Strengthening innovation-driven inclusive and sustainable development

Asia-Pacific Tech Monitor

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Fourth Industrial Revolution technologies for inclusive and sustainable development

Plus

- Technology News and Events
- Tech Ventures & Opportunities
- Business Coach

UNITED NATIONS ESCAP
Economic and Social Commission for Asia and the Pacific
Asian and Pacific Centre for Transfer of Technology (APCTT)

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The Economic and Social Commission for Asia and the Pacific (ESCAP) serves as the United Nations' regional hub promoting cooperation among countries to achieve inclusive and sustainable development. The largest regional intergovernmental platform with 53 Member States and 9 associate members, ESCAP has emerged as a strong regional think-tank offering countries sound analytical products that shed insight into the evolving economic, social and environmental dynamics of the region. The Commission's strategic focus is to deliver on the 2030 Agenda for Sustainable Development, which is reinforced and deepened by promoting regional cooperation and integration to advance responses to shared vulnerabilities, connectivity, financial cooperation and market integration. ESCAP's research and analysis coupled with its policy advisory services, capacity building and technical assistance to governments aims to support countries' sustainable and inclusive development ambitions.

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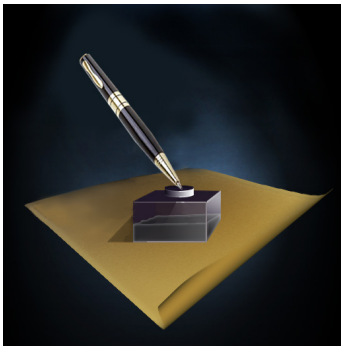
CONTENTS



Introductory note

We are pleased to share the second issue of the Asia Pacific Tech Monitor (April-June 2021), which focuses on the Fourth Industrial Revolution (4IR) technologies for inclusive and sustainable development.

Advancements in science and technology in recent years, spearheaded by 4IR technologies, are leading to large-scale digital transformation across the world. With rapid diffusion and adoption of these technologies, countries are realizing the range of opportunities to re-define their economies and meet social as well as environmental needs in an efficient manner.

The 4IR technologies have the potential to induce innovation in production processes and boost productivity. For instance, 4IR technologies together with data analytics can drive 'integrated manufacturing' that encompasses the entire range of product development and manufacturing activities. Such manufacturing is responsive, self-adjusting and can meet mass customization needs. Application of 4IR technologies have also contributed towards delivering public services, particularly during the COVID-19 pandemic. E-government services, especially in healthcare and education sectors has become increasingly prevalent over the last one year.

The potential of 4IR technologies in achieving the Sustainable Development Goals (SDGs) is significant. According to a report by the World Economic Forum, 70% of the 169 targets underpinning the SDGs for 2030 could be achieved by 4IR technologies that exist today.[1] For instance, 4IR technologies can improve processes in waste management such as in upcycling of post incineration waste and additive manufacturing of building components. Applications such as drone-based solutions for sustainable agriculture; smart sensors to improve efficiency of post-combustion carbon capture; Internet of Things (IoT) devices for efficient conversion of waste into clean fuel; and big data for early prediction of extreme weather events can contribute considerably towards enhancing resilience and greenhouse gas emissions reduction goals being announced by many countries.

With the latest SDG report for Asia and the Pacific indicating slow progress of SDGs in the region,[2] 4IR technologies can be crucial to accelerate sustainable development. However, such technologies also come with its own set of potential challenges, such as issues related to data capture and use, digital divide across different regions and socio-economic groups, and potential impact on employment. To harness the potential of these technologies, strategies will be needed to address the challenges and create an enabling environment with appropriate policy frameworks and adequate infrastructure.

This issue of *Asia-Pacific Tech Monitor* touches upon some of the challenges, strategies and good practices with examples from the Asia-Pacific region on Fourth Industrial Revolution technologies for inclusive and sustainable development. It features special articles suggesting application of 4IR technologies for integrated manufacturing and as an approach for decarbonization taking the case study of Singapore.

Preeti Soni
Head, APCTT-ESCAP

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1 World Economic Forum, 2020. Unlocking Technology for the Global Goals. 48 pp.

2 ESCAP, 2021. Asia and the Pacific SDG progress report 2021. 87 pp.

INTERNATIONAL

Commercialization of advanced X-ray systems

According to a report, the global X-ray market was valued at ~US$10.8 Bn in 2018 and is projected to expand at a CAGR of 5.5% from 2019 to 2027. Different types of X-ray devices are available in the market such as stationary/fixed and portable. These diagnostic X-ray devices can be used for various applications, including cardiovascular, respiratory, dental, and mammography.

Rise in prevalence of chronic diseases across the world and rapidly aging global population with augmented healthcare needs boost market growth. North America dominated the global X-ray market in 2018 and the trend is anticipated to continue during the forecast period. High awareness about medical imaging devices, financial capability to purchase expensive machines, rise in demand for technologically advanced & innovative products in hospitals, diagnostic laboratories, and outpatient ambulatory surgery centers; and high infrastructure investment supporting healthcare facilities boost the growth of the market in the region. Asia Pacific is likely to be a highly lucrative market for X-ray during the forecast period.

Recent introduction of advanced, highly portable digital X-ray systems have resulted in an increased demand globally. Moreover, demand for bedside imaging and diagnostics, home healthcare, and minimally invasive solutions is rising across the globe. New X-ray technology produces striking 3D images in full color. Various new and technologically advanced X-ray systems have been introduced by major manufacturers operating in this market.

