Small and Medium Enterprises Working Group

December 2025

Asia-Pacific
Economic Cooperation

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SECTION I

Executive Summary

Executive Summary

1. Digital and Low-Carbon Transition: Imperative to SME Survival

Contrastive case analysis found that Malaysia's Duramitt Sdn Bhd was able to reduce its carbon emissions by switching to biomass fuel; Chinese Taipei's Textile Research Institute effectively shortened fabric sampling cycles and reduced resource expenditure by developing DigiFab, an AI-based digital fabric simulation platform; US firm HARBEC, Inc. improved its operational efficiency by adopting energy management systems; and Viet Nam's Minh Dang Group enhanced its production capacity and export performance by replacing energy-intensive equipment with energy-efficient ones. These case studies indicate that digital and green transitions in businesses help reduce operating costs and increase operational efficiency. More notably, these digital and green solutions are often also replicable across industries and even economies.

2. Green Transition: Cuts Costs, Enhances Energy Efficiency, and Propels Productivity

Digital and low-carbon initiatives not only mitigate the pressures of high energy consumption and production costs faced by businesses but also enhance energy efficiency, production capacity, and product quality. The applicability of digital and low-carbon initiatives varies across industries. Equipment upgrades are particularly relevant to processing

sectors; energy management systems to manufacturing sectors; biomass energy to resource-based economies; and digital simulation technologies to design-intensive industries. Overall, the simultaneous advancement of digitalization and decarbonization constitutes a pivotal strategy for SMEs to strengthen their global competitiveness.

3. Implementing Financial Support, Digital Tools, and Market Regulation into Policy

Successful digital and green transformation is built on three pillars: (i) Financial support which reduces upfront investment barriers; (ii) Digital tools and AI-based simulation technologies, which improve data transparency and operational efficiency; and (iii) International standards, carbon tariffs, and certification mechanisms, which motivate businesses to transition. It is recommended that APEC economies formulate green policies aligned with domestic resource conditions while promoting cross-economy financing, technological collaboration, and mutual recognition of standards. Such coordinated efforts can help reduce SME compliance costs and other costs associated with duplicate verification requirements, thereby strengthening buyer confidence and supply chain trust across the region.

4. Regional Financing Platforms and Capacity-Building Mechanisms

APEC SMEs seeking to undergo green transition continue to face constraints in financing, technology, and skilled human resources. To address these challenges, APEC economies are encouraged to:

(i) Establish regional platforms for sharing best practices in green finance and for providing access to low-cost digital tools.

(ii) Integrate advisory services with training programs to deliver management, R&D, and technical support tailored to enterprise size and stage of development.

(iii) Promote mutual recognition of standards and supply chain mentorship mechanisms to accelerate technology transfer and facilitate SME market integration.

SECTION II

Research Background and Focus

Research Background and Focus

Beginning in 2023, Chinese Taipei has advanced a series of APEC-aligned initiatives to promote digital innovation and green transformation among SMEs in the region. These initiatives were designed to support SMEs in their transition toward low-carbon and sustainable practices and have been implemented progressively in three phases:

(i) Awareness raising; (ii) Capacity building; and (iii) Outcome dissemination.

(i) Phase 1: Awareness Raising (2023)

In 2023, Chinese Taipei launched the APEC Digital Innovation Accelerating SME Green Transformation Initiative, focusing primarily on raising awareness on sustainability among businesses. Forums, exhibitions, and competitions were organized under the initiative, bringing together SMEs, large enterprises, government agencies, and non-profit organizations to create a cross-sector platform for dialogue and knowledge exchange. The initiative also highlighted the risks that domestic SMEs may face—such as potential marginalization within global production networks—if they fail to respond to the growing demand for reduced carbon emissions and greater environmental accountability across supply chains.

(ii) Phase 2: Capacity Building (2024)

Implemented in 2024, the second phase emphasized the translation of knowledge and awareness into action and saw the implementation of the APEC Digital Innovation for SME Low-Carbon Transformation in Practice Initiative. This phase introduced policy forums, enterprise visits, and hands-on training programs, focusing on carbon inventory methodologies, international standards and regulatory frameworks, as well as the practical application of digital carbon management tools. These efforts aim to strengthen SMEs' ability to collect, analyze, and apply emissions data, thereby reducing technical and human resource barriers to green transition.

(iii) Phase 3: Outcome Dissemination (2025)

The third phase focuses on disseminating outcomes and scaling impact. Launched in 2025, the APEC Digital Innovation for Enhancing SME Green Supply Chain Competitiveness Initiative aims to facilitate digitally driven green transformation in SMEs' daily operations to achieve tangible improvements in market competitiveness. With the rapid advancement of AI, big data analytics, and other digital tools, SMEs can now monitor carbon emissions with greater precision, optimize energy efficiency, and enhance supply chain transparency—capabilities that help them gain recognition from large enterprises and international buyers. These developments not only strengthen SMEs' positioning within supply chains but also create new opportunities for cross-economy collaboration and market expansion.

