MAS-ESS ECONOMICS
ESSAY COMPETITION 2022

THE FUTURE OF SINGAPORE

What new industries could sustain and grow Singapore's economy, and create good jobs?

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Executive Summary

Climate change, ageing populations, and the fourth industrial revolution. These are 21st century forces of change that will deeply impact Singapore and the global economy. To remain relevant, competitive, and a bastion of economic excellence, Singapore should focus on three core industries.

Firstly, precision medicine offers an antidote to greying populations locally and abroad. Enabled by our strong healthcare infrastructure, advanced manufacturing capabilities and R&D instructure, Singapore will benefit from a larger, healthier labour force and precision medicine as an invaluable export in the long-run. Furthermore, elderly Singaporeans can stay competitive in our labour market. To stay ahead of foreign competitors and overcome regulatory barriers, Singapore should invest in productivity solutions and regulatory advisory for businesses.

Secondly, clean energy and technology power the global green transition. Singapore has established concrete transition plans, strong support services and a broad global network. Hence, Singapore is well-positioned to become a global green service and cleantech hub, which will create high-skill roles in niche specialisations. Nonetheless, Singapore must encourage further industry collaboration to surmount high upfront costs.

Lastly, digital supply chains form the backbone of the digital economy. As a pioneer in Industry 4.0 technologies equipped with a vibrant trade and logistics ecosystem, Singapore can spearhead digitalisation efforts to solidify our role as the nerve centre for regional trade and strengthen our supply chains. Thus, Singapore must adopt an industry-led approach to reorganise trade and logistics businesses and reskill workers to work alongside new technologies, rather than to be replaced by them. Additionally, Singapore should establish a regulatory sandbox to securely test and finetune promising technologies in real-life settings.

Overall, Singapore must create favourable regulatory, business and financial environments to seed emerging high-potential industries to continually generate vast economic value and high-quality jobs for Singaporeans.

Chapter 1: Introduction

Singapore's diverse, open economy calls for us to respond dynamically to ever-changing domestic and global conditions.

Figure 1: Singapore's maritime port that has continually anchored our economy yet rapidly evolved over the years

Today, three worrying trends have emerged: ageing populations, climate change and deglobalisation. However, these phenomena create new opportunities in precision healthcare, decarbonisation and supply chain digitisation. Hence, Singapore must steer its economic direction towards these fields to create value for our economy and workers and simultaneously cement the foundations for future growth.

Chapter 2: Precision Medicine

Introduction

Identified as a key pillar of Singapore's Research, Innovation and Enterprise 2025 plan, Precision Medicine (PM) is a rapidly-growing industry that will revolutionise traditional approaches to healthcare.

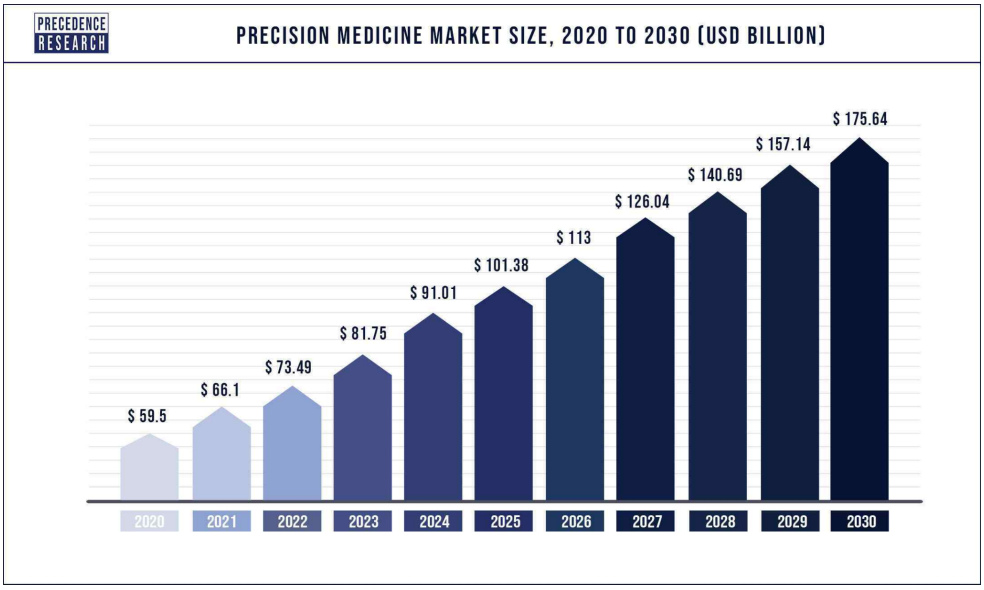


Figure 2: Expected growth of the global PM market with a CAGR of 11.5% from 2022 to 2030[1]

PM involves analysing vast amounts of data using genomics and Artificial Intelligence (AI) to identify key biomarkers associated with certain illnesses and biological responses. This grants healthcare providers with deeper insights into patients' unique medical profiles, allowing them to offer better diagnostics and early-stage prophylaxis. Hence, patients can receive personalised treatment and minimise healthcare costs by avoiding unnecessary treatments.

[1] Precedence Research, "Precision Medicine Market Size, Share, Report 2022 to 2030," n.d., https://www.precedenceresearch.com/precision-medicine-market.

Opportunities

As most Developed Countries (DCs), including Singapore, face an ageing population and rising healthcare costs,[2,3] Singapore should capitalise on PM for domestic use and export.

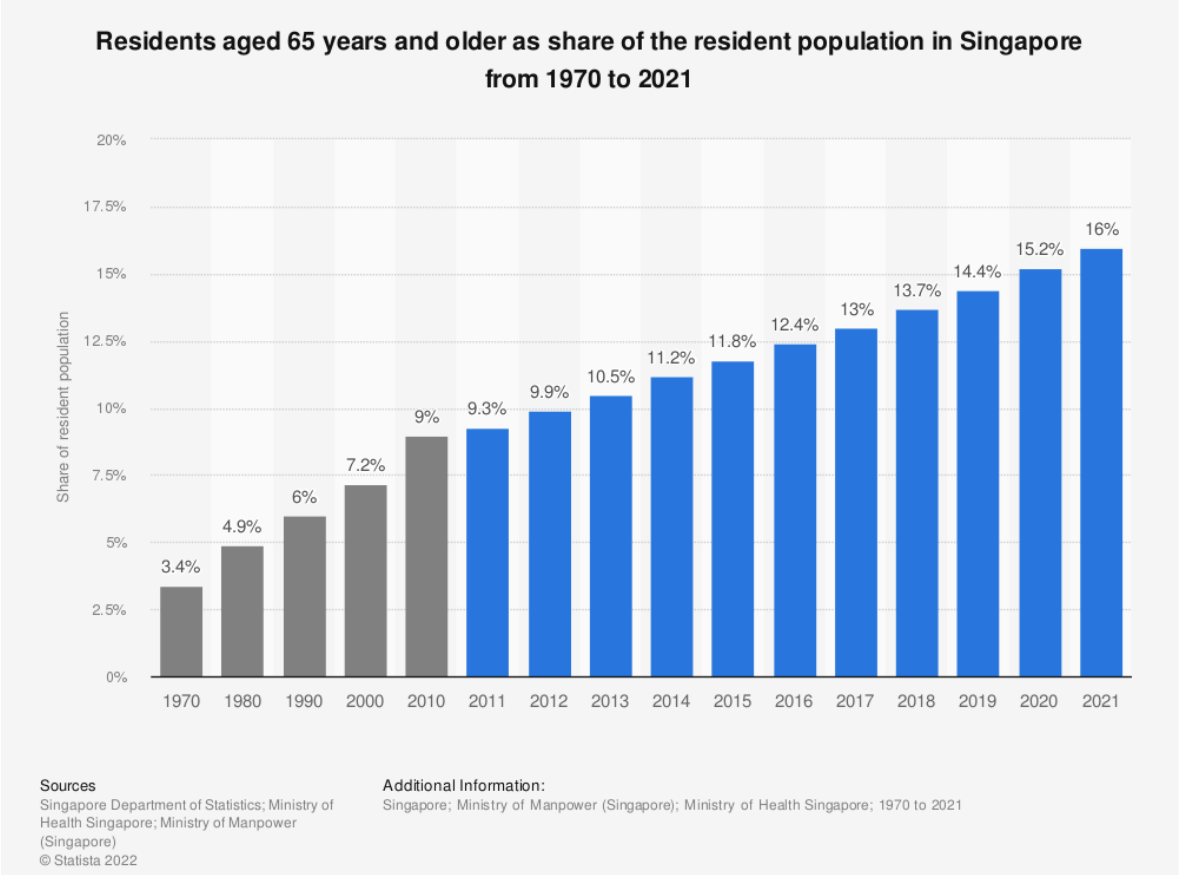


Figure 3: Singapore's rising percentage of elderly in our population[4]

A Resilient Workforce

Although elderly workers make up a growing share of our workforce, they are vulnerable to developing chronic medical conditions. However, by tackling their ailments early and incisively through PM, older workers can reduce downtime and raise their

[2] The Singaporean Department of Statistics reports that Medical & Dental Treatment costs have increased by 78% over the last 2 decades

[3] AIA, "Fighting Healthcare Inflation in Singapore | Life Matters," n.d., https://www.aia.com.sg/en/life-matters/money/fighting-healthcare-inflation-in-singapore.html.

[4] Raudhah Hirschmann, "Singapore: Elderly Share of Resident Population 1970-2021 | Statista," Statista, May 11, 2022, https://www.statista.com/statistics/1112943/singapore-elderly-share-of-resident-population/.

working-life-expectancy. Furthermore, by avoiding prolonged and costly treatments, employers' healthcare bills are lower[5]. Hence, coupled with their work experience, they can retain well-paying jobs across all industries. Furthermore, a greater LFPR[6] and lower medical costs keeps Singapore's labour force competitive to continually attract FDIs — a key economic driver.[7]

Exporting Precision Medicine

8 of our top 10 trading partners are considered ageing countries[8,9] and many of these countries have also started integrating genomics into their healthcare programmes[10].

[5]Elizabeth J J Berm et al., "Economic Evaluations of Pharmacogenetic and Pharmacogenomic Screening Tests: A Systematic Review. Second Update of the Literature," *PLOS ONE* 11, no. 1 (January 11, 2016), https://doi.org/10.1371/journal.pone.0146262.

[6] Labour Force Participation Rate (LFPR) refers to the proportion of residents of working age that are economically-ative

[7] Penelope B. Prime, "Utilizing FDI to Stay Ahead: The Case of Singapore," *Studies in Comparative International Development*, no. 47 (April 28, 2012): 139–60, https://doi.org/10.1007/s12116-012-9113-8.

[8]United Nations, *World Population Ageing 2019 Highlights* (United Nations, 2019).

[9]Department of Statistics, "Singapore's International Trade," 2022, https://singstat.gov.sg/modules/infographics/singapore-international-trade#:~:text=In%202022%2C%20Mainland%20China%2C%20Malaysia,exports%20to%20these%20trading%20partners.&text=Made%20up%2083.0%25%20of%20non-oil%20domestic%20exports.

[10]Precision Health Research, Singapore (PRECISE), "Why We Do It - Precision Health Research, Singapore (PRECISE)," May 19, 2021, https://www.npm.sg/about-us/why-we-do-it/.

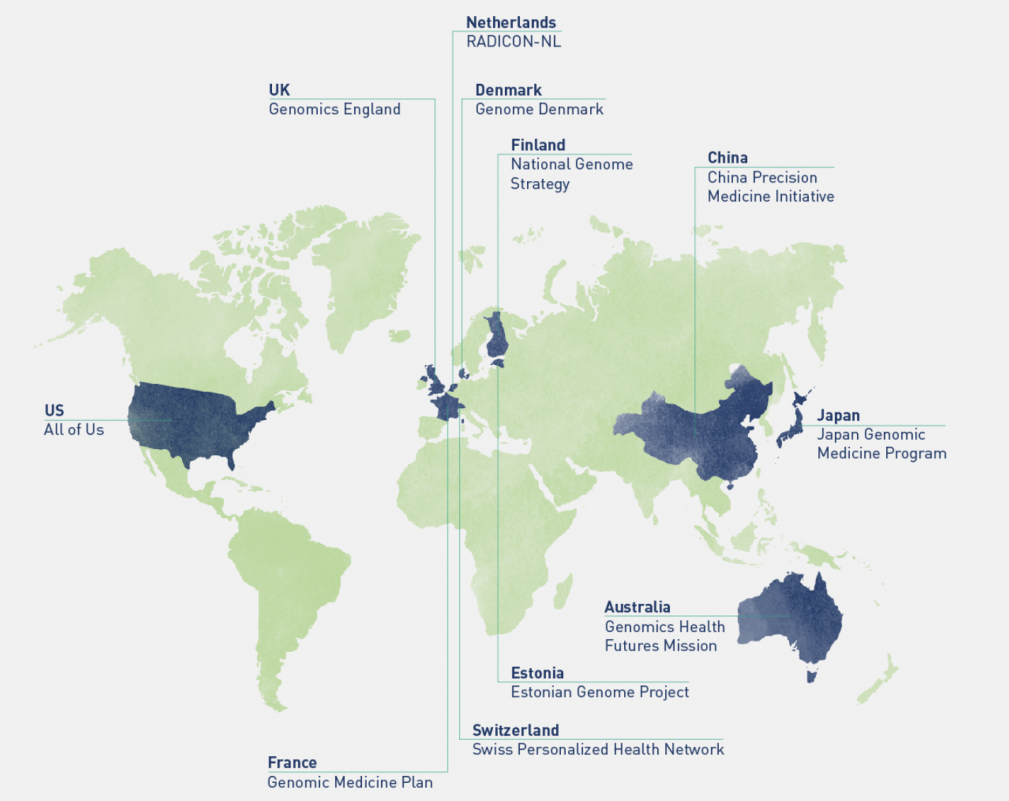


Figure 4: Precision Medicine efforts around the world including several major trade partners[11]

As foreign demand surges, our National Precision Medicine (NPM) programme highlights PM as an attractive export vertical. Being a highly technical yet nascent field, Singapore's PM industry has vast growth potential. Hence, it can bolster our flourishing export-driven biopharmaceuticals industry and create many high-value jobs[12] for Singaporeans.

[11]*Precision Health Research, Singapore (PRECISE), "Why We Do It - Precision Health Research, Singapore (PRECISE)."*

[12]Such jobs span across a broad range of skill sets; examples include biomedical researchers, engineers, quality control specialists and supply chain managers

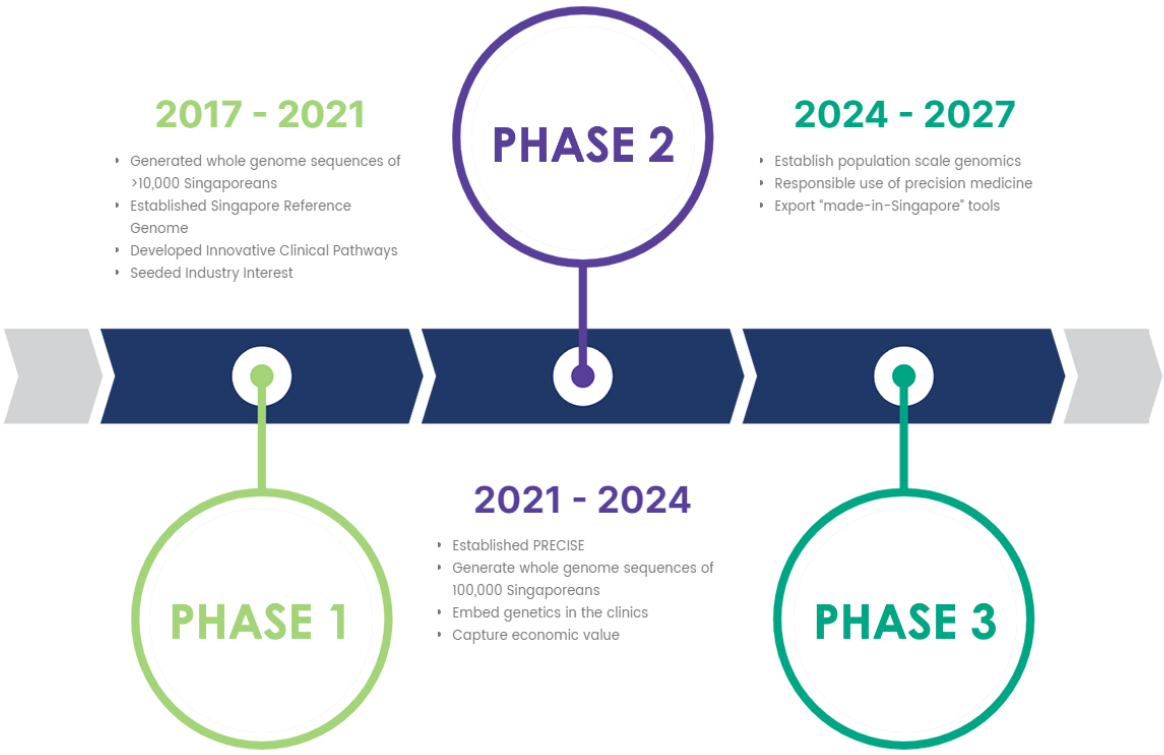


Figure 5: Roadmap of our National Precision Medicine strategy[13]

[13]Precision Health Research, Singapore (PRECISE), "Our Story - Precision Health Research, Singapore (PRECISE)," July 16, 2021, https://www.npm.sg/about-us/our-story/.

Our Advantage

Singapore is uniquely positioned to seamlessly integrate into our healthcare system and specialise in its development and manufacturing.

Robust Healthcare System

Singaporeans' healthcare data is currently well-connected by our NEHR[14] system. Soon, more population-level genetic data will be collected[15] and safeguarded[16] by the NPMDAC[17]. These services are easily accessible by both healthcare providers and patients. Moreover, Singapore's universal healthcare coverage guarantees PM's accessibility to all, especially the most in-need.

[14] National Electronics Health Record
[15]Precision Health Research, Singapore (PRECISE), "Our Story - Precision Health Research, Singapore (PRECISE)."
[16]A-Star Genome Institute of Singapore (GIS), "National Precision Medicine (NPM) Programme," n.d., https://www.a-star.edu.sg/gis/our-science/precision-medicine-and-population-genomics/npm.
[17] NPM Data Access Committee