Drawing on Chinese Taipei's experience, the present report seeks to examine, through trend and case analyses, how digital and low-carbon

transition can assist SMEs in meeting international decarbonization standards while enhancing their competitiveness in global supply chains and markets. The subsequent sections provide deeper insight into how the specific experiences of four APEC SMEs and organizations can be translated into practical, actionable, and scalable strategies for regional adoption.

SECTION III

How Digital Innovation Strengthens Green Competitiveness: APEC SME Case Studies

How Digital Innovation Strengthens Green Competitiveness: APEC SME Case Studies

This section presents a detailed examination of four APEC SMEs and organizations which, as a result of their digital and low-carbon initiatives, have experienced or contributed to demonstrable improvements in organizational performance and enterprise competitiveness. The section further investigates how these firms, through the strategic adoption of technological innovations, have successfully achieved the goals of emission reduction and operational efficiency while improving their brand image and competitiveness in global supply chains.

The analysis prioritizes APEC member economies actively advancing green and digital transformation in SMEs, while case selection was largely dependent on the availability of publicly accessible data and relevance to the study's objectives. Based on these criteria, four representative enterprises and organizations were identified: Minh Dang Group from Viet Nam; HARBEC, Inc. from the United States; Duramitt Sdn Bhd from Malaysia, and the Textile Research Institute from Chinese Taipei. Case analyses are organized around three key dimensions—problem solving, efficiency enhancement, and replicability—to illustrate how digital and low-carbon transitioning can help SMEs overcome

operational challenges, improve business performance, and remain competitive within global supply chains and markets.

1. Viet Nam: Minh Dang Group

BOX 01

Minh Dang Group Case Summary

This case demonstrates how SMEs, supported by government financing and international technical collaboration, can successfully implement low-carbon equipment replacement and energy-efficient production processes that lead to higher production capacity and better export performance, illustrating the benefits of public–private collaboration in advancing digital and low-carbon transition in SMEs.

Minh Dang Group is a small to medium-sized seafood processing enterprise located in the Mekong Delta region of Viet Nam. The company had long relied on conventional piston (reciprocating) compressors and refrigeration systems, which caused significant energy waste and high carbon emissions, posing major challenges to operational and sustainability goals over time. Key problems that Minh Dang Group faced prior to its green transition are as follows:

(i) Low equipment efficiency and heavy maintenance burden

Piston compressors rely on repetitive movement within cylinders, causing high friction, energy loss, and frequent part replacements.

Moreover, additional cooling systems were needed to combat high discharge temperatures, further increasing energy consumption.

(ii) Rigid operation

The equipment operated in a binary "on/off" mode and was unable to respond to fluctuating production demand, resulting in electricity waste when demand levels were low.

(iii) High electricity consumption and environmental risks

Viet Nam's electricity supply is largely dependent on coal and natural gas. Consequently, the high electricity consumption of piston compressors directly increased the company's carbon emissions. Additionally, the refrigerants used possessed a high Global Warming Potential (GWP), which exposed the business to considerable climate and sustainability risks.

Green solution adopted

To overcome these challenges, Minh Dang Group participated in the Viet Nam–Denmark Low-Carbon Energy Efficiency Transition Program in 2015 and obtained a USD163,000 loan from the Green Investment Fund. The funding enabled the company to replace its energy-inefficient compressors with high-efficiency screw compressors equipped with variable frequency control. This equipment upgrade allows for dynamic load adjustment, substantially lowering energy consumption and consequent carbon emissions.

Results

- 30% decrease in electricity consumption
- Appx. 500 tons reduction in carbon emissions annually
- 40% increase in production capacity (with exports increasing from 2,700 to 3,900 tons)
- 58% increase in profit (from USD227,000 to USD359,000)

With the introduction of carbon pricing and carbon border adjustment policies—such as the EU's Carbon Border Adjustment Mechanism (CBAM)—suppliers that fail to demonstrate low-carbon performance and high efficiency risk might lose orders. Minh Dang Group, which obtained international certifications recognizing its improved product quality and environmental compliance, successfully gained access to high-standard markets such as Japan and the United States.

Replicability

The integrated use of screw compressors and variable frequency drives has strong applicability across sectors such as food processing, cold-chain logistics, and agricultural preservation. Supported by low-interest green financing mechanisms, this approach offers a replicable and scalable model for other SMEs undertaking low-carbon transformation.