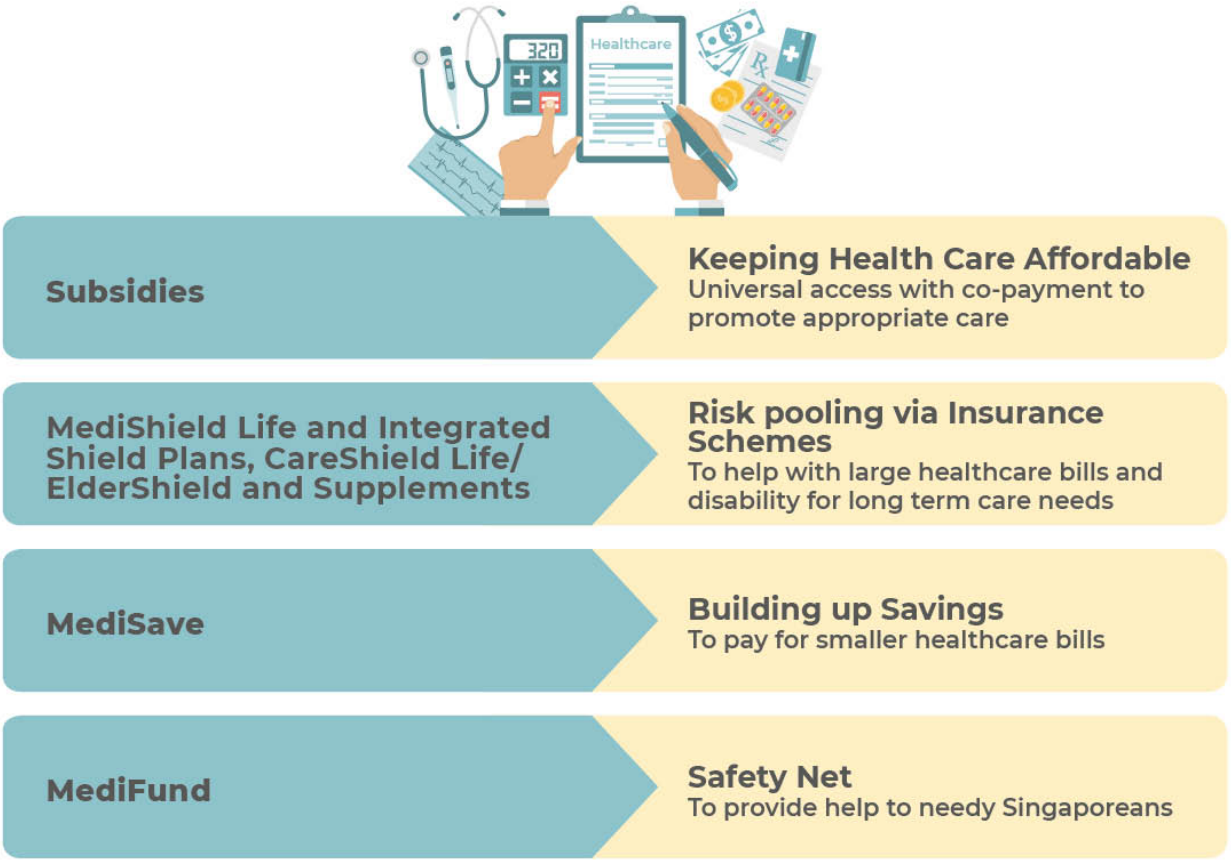


Figure 6: Infographic on Singapore's comprehensive public healthcare financing schemes[18]

Well-established R&D and Manufacturing Infrastructure

A*STAR's Genome Institute of Singapore will continue to release comprehensive genomics datasets like SG10K[19] and SG100K[20,21], while the Precision Health Research

[18]CPF Board, "CPFB | Healthcare for Young People," April 20, 2020, https://www.cpf.gov.sg/member/infohub/educational-resources/healthcare-for-young-people.
[19] SG10K_Health is a genome dataset that comprises 10,000 sequences from healthy Chinese, Indian, and Malay volunteers that represents approximately 80% of Asia's genetic variations
[20] SG100K will be an expanded version of SG10K that includes the genetic data of 100,000 healthy Singaporeans alongside up to 50,000 Singaporeans with specific diseases
[21]Agency for Science, Technology and Research, "To 100,000 and beyond: Scaling the Singapore Genetic Databank," April 7, 2021, https://www.a-star.edu.sg/News/astarNews/news/features/to-100-000-and-beyond-scaling-the-singapore-genetic-databank-with-analytics-and-ai-technologies.

Singapore (PRECISE) promotes public-private partnerships and clinical trials[22,23] to test applications of PM innovations.

Singapore is home to some of the world's most advanced biopharmaceuticals manufacturing facilities[24,25], granting us a cost and time advantage in establishing PM production lines. Moreover, Singapore has FTAs with the world's largest producers of inputs[26] and end-markets for PM therapies[27,28], with several major pharmbio companies in Singapore already expressing interest in PM[29].

With advantages in R&D, manufacturing and export potential, Singapore can springboard PM breakthroughs.

[22]Precision Health Research, Singapore (PRECISE), "Collaboration Models - Precision Health Research, Singapore (PRECISE)," April 13, 2021, https://www.npm.sg/collaborate/collaboration-models/.
[23]Precision Health Research, Singapore (PRECISE), "Clinical Implementation Pilots - Precision Health Research, Singapore (PRECISE)," November 25, 2022, https://www.npm.sg/cip/.
[24]Scientific American, "Scientific American WorldVIEW - a Global Biotechnology Perspective," 2013, https://static.scientificamerican.com/wv/assets/2016_SciAmWorldView.pdf.
[25]Aradhana Aravindan, "Pharma Exports a Rare Bright Spot for Singapore Economy as Pandemic Drives Demand," *Reuters*, May 27, 2020, https://www.reuters.com/article/health-coronavirus-singapore-pharmaceuti-idUSL4N2D8199.
[26]Typical inputs used to manufacture cell and gene therapies include cell lines, viral vectors, specialised equipment and chemicals
[27]Examples of such end-markets and input producers include China, Germany, Switzerland and the US; these countries are also among our top 10 trading partners
[28]Ministry of Trade and Industry, "Free Trade Agreements," MTI, n.d., https://www.mti.gov.sg/Trade/Free-Trade-Agreements.
[29]Such companies include Novartis, AstraZeneca, GlaxoSmithKline, Illumina and Thermo Fisher Scientific

Challenges

Foreign Competition

Singapore faces strong competition from incumbents[30], and emerging players[3132]. However, our limited population forces PM firms to compete in foreign markets and face tight labour supply. Alongside land constraints, Singapore may face cost disadvantages and struggle to scale.

Regulatory Barriers

Safety and privacy concerns have impelled global regulators to enforce stringent medicine approval and data-sharing standards[33], and limited access to foreign data will impede PM research. Meanwhile, tighter approval processes will restrict foreign market access and increase compliance costs[34]. With a small domestic market, PM firms in Singapore are forced to swallow these high barriers to entry.

[30]Mordor Intelligence, "Precision Medicine Market Size & Share Analysis - Industry Research Report - Growth Trends," 2023, https://www.mordorintelligence.com/industry-reports/precision-medicine-market.
[31]Jennifer L. Schenker, "China Leaps Ahead In Precision Medicine - The Innovator News," *Medium*, December 11, 2021, https://innovator.news/china-leaps-ahead-in-precision-medicine-72cfc469df3d.
[32]Examples of existing major players include the US, Japan and Germany while rising players include Cgina
[33]McKinsey&Company, "Precision Medicine - Opening the Aperture," 2018, https://www.mckinsey.com/~/media/mckinsey/industries/pharmaceuticals%20and%20medical%20products/our%20insights/precision%20medicine%20opening%20the%20aperture/precision-medicine-opening-the-aperture.pdf.
[34] These may include conducting clinical trials and hiring compliance staff.

Recommendations

Investing in Productivity

Our limited land and workforce impels us to rely on productivity as our primary growth engine. Hence, Singapore must further engage the private sector to induce greater capital investment alongside technological and skills transfers that are indispensable for catching up to our foreign competitors.

Firstly, Singapore should introduce an accelerated depreciation[35] scheme to minimise the initial capex of up-to-date PM equipment, which typically incur high upfront costs, in a budget-neutral manner. This will help existing PM firms incorporate modern technologies into their facilities while lowering financial barriers for new firms to enter Singapore.

Secondly, Singapore should offer tax deductibles for in-house training costs. This incentivises PM firms to teach Singaporean employees technical know-hows consolidated from their overseas branches and shift high-skill operations to Singapore. This will increase our long-term workforce productivity, thereby improving Singaporeans' competitiveness and job quality while increasing our export value.

By upgrading workers and technologies, firms benefit from higher-quality research findings and greater value-added products. This will allow Singapore to specialise in niche, high-end markets with lower competition and thus larger margins. Thus, Singapore can maximise the economic value generated from its limited resources for firms and workers.

[35]Accelerated depreciation is a tax incentive that allowing firms to claim a larger portion the depreciation cost of an asset earlier in its useful life, in contrast to the typical straight-line depreciation where depreciation costs are evenly distributed over an asset's useful life

Regulatory Advisory

As a founder of GA4GH[36] and active member of ICH[37], Singapore is heavily-involved in harmonising international standards for genetic data and drug development. With decades of experience in major biopharmaceuticals markets, Singapore is particularly well-equipped to offer legal advisory to PM firms. This will minimise firms' compliance costs and time lags while broadening their access to global markets, allowing them gain a first-mover's advantage in otherwise inaccessible markets, which will be a significant pull factor for foreign PM firms.

[36]The Global Alliance for Genomics and Health (GA4GH) is an international non-profit involving over 600 organisations to create frameworks for the secure, responsible and ethical sharing of genomic data

[37]The International Conference on Harmonisation of Technical Requirements for Registration of Pharmaceuticals for Human Use (ICH) brings together global regulatory authorities and pharmaceutical industry representatives to establish drug development standards in various aspects, including quality, safety, and efficacy.

Chapter 3: Clean Energy and Cleantech

Introduction

Identified as one of Singapore's strategic growth areas[38], clean energy and cleantech are major growth industries crucial to Singapore's economic competitiveness.

[38] National Climate Change Secretariat, "Clean Technology," n.d., https://www.nccs.gov.sg/singapores-climate-action/clean-technology/.

Opportunities

Singapore can establish itself as a regional hub in the R&D of cleantech. Firstly, there is a growing demand for cleantech by regional trading partners.[39] Making large strides in the still-nascent fields of CCUS and green hydrogen would grant Singapore the first-mover advantage.