2. The United States: HARBEC, Inc.

BOX 02

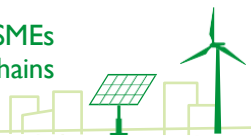
HARBEC, Inc. Case Summary

This case demonstrates how an SME in the precision manufacturing industry improved its energy performance and competitiveness by adopting the energy management standard ISO 50001 and the Superior Energy Performance (SEP™) process in its operations. It further highlights how systematic and data-driven decision-making can advance both operational efficiency and carbon reduction goals.

HARBEC Inc. is a precision manufacturing firm based in the United States which specializes in the production of injection-molded plastic components, computer numerical control (CNC) precision parts, and molds for the aerospace, medical, and transportation sectors. Due to the high precision and quality requirements of its products, the company's manufacturing process consumes substantial amounts of electricity, fuel, water, compressed air, and thermal energy. Over time, several energy-intensive subsystems, particularly the Combined Heat and Power (CHP) unit, cooling water system, and compressed air system—posed challenges to both operational efficiency and sustainability performance, and are outlined below:

(i) Energy waste

The microturbines in the CHP system lacked demand-based start–stop control, consuming energy even during low production periods.



Also, constant-speed water pumps ran continuously, wasting electricity.

(ii) Energy-intensive cooling operations

The cooling water system operated continuously at high speed, supplying chilled water to injection molding machines, cooling coils, and heat exchangers. This consumed a large amount of electricity and water resources, with no mechanism to adjust operations to actual production demand.

(iii) Increasing supply chain pressure

Aerospace and medical industry clients are placing growing emphasis on suppliers' environmental responsibility. Enterprises that fail to meet these standards risk losing contracts and being excluded from supply chains.

Green solution adopted

To address these issues, HARBEC, Inc. obtained SEP™[1] certification and introduced a digital monitoring platform under the ISO 50001[2] framework in its manufacturing process, enabling real-time tracking

1. The Superior Energy Performance (SEP) program—jointly advanced by the U.S. Department of Energy (DOE) together with U.S. industry partners—is a certification scheme that builds on the ISO 50001 energy management system standard to help organizations institutionalize robust energy management. DOE has also issued SEP program requirements and system-level assessment protocols (for example, for pumping, process heating, compressed air, etc.), which provide consistent criteria for auditing specific energy systems.
2. ISO 50001 is a voluntary international standard designed to help organizations of any size establish, implement, maintain, and continually improve an Energy Management System (EnMS). It provides a structured framework for improving energy performance in a systematic way—enhancing energy efficiency, reducing energy costs, and lowering greenhouse-gas emissions.

of energy consumption across various systems and any subsequent adjustments. Technical upgrades included improving the CHP system's start-stop control logic, installing variable frequency drives, and optimizing cooling systems. Additionally, HARBEC, Inc. also integrated energy saving into its daily operations and corporate culture.

Results

HARBEC, Inc. achieved the following results within three years:

- 16.5% improvement in energy performance
- 1.75 million kWh saved annually
- USD52,000 in annual cost savings
- 2.4-year investment payback period. By demonstrating measurable reductions in energy use and emissions, HARBEC, Inc. was recognized as a demonstration plant by the United States Department of Energy, gained entry into aerospace and defense supply chains, and secured contracts from major multinational corporations. Adopting green solutions also allowed the enterprise's products to meet low-carbon material standards in both European and Asian markets.

Replicability

The ISO 50001–SEP™ energy management framework adopted in this case study provides standardized mechanisms for tracking and improving performance across diverse industries. The technical upgrades implemented—such as the installation of variable frequency drives and optimization of cooling efficiency—do not require large investments and can be easily adopted by SMEs. When coupled with supportive

public policies and accessible financing channels, this model offers a replicable and cost-effective pathway for SMEs to achieve low-carbon transformation.

3. Malaysia : Duramitt Sdn Bhd

BOX 03

Duramitt Sdn Bhd Case Summary

This case illustrates how SMEs in export-oriented manufacturing industries can integrate biomass energy and digital control to improve energy efficiency, reduce emissions, and improve brand image while enhancing production capacity and yield.

Duramitt Sdn Bhd is an SME specializing in the manufacture of industrial and medical protective gloves which are exported to various global markets. The manufacturing process, particularly the drying and vulcanization stages, had required large amounts of thermal energy, which gave rise to the following challenges over time:

(i) High energy consumption and carbon emissions

Drying and vulcanization during glove production requires significant steam and thermal energy. Before Duramitt Sdn Bhd's green transition, heating accounted for 70% of its electricity consumption.

(ii) Single-source dependency

Duramitt relied heavily on conventional fossil fuels and grid electricity for thermal energy, resulting in significant CO_2 emissions and other pollutants. This dependency not only increased waste treatment and compliance costs but also undermined the company's environmental image, making it difficult to meet international green manufacturing standards and growing buyer expectations for low-carbon products.

Green solution adopted

In 2021, in an effort to partially replace its traditional energy sources, Duramitt Sdn Bhd introduced an automated biomass boiler system which utilized agricultural and forestry by-products as fuel. The system features automatic feeding, sealed combustion, and digital temperature control, which enhances operational safety, combustion efficiency, and emission performance. Moreover, residual ash from combustion is reused as fertilizer, closing the resource loop in the manufacturing process. This project received funding support from the Malaysian Rubber Council, reducing Duramitt Sdn Bhd's financial risk during its green transition.

Results

- More than 52% reduction in energy costs
- More than 50% reduction in carbon emissions
- Significant decrease in the cost of production waste disposal

The reuse of combustion ash as fertilizer also created additional resource value, while the introduction of an automated boiler improved energy efficiency and ensured a stable steam supply, hence reducing the

risk of production disruptions and improving product yield.

Replicability

Biomass fuels are often derived from by-products sourced locally, contributing to stable supply chains and cost-effective energy alternatives. The green model adopted in this case study is particularly applicable to agriculture-based economies such as Indonesia; Thailand; and Viet Nam, especially when complemented by policy incentives such as public funding.

4. Chinese Taipei: Textile Research Institute's DigiFab Platform

BOX 04

DigiFab Case Summary

This case illustrates how digital and green transformation can help reduce energy consumption and carbon emissions within high-carbon manufacturing sectors. It further demonstrates how AI-driven fabric simulation and digital twin technology have replaced physical sampling with data-driven design, fundamentally restructuring the domestic textile sampling process.

Chinese Taipei's Textile Research Institute (TTRI) has pioneered an integrated digital framework that combines AI simulation, 3D scanning, physical property measurement, and visual texture modeling, enabling

fabrics to be rendered as functional digital twins, greatly reducing the need for physical fabric samples in textile production.

Physical fabric samples have long formed the backbone of textile development and sample production. However, in the face of increasing demands by the fast and premium fashion markets for greater fabric diversity, texture precision, and rapid response times, the limitations of conventional sampling have become more pronounced. These challenges manifest primarily in two dimensions:

(i) High energy and resource consumption in sample production

Traditional fabric sampling requires repeated weaving, dyeing, and finishing processes to test texture, color, and drape, resulting in intensive use of electricity, water, and chemicals while generating wastewater and carbon emissions. Because initial fabric sample outputs often deviate from design expectations, multiple rounds of modification and consequently, sample production, are often needed, causing significant energy and material wastage.

(ii) High carbon emissions from sample transportation

Given that designers and brand clients are not always based domestically, physical fabric samples often have to be shipped internationally. This process generates substantial energy consumption, logistics-related carbon emissions, and packaging waste. Repeated shipping and back-and-forth communication often contribute to the elongation of product development cycles and exert unnecessary pressure on the environment.

Green solution adopted

In response to the environmental challenges detailed above, TTRI developed DigiFab, a digitalized system that replaces physical sampling with a fully virtual workflow. Through the integration of 3D scanning and physical property measurement, DigiFab is able to generate high-fidelity digital representations of fabrics, while AI-driven simulation enables designers to view fabric properties and simulate garment behavior online, eliminating the need for most physical fabric samples. Moreover, designers and brands can collaborate in real time, reducing the need for sample production and transportation and shrinking production lead time.

Results

- Average sample development time decreased from 37 days to 27 hours
- Significant reductions in material, dye, water, and chemical use
- Reduction in logistics and packaging waste

The innovation won the 2023 Edison Gold Award in the United States and was piloted by Under Armour, Inc., enhancing Chinese Taipei's visibility in the global textile supply chain.

Replicability

As demonstrated by TTRI, digitalized fabric selection and AI-based simulation offer a low-carbon solution for sample-intensive industries, particularly in textiles and fashion manufacturing. Widespread

implementation across APEC economies could significantly contribute to supply chain decarbonization and the advancement of circular economy practices.

SECTION IV

How Digital Innovation Strengthens Green Competitiveness: Policy Tools

How Digital Innovation Strengthens Green Competitiveness: Policy Tools

The preceding four case studies highlight two critical drivers for enhancing SME competitiveness in green supply chains: financial support mechanisms and digital upgrading and empowerment. This section explores policy measures adopted by different APEC economies to provide SMEs with financial support and digital empowerment, with policy selection based on publicly verifiable data and alignment with the study's objectives.