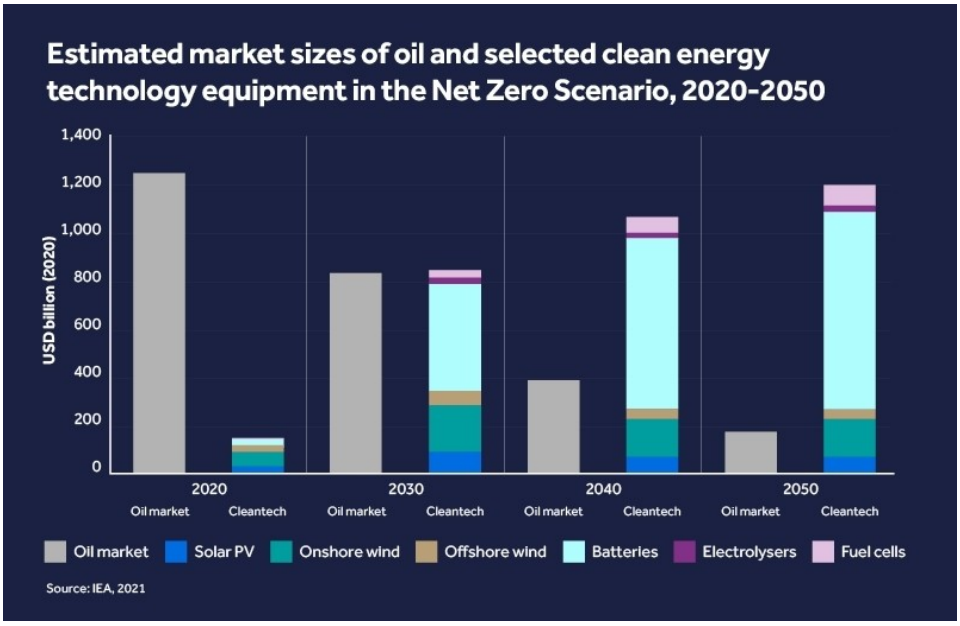


Figure 7: Cleantech is projected to experience strong growth in the next decades[40]

Singapore can also become greenification centre[41] by taking advantage of the synergistic relationship between sustainable technologies. For example, advanced R&D in solar panels may aid the development of more efficient electric vehicles which run on solar power.[42]

[39] Renewable investments in APAC are set to double by 2030 and the regional RE sector set to grow at a compounded annual growth rate of 7.4% (D'Arshot, 2023).
[40]IEA, "Estimated Market Sizes of Oil and Selected Clean Energy Technology Equipment in the Net Zero Scenario, 2020-2050 – Charts – Data & Statistics - IEA," October 16, 2022, https://www.iea.org/data-and-statistics/charts/estimated-market-sizes-of-oil-and-selected-clean-energy-technology-equipment-in-the-net-zero-scenario-2020-2050.
[41] This may refer to adopting more environmentally friendly practices, or improving energy efficiency.
[42] World Economic Forum, "Can You Solar-Charge Your Electric Vehicle? Yes, Say Experts," January 8, 2022, https://www.weforum.org/agenda/2022/01/could-solar-energy-power-an-electric-vehicle-future/.

Advancements in the green economy will create high-value jobs[43]. In 2021, clean energy accounted for virtually all of the growth in energy employment,[44] which employs above-average levels of high-skilled labour.

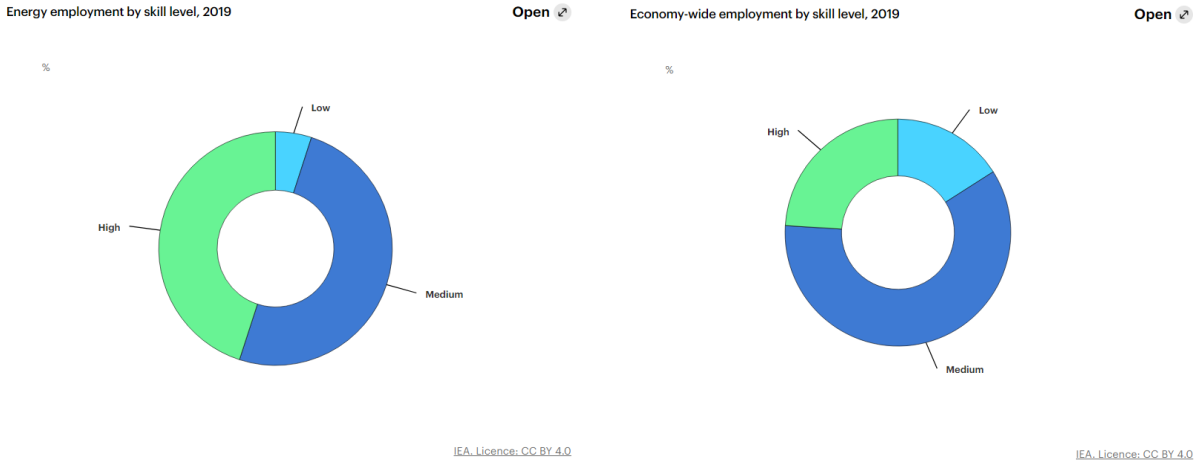


Figure 8: Comparison of employment by skill level across the economy (left) and in the energy sector (right)

[43] These may range from sustainable engineering and regulatory advisory, to green data analytics and technology road mapping.
[44] IEA, "Overview – World Energy Employment – Analysis - IEA," 2022, https://www.iea.org/reports/world-energy-employment/overview.

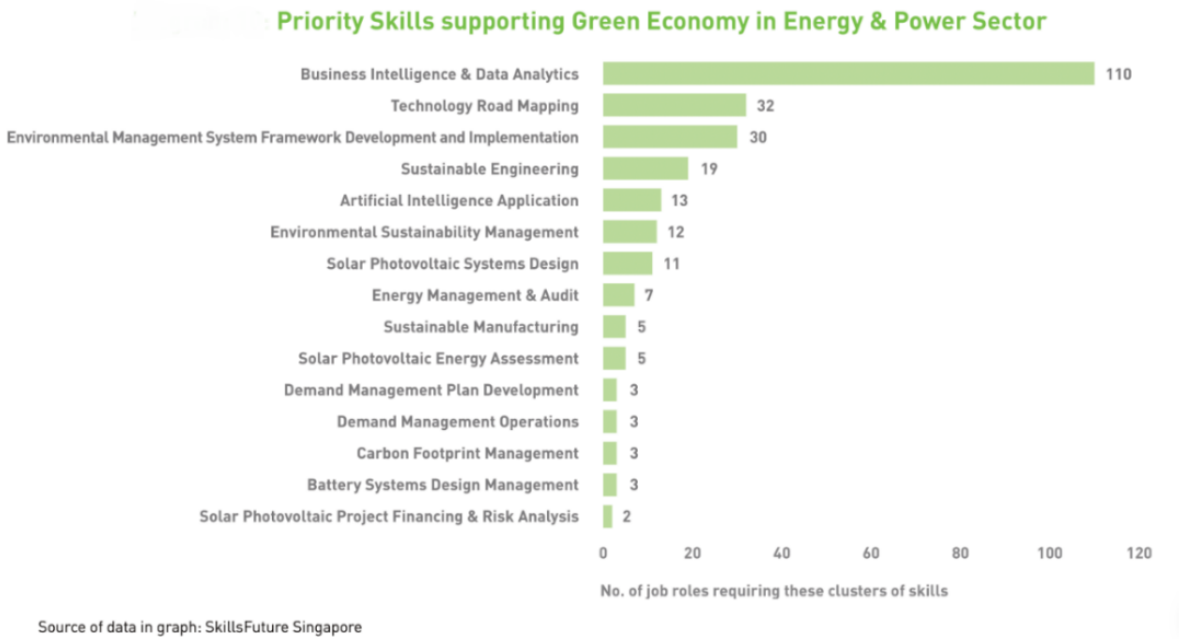


Figure 9: In green industries such as the renewable energy sector, high value-adding jobs such as those involving data analytics and framework development will be in demand[45]

[45] SkillsFuture Singapore, "The Green Economy Explained: Trends, Skills & Jobs You Need to Know About | Myskillsfuture.Gov.Sg," December 15, 2022, https://www.myskillsfuture.gov.sg/content/portal/en/career-resources/career-resources/job-skills-insights/the-green-economy-explained--trends--skills---jobs-you-need-to-k.html.

Our Advantage

Singapore's recognition of the importance of sustainability with the Green Plan 2030 sets up the cleantech sector for future growth. Increased demand for sustainable technology locally fosters a more favourable environment for technological advancements.

Figure 10: Singapore's Green Plan 2030

Prospective investors may benefit from research grants, like the LCER-FI,[46] The E2F[47] and the REG(E)[48] schemes provide businesses with an excellent opportunity to kickstart their sustainability transition.

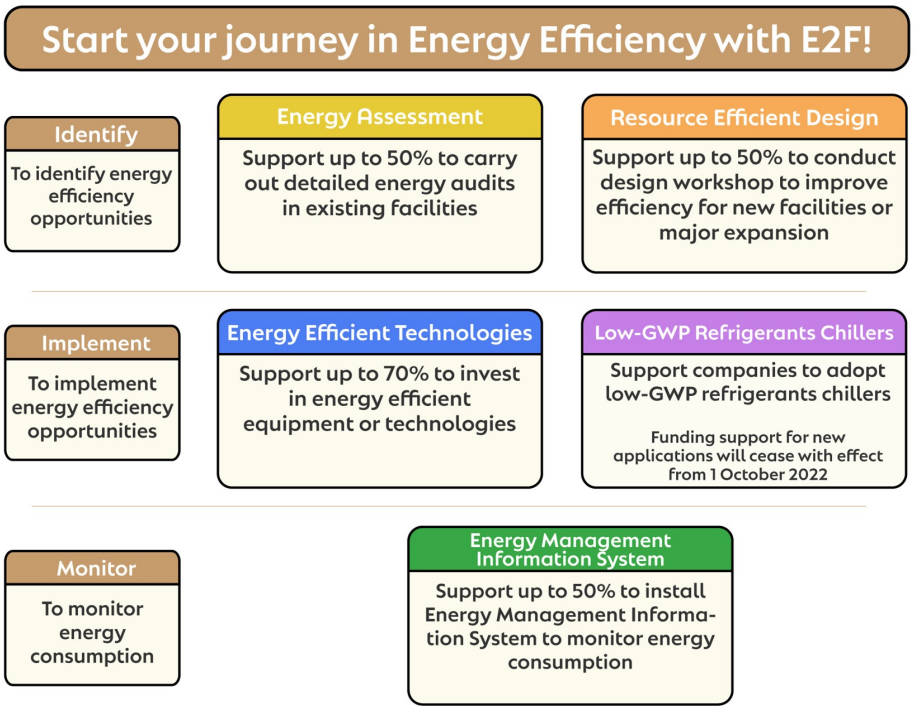


Figure 11: Grants provided by the E2F

Furthermore, Singapore is establishing a robust green financing ecosystem to accelerate the development of sustainable projects. The MAS green finance plan[49] encourages sustainable investments,[50] reducing capital costs and stimulating green