(i) Financial Support

1. Malaysia: Low Carbon Transition Facility (LCTF)[3]

Launched in 2022 by Bank Negara Malaysia (BNM), the Low Carbon Transition Facility (LCTF) aims to assist SMEs in adopting low-carbon business models and achieving net-zero emissions by 2050. The funding facility has a total fund size of MYR2 billion (approximately USD475 million), co-funded equally by BNM and participating financial institutions.

Loans are provided at an interest rate capped at 5%, a loan tenure of up to 10 years and a guarantee mechanism to support SME investments in energy efficiency, renewable energy systems, and green materials, thereby facilitating corporate decarbonization. As of 2024, LCTF has supported the green transition of several SMEs. Notably, key partner institution RHB Bank alone approved over MYR411 million (USD97.5 million) in green transition loans, supporting a plethora of projects centering on renewable energy, green equipment acquisition, and business operation improvement.

2. Singapore: Enterprise Financing Scheme – Green (EFS-Green)[4]

Introduced in 2021 by Enterprise Singapore (EnterpriseSG), the Enterprise Financing Scheme–Green (EFS-Green) helps businesses develop green practices, supporting corporate decarbonization and sustainable development. Under the EFS-Green scheme, the government assumes up to 70% of the loan risk, encouraging financial institutions to extend credit to qualifying SMEs. The supported projects encompass a broad range of sectors, including solar and energy-storage technologies, energy-efficiency solutions, electric vehicles, green maritime technologies, green building materials and technologies, as well as waste recycling, reuse, remanufacturing, and repair.

3. https://www.skrine.com/insights/alerts/january-2022/bank-negara-launches-low-carbon-transition-facilit

4. https://www.enterprisesg.gov.sg/resources/all-faqs/enterprise-financing-scheme--green

3. Thailand: Integrating Green Finance with Digital Platforms

The Bank of Thailand (BOT) has implemented several policies to support green and transition financing[5], requiring financial institutions to disclose green loan plans and targets, and to adopt a Green Taxonomy that directs capital toward environmentally sustainable projects. In addition, BOT has introduced environment-related data disclosure standards[6], prompting the Stock Exchange of Thailand (SET) to launch the digital SET Carbon platform[7], which aims to improve the transparency of corporate carbon footprint reporting and encourage the growth of green investment and financing. SET also signed a memorandum of understanding with the Department of Climate Change and Environment (DCCE) to establish an end-to-end data management ecosystem through SET Carbon from upstream data collection to downstream processing for green financial product development. Following BOT's policy framework, the Thai public and private sectors jointly established the National Green Data Platform[8], integrating and standardizing environmental data for risk assessment, investment, and product innovation.

Through these initiatives, which integrate financial policy with digital infrastructure, Thailand continues to strive for investment transparency and efficiency in green capital allocation, hence reducing barriers to corporate green transition.

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5. https://www.bot.or.th/en/financial-innovation/sustainable-finance/green.html
6. https://www.bot.or.th/content/dam/bot/financial-innovation/sustainable-finance/green/GreenDirectionalPaper-EN.pdf
7. https://www.aseanexchanges.org/content/set-and-partners-launch-set-carbon-to-advance-thailands-carbon-data-management/
8. https://www.bot.or.th/content/dam/bot/financial-innovation/sustainable-finance/green/GreenDirectionalPaper-EN.pdf