[46] The Low-Carbon Research Funding Initiative aims to develop low-carbon energy technologies in the domains of hydrogen and carbon capture, utilisation, and storage (CCUS), to support the decarbonisation of the power and industry sectors. SGD 55 million was awarded to 12 selected projects in 2021.
[47] The Energy Efficiency Fund (E2F) is an umbrella scheme consisting of 5 different grants to support businesses with industrial facilities to improve energy efficiency.
[48] The Resource Efficiency Grant for Emissions (REG(E)) aims to encourage improvement in energy efficiency of manufacturing facilities and data centres.
[49] Monetary Authority of Singapore, "MAS Green Finance Action Plan," Press release, June 30, 2022, https://www.mas.gov.sg/-/media/MAS-Media-Library/development/sustainable-finance/without-retail-ESG-funds-GFAP-Infographic_June-2022.pdf?la=en&hash=B49713D36266B8D8EF3CA8EEBD0FEFFD9ACBDAA0.
[50] The action plan makes use of green bonds and awards green investment mandates to asset managers.

investment. In the private sector, a strong network of professional services firms are available to handle complex legal and regulatory matters[51].

[51] These may include compliance requirements, or other necessary services for the development of the sector such as carbon accounting and sustainability accounting and reporting.

Challenges

Developing the nascent cleantech sector requires a relatively-high initial capex, for expenses including R&D, equipment and specialised expertise.[52] However, given its uncertain outcomes, investors may be apprehensive about committing to cleantech projects, stifling its growth.

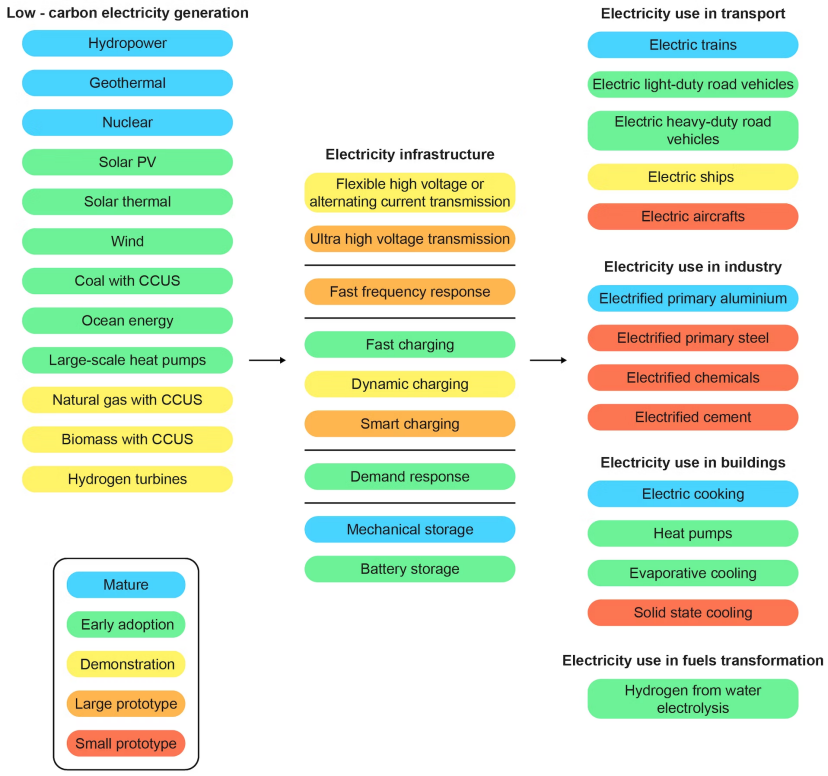


Figure 13: Novel Cleantech technologies remain relatively underdeveloped[53]

[52] The average cost per megawatt-hour of installing a solar system in 2017 was more than double that of installing a new natural gas plant (Union of Concerned Scientists, 2014).
[53] IEA, "Innovation Needs in the Sustainable Development Scenario – Clean Energy Innovation – Analysis - IEA," 2020, https://www.iea.org/reports/clean-energy-innovation/innovation-needs-in-the-sustainable-development-scenario.

On the demand side, Singapore's limited land area heavily limits domestic demand for alternative energy sources[54]. Hence, cost savings from large-scale infrastructural and R&D investments will likely be minimal, making it difficult to justify the high initial cost.

[54] In a 2020 report, the Solar Energy Research Institute of Singapore (SERIS) estimated Singapore has the potential to deploy up to 8.6 Gigawatt-peak (GWp) of solar energy by 2050 – only around 10 percent of the nation's projected electricity demand then. Singapore's main energy source is hence likely to continue to be imported natural gas in the near future.

Recommendations

To accelerate the development of novel cleantech and construct clearer investment timelines, Singapore should explore more pathways for industry collaboration. Existing projects including that of the Punggol EcoTown[55] and CleanTech Park[56], but a more structured platform is required to encourage further industry collaboration that involves greater private sector participation. Singapore may adopt the structure of the IEA's TCP[57] for its domestic use, whereby international collaboration in research of groundbreaking cleantech is fostered across a multitude of energy sectors (see **Annex**).

Figure 14: JTC CleanTech One, located in Cleantech Park

Such collaborations help promising cleantech products to attract funding and guidance from industry experts to expedite their commercialisation.[58]

[55] Housing & Development Board, "HDB | Eco@Punggol," n.d., https://www.hdb.gov.sg/community/practising-ecoliving/eco-punggol#:~:text=Punggol%20is%20Singapore's%20first%20eco,%2C%20water%2C%20and%20waste%20management.
[56] Enterprise Singapore, "JTC CleanTech Park," n.d., https://www.enterprisesg.gov.sg/grow-your-business/partner-with-singapore/infrastructure/notable-projects/cleantech-park.
[57] The Technology Collaboration Programme (TCP) involves collaborations between over 6 000 experts worldwide who represent nearly 300 public and private organisations located in 55 countries, including many from IEA Association countries such as China, India and Brazil.
[58] Steve Akman, "Investing in Clean Tech: Opportunities and Challenges," TD Securities, June 18, 2022, https://www.tdsecurities.com/ca/en/investing-in-clean-tech.

We posit that a greater degree of industry collaboration spreads technical risk, and enables the reaping of cost savings through pooled resources and access to global markets; this would allow for a more consistent flow of investments into the cleantech sector over the long term.

Chapter 4: Supply Chain Digitisation

Introduction

Technological advances in areas like Internet of Things (IoT), Artificial Intelligence (AI) and blockchain, are revolutionising international commerce today. Singapore must take advantage of these developments to remain a leading Trade & Logistics (T&L) hub, a key enabler of our export-oriented economy.

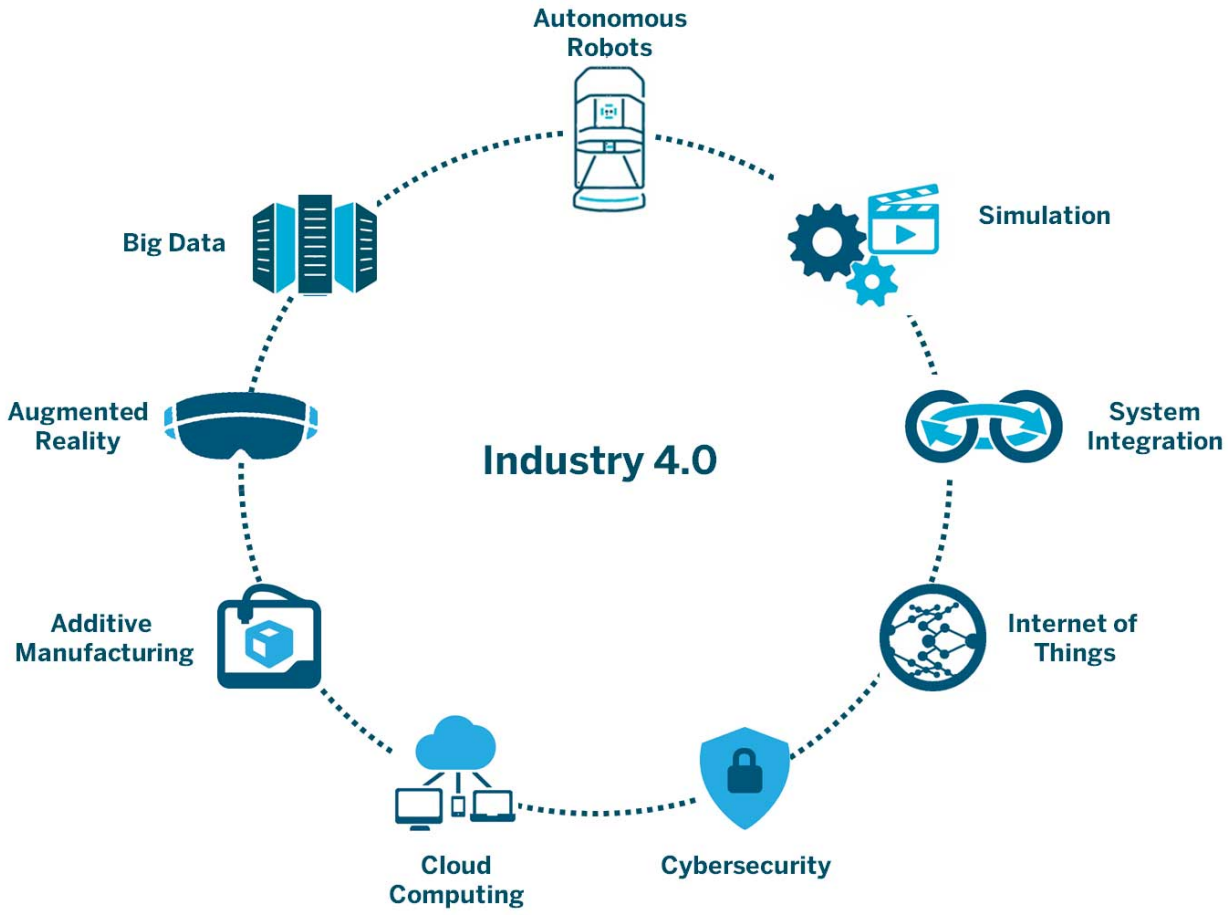


Figure 15: Industry 4.0 (4IR) capabilities[59]

[59]Tony Melanson, "What Industry 4.0 Means for Manufacturers," *Aethon*, November 7, 2018, https://aethon.com/mobile-robots-and-industry4-0/.