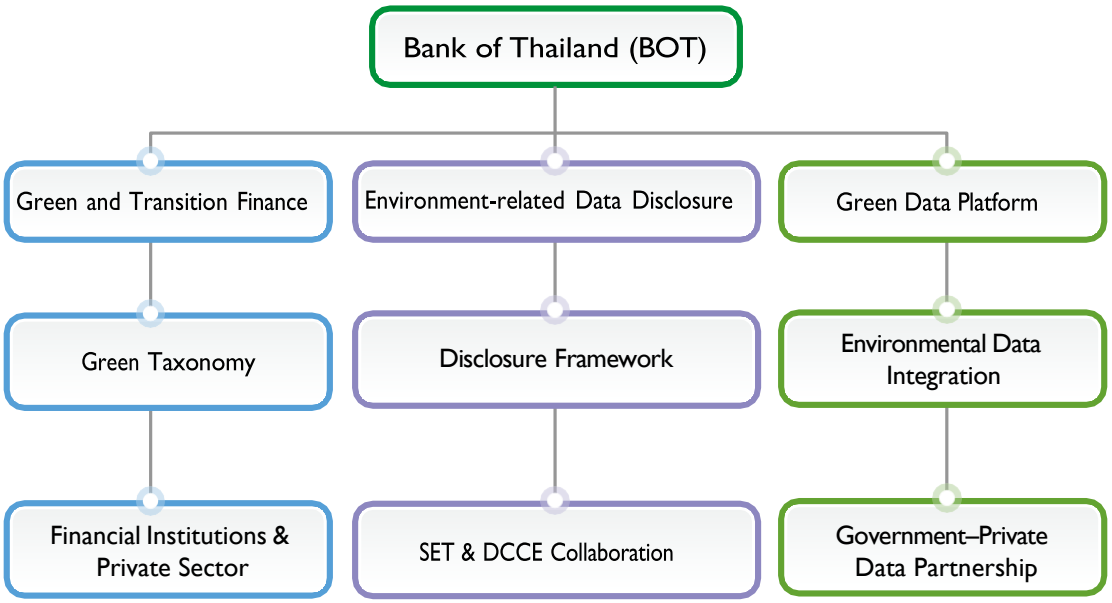

Figure 1: Bank of Thailand's Green Finance Framework

(ii) Digital Upgrading and Empowerment

1. Chinese Taipei: Net-Zero Transition for SME Revitalization

Chinese Taipei has launched the Revitalizing MSMEs through Net-Zero Transition initiative[9] to empower SMEs seeking to undergo green transition. The initiative is rooted in three key aspects:

(1) **Carbon reduction literacy and empowerment:** Features collaboration with various chambers of commerce and other industrial associations

9. https://english.ey.gov.tw/Page/61BF20C3E89B856/6748328f-b470-4aaa-9f80-bb6a0cb601a0

to organize carbon reduction seminars, enterprise study visits, and the production and dissemination of digital learning materials.

(2) **Carbon audits and diagnostics:** Provides businesses with industry-specific carbon estimation tools and connects them with a network of certified accountants to establish carbon ledgers and to utilize AI-based carbon management platforms.

(3) **Deep decarbonization:** Matches SMEs with Energy Service Companies (ESCOs) for professional consultation, diagnostics, and equipment-upgrade subsidies. Deep decarbonization is also incentivized, with subsidy levels being determined by actual energy savings performance.

2. Canada: Regional Artificial Intelligence Initiative (RAII)[10]

Canada's Regional Artificial Intelligence Initiative (RAII) supports the application of AI in energy management, sustainable agriculture, and clean-technology innovation. The initiative primarily provides support in two ways. The first focuses on AI productization and commercialization, assisting AI start-ups and growth-oriented enterprises in expanding their operations while addressing critical bottlenecks in transforming laboratory-based prototypes into market-ready solutions, including challenges related to capital access, human resource acquisition, data governance, and regulatory compliance. The second component emphasizes the adoption of AI in key industries, aiming to enhance SME productivity, growth, and competitiveness by helping them bridge

technical integration gaps and overcome skill shortages that hinder effective AI deployment.

Canada's 2024 federal budget saw the allocation of CAD200 million (approximately USD140 million) to the initiative, carried out by regional development agencies such as the Canadian Northern Economic Development Agency (CanNor). CanNor received CAD4.1 million (USD2.9 million) to fund AI projects in Northern Canada, benefiting businesses, non-profit organizations, Indigenous organizations, and all levels of government, and reflects an inclusive approach to advancing AI-driven low-carbon innovation across the region

3. Republic of Korea: Smart Manufacturing Innovation Policy[11]

Now entering its third phase in 2025, the Smart Manufacturing Innovation Policy was implemented under the Republic of Korea's Smart Manufacturing Industry Act. The policy calls for industrial automation and intelligent factory development based on digital transformation and is built on a tripartite model that underscores the interaction among the government, manufacturing SMEs, and specialized technology providers (Figure 2).

Under this framework, specialized technology providers share their expertise in building smart factories and offer digital transformation solutions to manufacturers, who then adopt and implement these

10. https://www.canada.ca/en/atlantic-canada-opportunities/services/regional-artificial-intelligence-initiative.html.

11. https://www.mss.go.kr/site/eng/ex/bbs/View.do?cbIdx=244&bcIdx=1055757.