Opportunities

Recent supply shocks, including the COVID-19 pandemic and the Russo-Ukrainian war, have severely disrupted global value chains.[60] Governments have begun prioritising self-sufficiency, looking closer to home and trusted partners amidst a global trend towards deglobalisation.[61]

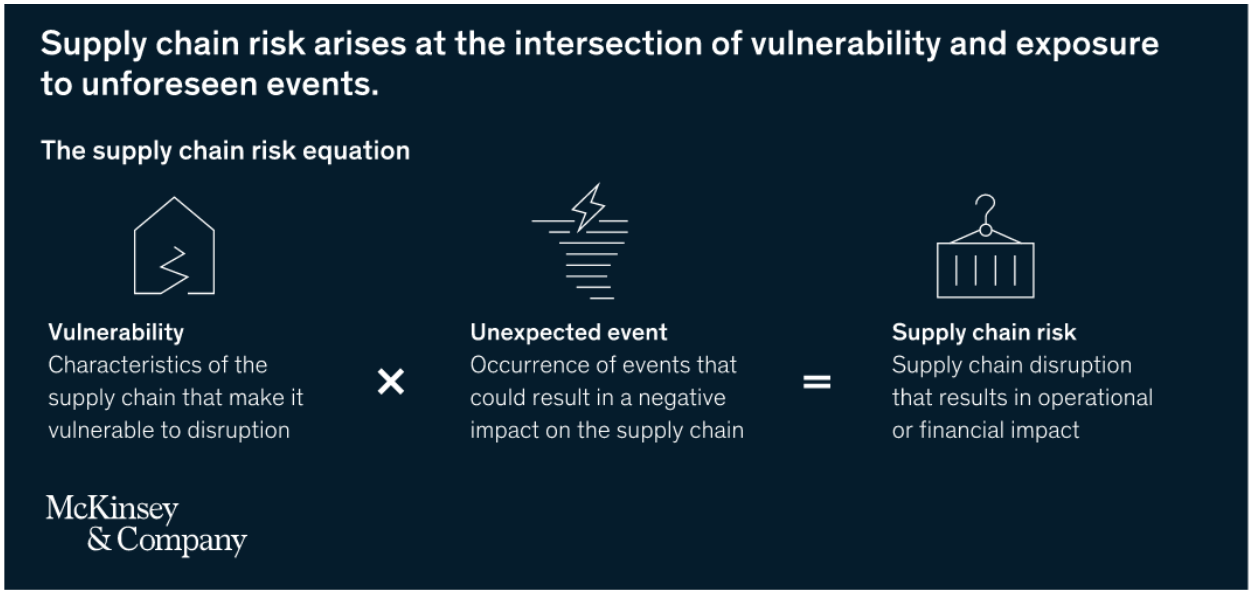


Figure 16: Origins of supply chain disruptions[62]

[60]Christian Keller and Renate Marnold, "Deglobalisation: Here's What You Need to Know," World Economic Forum, January 18, 2023, https://www.weforum.org/agenda/2023/01/deglobalisation-what-you-need-to-know-wef23/.
[61] Keller and Marnold, "Deglobalisation: Here's What You Need to Know."
[62]Jan Heinrich et al., "Future-Proofing the Supply Chain," McKinsey & Company, June 14, 2022, https://www.mckinsey.com/capabilities/operations/our-insights/future-proofing-the-supply-chain.

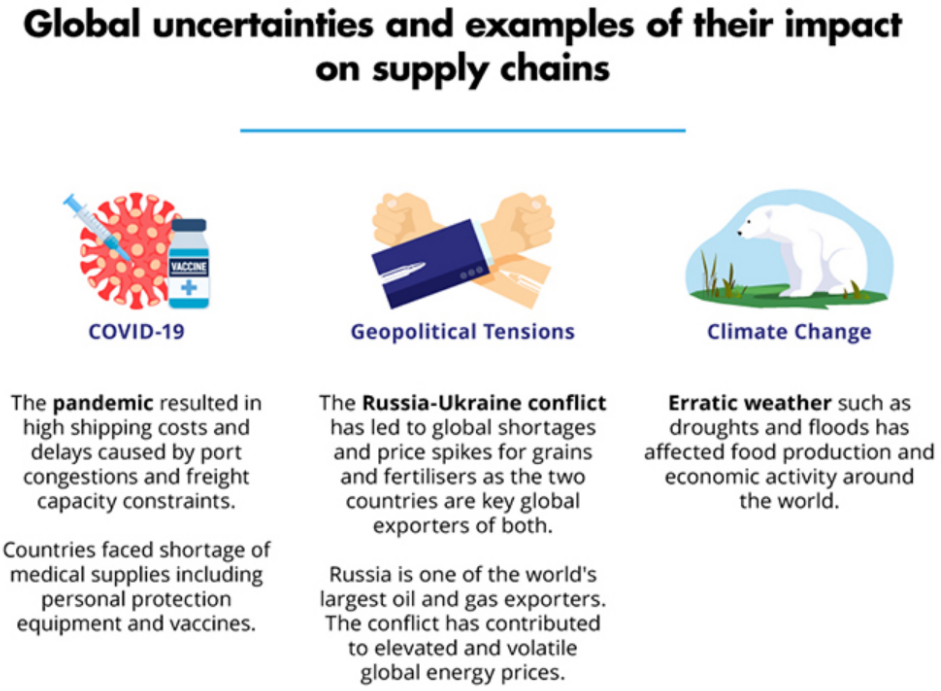


Figure 17: Key risks to global supply chains[63]

By digitising and fully integrating their supply chains using technologies like IoT, businesses can gain real-time insights into the performance of their suppliers and inventories[64], anticipating customer needs and reacting to sudden disruptions[65]. This significantly reduce resource wastage. Furthermore, automated supply chains reduce processing and communication costs. This will attract participants along all stages, keeping Singapore as a key node in global value chains[66].

[63] Singapore Public Sector Outcomes Review, "Strengthening Our Supply Chain Resilience," SPOR, n.d., https://www.mof.gov.sg/singapore-public-sector-outcomes-review/citizens/our-shared-future-and-place-in-the-world/strengthening-our-supply-chain-resilience.
[64]RiskOptics, "5 Benefits of the Digital Supply Chain & How to Implement One at Your Company," February 4, 2022, https://reciprocity.com/blog/benefits-of-a-digital-supply-chain/.
[65]Ernst & Young Singapore, "Study of the Impact of Industry 4.0 on Singapore's Logistics Workforce," 2020, https://www.wsg.gov.sg/docs/default-source/content/logistics-sector.pdf?sfvrsn=4f4048de_1.
[66] Andrew Allen, "Singapore's Plan to Be Part of Supply Chains in a 'World of Flux,'" Supply Management, September 14, 2022, https://www.cips.org/supply-management/news/2022/september/singapores-plan-to-be-part-of-supply-chains-in-a-world-of-flux/.

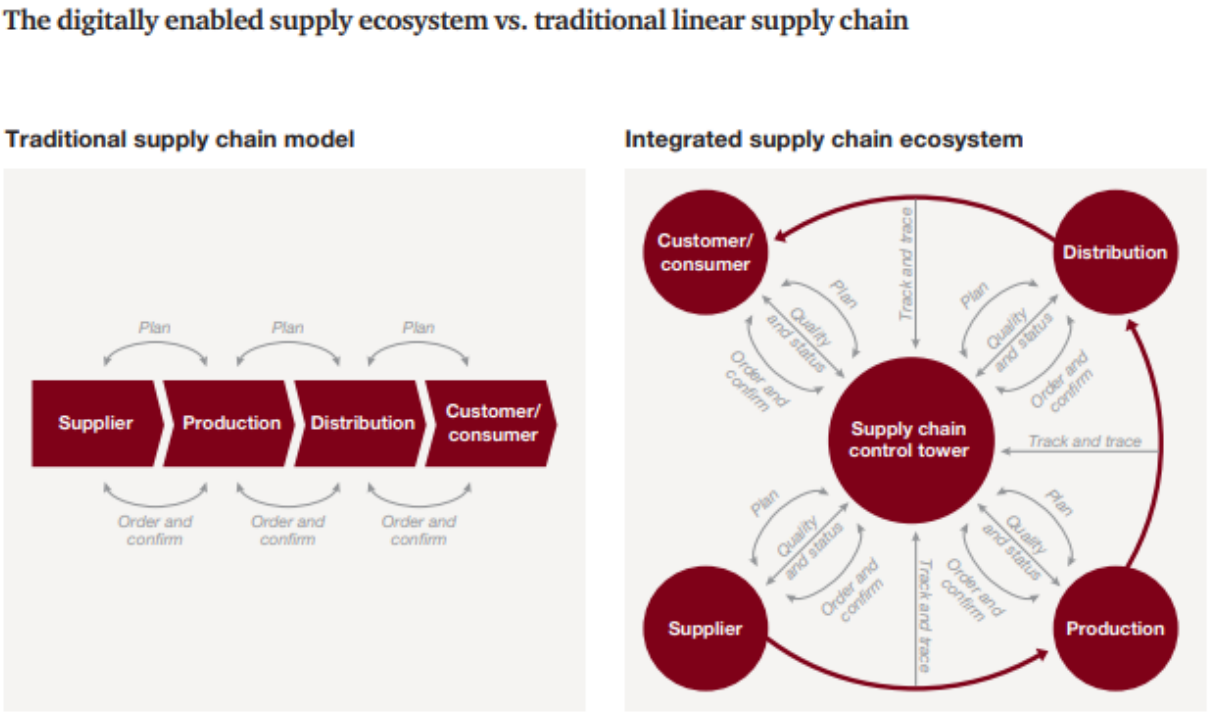


Figure 18: Industry 4.0 paves the way for the formation of an integrated supply chain ecosystem[67]

[67]Schrauf and Berttram, "How Digitization Makes the Supply Chain More Efficient, Agile, and Customer-Focused."