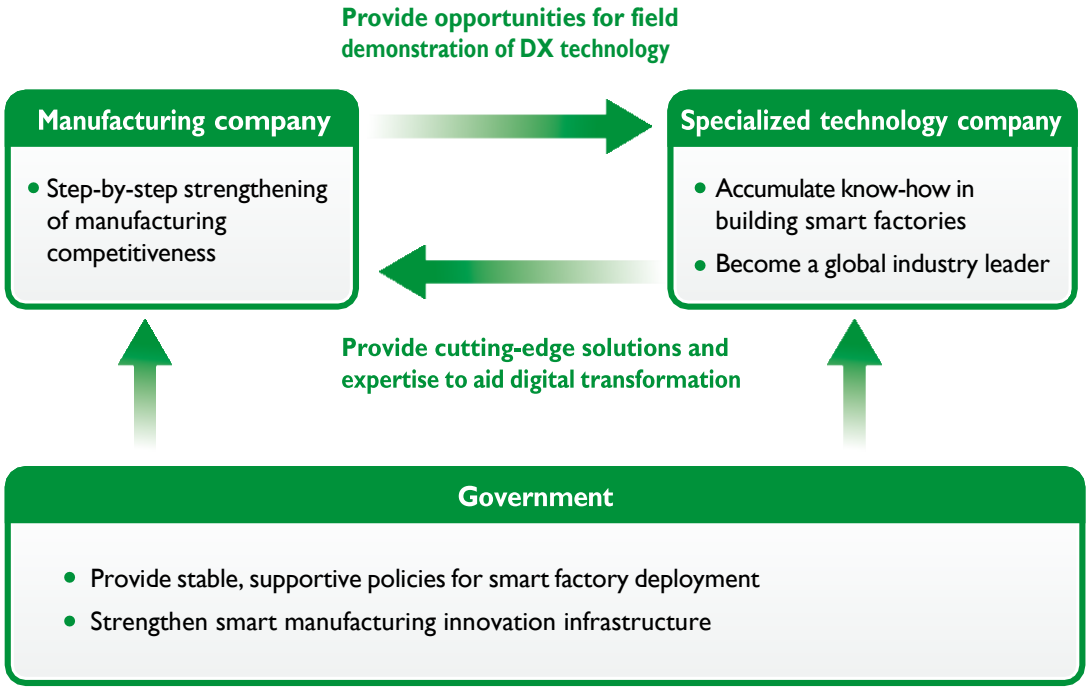

Figure 2: Korea's Tripartite Smart Innovation Model

technologies through pilot verification, gradually advancing from automation to autonomy.

The government is responsible for providing stable policy direction and infrastructure, offering three levels of smart manufacturing transformation support based on the digital maturity of each enterprise. Early-stage businesses are encouraged to adopt industrial robots and automation equipment and are given access to credit guarantees and financing programs. Intermediate enterprises receive assistance in deploying real-time data analytics systems and managing smart factory operations, supported by integrated services across research and development (R&D), marketing, and financing. Finally, advanced enterprises are guided toward building autonomous factories by

leveraging generative AI for process simulation, as well as developing collaborative data-sharing platforms.

4. Chile: Sustainable Growth for the Metropolitan Region 2025 program[12]

Chile's Sustainable Growth for the Metropolitan Region 2025 program (*Crece Sostenible Región Metropolitana 2025*) provides financial support to SMEs designing and implementing management plans that integrate sustainable technologies, with the objectives of improving corporate energy efficiency, reducing environmental impact, and strengthening operational capacity. Implemented by Chile's Technical Cooperation Service (SERCOTEC), the program has established restrictions on funding amount and usage—for instance limiting funds application to technical consulting and training, marketing improvement, and process optimization—ensuring that subsidized projects contribute to global sustainability goals.

SERCOTEC also launched the business improvement program *Mejora Negocios* [13], assisting micro and small enterprises in engaging technical consultants to provide guidance in digital tool adoption, waste reduction, energy efficiency, and renewable energy use. The scope of advisory services even extends to quality management certification, audit processes, cleaner production initiatives, and the optimization of manufacturing workflows.

12. https://www.sercotec.cl/crece-sostenible-region-metropolitana-2025/

13. https://www.sercotec.cl/mejora-negocios/

SECTION V

Conclusion

Conclusion

This study compares experiences from economies including Canada; Chile; Republic of Korea; Malaysia; Singapore; Chinese Taipei; Thailand; the United States; and Viet Nam, revealing that the adoption of AI and digital technologies has become a core driver of innovation and green transformation among APEC SMEs. However, most economies still face structural challenges pertaining to digital infrastructure, green investment motivation, supply chain integration, and capacity building, which collectively impede the widespread application of AI in APEC SMEs and consequently, its ability to provide these businesses with competitive advantages.

Drawing on these findings, this report provides two categories of recommendations— for MSMEs and for government agencies—to strengthen cross-economy cooperation and accelerate green transition in the APEC region.

(i) Recommendations for MSMEs

1. Implement Equipment Upgrading and Digital Energy Management

SMEs often contend with obsolete, energy-intensive equipment and inefficient use of production resources, resulting in higher operational costs and carbon emissions, as in the cases of Viet Nam's Minh Dang

Group and the United States' HARBEC, Inc. The experiences of these two firms have shown that adopting high-efficiency equipment and energy management systems in the production process can reduce excessive energy consumption while enhancing productive capacity and global competitiveness.

Recommended action:

SMEs should prioritize the replacement of outdated and energy-inefficient machinery and implement energy management systems or digital monitoring platforms to minimize energy waste and lower carbon emissions.

2. Leverage Government Resources and Green Finance

Insights from Malaysia's Duramitt Sdn Bhd and Viet Nam's Minh Dang Group indicate that access to low-interest loans and public subsidies help mitigate risks in biomass energy and high-efficiency equipment investments, expediting low-carbon transition. Yet, limited awareness of available public programs often leads to enterprises underutilizing governmental and financial support mechanisms.

Recommended action:

SMEs should actively seek and apply for government-funded green financing schemes, grants, and technical assistance programs to lower green transition costs and gain access to expert technical support.

3. Adopt Digital Tools and AI-Based Simulation

A considerable proportion of energy-intensive industries continue to rely on conventional physical production processes, resulting in low transformation efficiency and significant environmental impact. As demonstrated by Chinese Taipei's DigiFab platform, AI-based simulation and digital twin technology can significantly shorten product development cycles and minimize material and energy consumption during the production process.

Recommended action:

SMEs engaged in product design or sample-based manufacturing—such as those in the textile and apparel industries—should consider deploying AI simulation and digital twin tools to reduce material and energy consumption while enhancing market responsiveness.

(ii) Recommendations for Governments

1. Establish Shared Digital Platforms for Low-Carbon Tools

Significant disparities exist among enterprises in terms of access to carbon monitoring, energy management, and digital tools. Cross-economy collaboration can enhance the accessibility and adoption of such technologies.

Recommended action:

Governments of member economies are encouraged to jointly develop open-source or low-cost toolkits for energy monitoring, carbon accounting, and AI modeling across the region. Economies should also establish data interoperability standards and application programming interfaces (APIs) to reduce redundant development efforts and mitigate data fragmentation.

2. Promote Mutual Recognition of Standards and Capacity Building

It is evident from Minh Dang Group and HARBEC, Inc.'s experiences that standardized management systems and third-party certifications can enhance SME participation in international supply chains. However, cross-economy compliance remains a persistent challenge till this day.

Recommended action:

Governments of member economies should promote mutual recognition mechanisms for cross-economy certification based on established international standards such as ISO 50001, Superior Energy Performance (SEP™), and Product Carbon Footprint (PCF). These efforts should be complemented by regional training programs to reduce SME compliance costs.

3. Develop Supply Chain Mentorship and Technical Resource-Matching Mechanisms

The enterprise case studies and policy reviews in the preceding sections reveal that access to technology and policy support is critical to successful SME low-carbon transition. This is especially important as individual SMEs often lack the capacity to achieve low-carbon transitions independently.

Recommended action:

Policymakers should incentivize large enterprises and multinational brands to act as supply chain mentors and promote systematic programs that match enterprises with available industrial and technical resources, thereby improving the efficiency and scalability of SME low-carbon transformation.

4. Develop Cross-Economy Performance Evaluation and Data-Governance Frameworks

Findings from policy and case analyses reveal that inconsistent evaluation metrics and data fragmentation across APEC economies can impede the translation of financial investments into measurable competitive advantages in regional SMEs.

Recommended action:

Governments should design cross-economy key performance indicators (KPIs)—such as energy intensity reduction, carbon intensity improvement, and production cycle shortening ratios—and implement third-party auditing and data recognition mechanisms to ensure that financial and technological resources are managed under a results-oriented framework.

5. Strengthen Cross-Sector Collaboration (Enterprise–Public Sector)

The case analyses demonstrate that the effectiveness of technological and policy implementation in SMEs depends heavily on the availability of practical guidance and capacity-building support from both the industry and public institutions.

Recommended action:

Scenario-based pilot programs supported by various APEC frameworks should be organized regularly to help SMEs internalize policy and technical guidance within their operations. Feedback from subsequent real-world implementation should, in turn, inform the refinement of policy frameworks and strategic directions.

By strengthening cross-economy cooperation within the APEC framework and developing key policy instruments as regional public goods—such as a cross-economy platform for sharing best practices in green finance, open-access digital tools to encourage SME adoption,

and mutual recognition systems to enhance institutional coherence—member economies can collectively build a more inclusive, resilient, and interconnected green transition ecosystem.

Such coordinated efforts would not only enhance SME visibility and credibility in global supply chains but also lay the institutional groundwork for APEC economies to jointly advance the transition toward digitalization and decarbonization, ensuring sustainable and equitable growth across the region.