Our Advantage

Singapore is a global pioneer in I4.0 integration. For instance, EDB was responsible for the development of the SIRI[68], the globally-renowned[69] framework for manufacturing firms to assess and develop their I4.0 readiness[70].

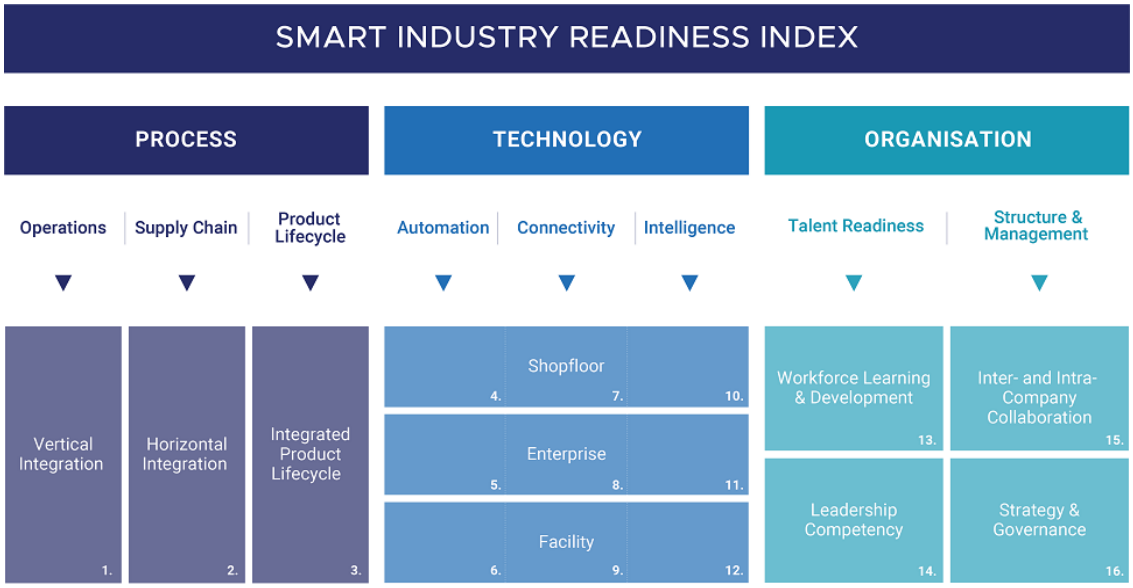


Figure 19: An overview of the SIRI developed in 2017[71]

Singapore has also leveraged blockchain to augment its trade processes, through the TradeTrust framework.[72] The framework enables trusted interoperability of trade

[68] The Smart Industry Readiness Index (SIRI) was created in Singapore, in partnership with a network of leading technology companies, consultancy firms, and industry, and academic experts. SIRI comprises a suite of frameworks and tools to help manufacturers – regardless of size and industry – start, scale, and sustain their manufacturing transformation journeys. Today, SIRI has been adopted internationally by both multinational corporations (MNCs) and small, medium enterprises (SMEs), with nearly 600 manufacturing companies across 30 different countries having completed the Official SIRI Assessment (OSA). (EDB, 2017)

[69] As part of the World Economic Forum's Global SIRI Initiative, the International Centre for Industrial Transformation (INCIT) was established in 2021 to bring SIRI to the next level. (EDB, 2017)

[70] Economic Development Board, "The Smart Industry Readiness Index," Press release, October 22, 2019, https://www.edb.gov.sg/en/about-edb/media-releases-publications/advanced-manufacturing-release.html.

[71] Economic Development Board, "The Smart Industry Readiness Index."

[72] TradeTrust is a framework that comprises globally accepted standards connecting governments and businesses to a public blockchain.

documents on digital platforms,[73] lowering operating costs[74] and laying the foundation for future developments to improve the security and transparency of cross-border digitised supply chains.

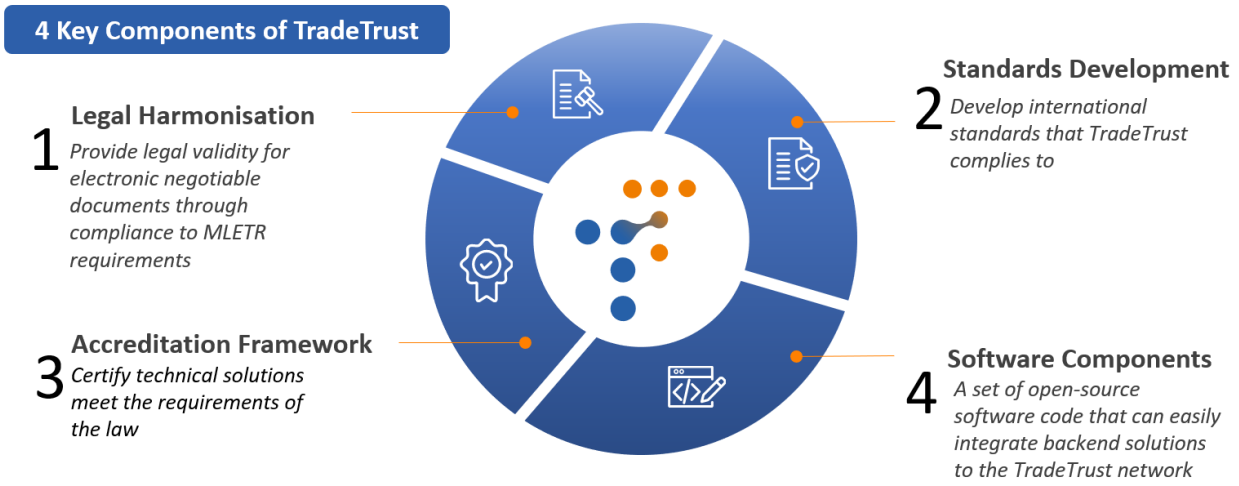


Figure 20: Key components of TradeTrust[75]

With the top 25 global logistics firms conducting operations in the country,[76] and a strong intellectual property regime,[77] the stage is set for I4.0 innovations to thrive in Singapore's economy.

[73]Singapore Government Developer Portal, "TradeTrust - Transform the Way You Trade," *Singapore Government Developer Portal* (blog), October 17, 2022, https://www.developer.tech.gov.sg/products/categories/blockchain/tradetrust/overview.html.
[74]"TradeTrust - Infocomm Media Development Authority," Infocomm Media Development Authority, April 4, 2023, https://www.imda.gov.sg/how-we-can-help/international-trade-and-logistics/tradetrust.
[75] "TradeTrust - Infocomm Media Development Authority."
[76] Singapore Tourism Board, "Why Singapore Is a Global Logistics Hub - Visit Singapore Official," Visit Singapore, March 27, 2020, https://www.visitsingapore.com/mice/en/newsroom/why-singapore-is-a-global-logistics-hub/.
[77] Singapore ranked 2nd globally in the International Property Rights Index 2021

Challenges

Skills Mismatch

I4.0 inevitably threatens countless T&L jobs. Low-order, automatable jobs will be displaced while middle-level roles will require significant restructuring[78]. However, many employees may lack the skills to operate new technologies while employers may not fully understand how to incorporate them[79]. This prevents Singapore from unlocking the full potential of its workforce and digitalisation.

Retrofitting Technologies

Implementing I4.0 technologies into Singapore's existing T&L industry could prove challenging. Firstly, the interoperability of different technologies installed could become a more significant issue with more multifaceted systems. Secondly, differing regulations and data management standards between countries increases the regulatory complexity of implementing such technologies in our globalised T&L sector. Without adapting them to account for Singapore's needs, they will struggle to integrate into our diverse trade infrastructure.

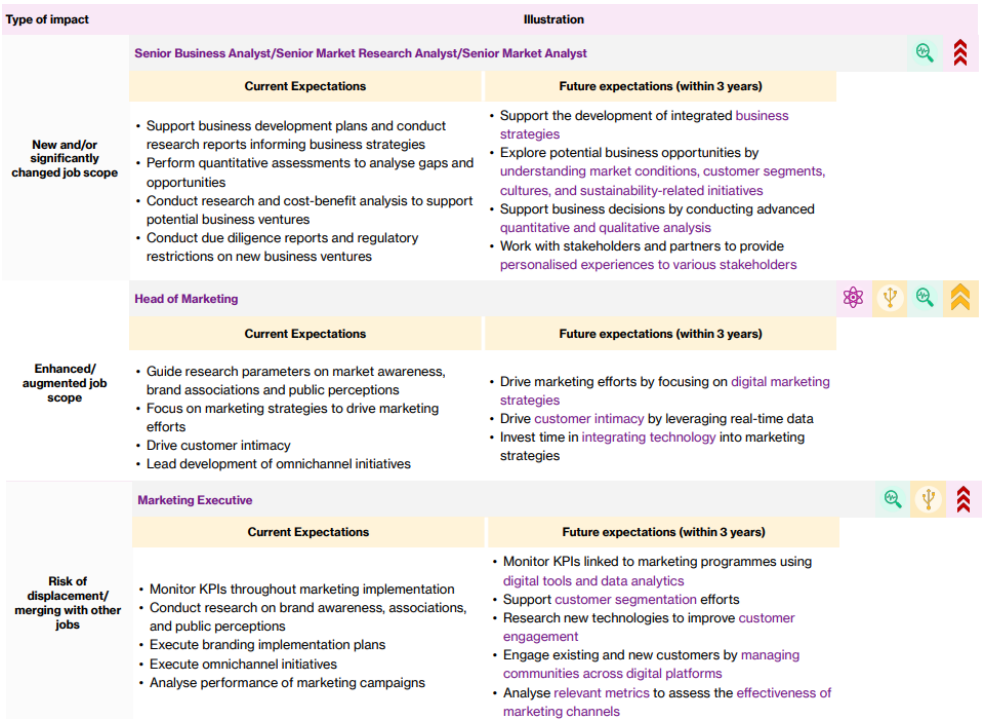
[78] Ernst & Young Singapore, "Study of the Impact of Industry 4.0 on Singapore's Logistics Workforce."
[79] Ernst & Young Singapore, "Study of the Impact of Industry 4.0 on Singapore's Logistics Workforce."

Recommendations

Restructuring T&L Businesses and Jobs

EDB should work closely with both technology providers and trade associations[80] to understand changing industry demands and challenges. Thereafter, EDB should directly consult T&L business leaders to formulate integrated business strategies[81], helping executives progressively restructure their operations and manpower to cohesively integrate new technologies.

SkillsFuture should engage T&L businesses to recommend specific courses and expand its offerings across all skill levels. This will incentivise employer-sponsored training by raising awareness on available programmes and minimising training time and costs by ensuring employees are enrolled only in appropriate courses.



Type of impact	Illustration	
New and/or significantly changed job scope	**Senior Business Analyst/Senior Market Research Analyst/Senior Market Analyst**	
	Current Expectations	**Future expectations (within 3 years)**
	• Support business development plans and conduct research reports informing business strategies • Perform quantitative assessments to analyse gaps and opportunities • Conduct research and cost-benefit analysis to support potential business ventures • Conduct due diligence reports and regulatory restrictions on new business ventures	• Support the development of integrated business strategies • Explore potential business opportunities by understanding market conditions, customer segments, cultures, and sustainability-related initiatives • Support business decisions by conducting advanced quantitative and qualitative analysis • Work with stakeholders and partners to provide personalised experiences to various stakeholders
Enhanced/ augmented job scope	**Head of Marketing**	
	Current Expectations	**Future expectations (within 3 years)**
	• Guide research parameters on market awareness, brand associations and public perceptions • Focus on marketing strategies to drive marketing efforts • Drive customer intimacy • Lead development of omnichannel initiatives	• Drive marketing efforts by focusing on digital marketing strategies • Drive customer intimacy by leveraging real-time data • Invest time in integrating technology into marketing strategies
Risk of displacement/ merging with other jobs	**Marketing Executive**	
	Current Expectations	**Future expectations (within 3 years)**
	• Monitor KPIs throughout marketing implementation • Conduct research on brand awareness, associations, and public perceptions • Execute branding implementation plans • Execute omnichannel initiatives • Analyse performance of marketing campaigns	• Monitor KPIs linked to marketing programmes using digital tools and data analytics • Support customer segmentation efforts • Research new technologies to improve customer engagement • Engage existing and new customers by managing communities across digital platforms • Analyse relevant metrics to assess the effectiveness of marketing channels

Figure 21: Examples of how T&L jobs must adapt to digitalisation[82]

[80] Examples of relevant TACs include SGTech, Singapore International Chamber of Commerce and Singapore Shipping Association

[81] These may include detailed implementation and transition plans.

[82] Ernst & Young Singapore, "Study of the Impact of Industry 4.0 on Singapore's Logistics Workforce."

Regulatory Sandbox

The government should establish a regulatory sandbox[83] to trial emerging technologies in real-life environments under controlled conditions before conferring regulatory approval. Through regulators' reviews and industry feedback, technology operators can uncover latent weaknesses and adapt their products to conform to industry needs. By implementing new technologies in phases, this will test their feasibility and compatibility with existing systems at varying scales while containing their potential disruptions. Hence, like MAS' FinTech equivalent[84], this would help Singapore sieve promising technologies to integrate into our vast trade network at-scale.

[83] A regulatory sandbox allows selected companies to operate within specific parameters, with relaxed regulatory requirements over a specified timeframe,

[84] Monetary Authority of Singapore, "Sandbox," MAS, 2023, https://www.mas.gov.sg/development/fintech/sandbox.

Chapter 5: Conclusion

Overall, Singapore should focus on three key industries to future-proof our economy and create high-value jobs. Nonetheless, as the global economy evolves, Singapore must remain vigilant and consistently explore new verticals in accordance with our comparative advantages.

Annex

The Technology Collaboration Programme

The TCP offers a framework for international collaboration in the goals of advancing the research, development and commercialisation of energy technologies. These collaborations involve over 6000 experts, representing over 300 public and private organisations over 55 countries. Collaborations span across 8 categories, including buildings, electricity, industry, transport, renewable energy, fossil energy, fusion power and cross-cutting.[85]

The TCP accommodates collaboration among a myriad of entities, such as government institutions, universities, research institutes, utilities, and private companies.[86] Members of individual TCPs are contracting parties to an Implementing Agreement, which may include governmental bodies or government-designated entities of the countries involved.[87]

Each TCP is divided into tasks, which are individual research projects that focus on a particular aspect of the field with a completion deadline. Members collaborate on tasks by funding their representatives to collaborate on that task according to the commitment level agreed.[88]

[85]IEA, “Technology Collaboration - Advancing the Research, Development and Commercialisation of Energy Technologies,” 2023, https://www.iea.org/about/technology-collaboration.
[86]IEA Photovoltaic Power Systems Programme, “Membership : How to Join - IEA-PVPS,” IEA-PVPS, October 19, 2021, https://iea-pvps.org/about-iea-pvps/membership-how-to-join/.
[87]SolarPACES, “Task Annexes Under the IEA TCP - SolarPACES,” February 25, 2018, https://www.solarpaces.org/csp-research-tasks/task-annexes-iea/.
[88] IEA Hydrogen, “History of the Hydrogen TCP (IEA Hydrogen),” April 5, 2021, https://www.ieahydrogen.org/faq/.

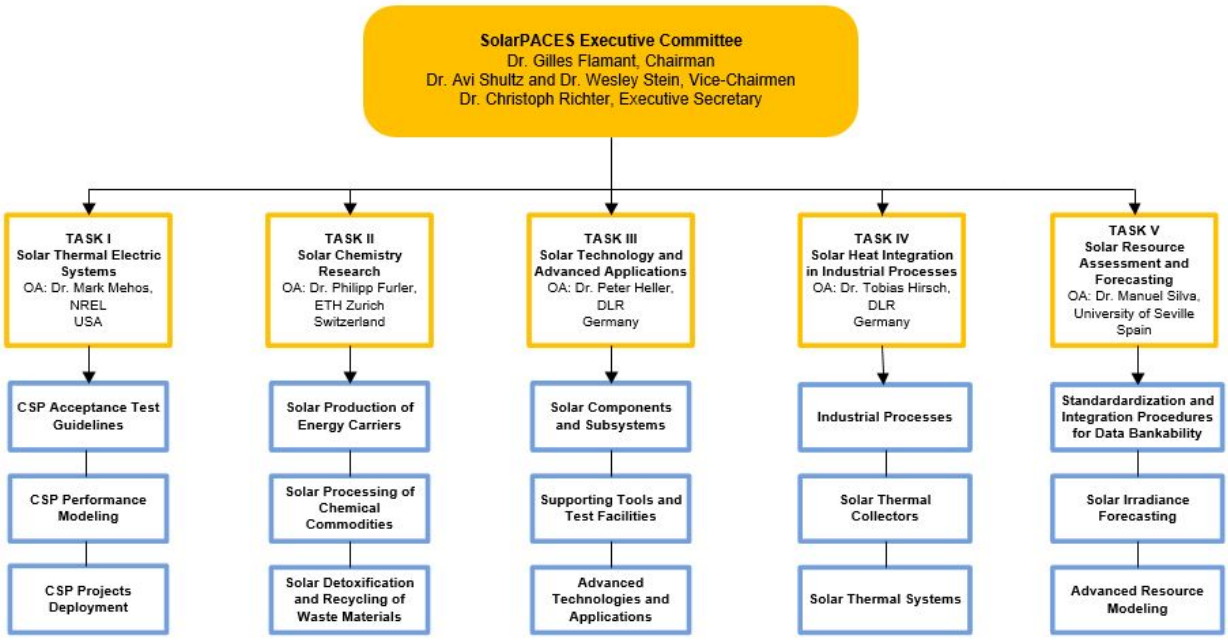


Figure 28: Example of division of work through individual 'tasks' in the SolarPACES TCP[89]

There are widespread benefits in collaborating in the cleantech sector, including the pooling of resources, spreading of technical risk, and acceleration of commercialisation of novel technologies. We posit that Singapore can potentially take inspiration from this collaborative framework and apply it in a local context to attract foreign investors while strengthening its global reputation as an innovation hub, thereby securing a steady flow of R&D investments, effectively developing its cleantech sector.

[89] SolarPACES, "Overview of IEA TCP Research Tasks Leadership - SolarPACES," December 16, 2022, https://www.solarpaces.org/csp-research-tasks/overview-of-research-tasks-leadership/.

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