Based on product type, the global X-ray market has been bifurcated into stationary/fixed and portable. The portable segment has been split into mobile and handheld. The stationary/fixed segment dominated the global X-ray market in 2018. However, the portable segment is expected to expand at the highest CAGR from 2019 to 2027. Advent of wireless and low-power-consuming portable X-ray technologies, which are leading to innovation and development of advanced portable X-ray, fuels the growth of the global market. In February 2015, GE Measurement and Control launched portable ERESCO 300 MF4-R X-ray tube, which helps in geometric magnification and inspection time reduction in film-based and digital radiography.

In terms of technology, the global X-ray market has been classified into analog and digital. The digital segment has been segregated into computed radiography and direct digital radiography. The digital segment is expected to expand at the highest CAGR during the forecast period. Sensors integrated in digital X-ray systems, especially in systems with direct digital radiology technology, help the system to capture images at a rapid rate of 60 images per hour. Better image quality in less time is a major factor driving the digital X-ray segment.

Based on application, the global X-ray market has been segmented into cardiovascular, respiratory, dental, mammography, and others. The mammography segment is expected to expand at the highest CAGR during the forecast period. According to the World Cancer Research Fund International, there were over 2 million new cases of cancer in 2018. The introduction of new and technologically advanced X-ray systems, rise in awareness about the disease & its diagnosis, and affordability of people fuel the growth of the global market.

https://www.medgadget.com

ASIA-PACIFIC

SMEs optimistic in the wake of COVID-19

Small businesses in the Asia-Pacific region are upbeat about their future as they begin to emerge from the economic uncertainty caused by COVID-19. CPA Australia's 12th annual Asia-Pacific small business survey report shows many businesses remain resilient across the region despite the shadow cast by the pandemic over long-term economic recovery. Unsurprisingly, 2020 saw every market surveyed register its lowest recorded percentage of small business growth, with Australia and Hong Kong recording the worst results. Of the 4,227 small businesses surveyed across 11 markets, a record low of 46.2% of small businesses reported growing during 2020, down from 65.8% in 2019. The challenging environment has also meant 31.3% of businesses shrank last year, more than double the 14.5% result in 2019.

The expectations for 2021 are for a better year for many of the region's small businesses. A total of 60.8% expect to grow this year, with 20.1% expecting to rebound strongly. However, the environment remains uncertain, with 17.1% forecasting they will shrink or close their business. Small business expectations are weakest in Hong Kong. Only 21.2% expect to grow, and 49% expect to shrink or shut down this year.

Businesses also reported higher rate of job losses than in previous years, with 14.7% of small enterprises shedding staff in 2020, compared with 6.7% in 2019. The potential severity of job losses was however partially offset by government wage subsidy schemes, like JobKeeper in Australia. Not surprisingly, small businesses that didn't grow or shrink in 2020 were more likely to reduce employee numbers, with 21.8% cutting staff, compared with only 2.5% of high-growth small businesses. Fortunately, businesses are moderately confident about hiring, with 36.1% of the region's small businesses expecting to add employees this year.

https://www.intheblack.com

One-stop SME information portal

The ASEAN Coordinating Committee on Micro, Small, and Medium Enterprises (ACCMSME) launched ASEAN Access, a one-stop business information gateway for international-oriented businesses to expand their market outreach within the ASEAN and beyond. The launch took of aseanacces.com place in commemoration of the upcoming International MSME Day, celebrated every 27 June annually.

Intra-ASEAN trade accounts for the largest share of ASEAN's trade, reaching 22.5%

of total merchandise in 2019, indicating a high level of inter-dependency among ASEAN Member States. When the COVID-19 pandemic hit, businesses within the region were severely impacted by the drastic reduction in demands for goods and services. However, it was also an opportune moment for accelerating businesses' digital transformation and diversification of sources.

The ASEAN Access is a flagship initiative of the ACCMSME, spearheaded by the OSMEP, Thailand and supported by the Federal Government of Germany and the German Agency for International Cooperation (GIZ). It contributes to the implementation of the ASEAN Strategic Action Plan for SME Development 2016–2025 which envisions to create globally competitive MSMEs that are seamlessly integrated into the ASEAN community by focusing on initiatives to promote productivity, technology, and innovation; increase access to finance, enhance market access and internationalization; enhance policy and regulatory environment and promote entrepreneurship and human capital development.

https://www.thailand-business-news.com

BANGLADESH

Bangladesh SME trade finance network

Blockchain trade finance initiative Contour has launched a domestic network in Bangladesh that will provide digital letters of credit (LCs) to SMEs in the country. Owned by eight shareholder banks—Bangkok Bank, BNP Paribas, Citi, CTBC, HSBC, ING, SEB, and Standard Chartered—Contour delivers a global network for trade finance over distributed ledger, which allow parties to transact and view information electronically.

Contour's central offering is the LC, for which the network has managed to reduce processing time by as much as 90% during testing, from an average of 10 days to under 24 hours end-to-end.

With this new launch, Contour is tackling adoption from the ground up. Through a purpose-built network, Contour will offer digital LCs to SMEs in Bangladesh for local and international transactions.

https://www.gtreview.com

CHINA

Patent law promises new protections for drugmakers

China is changing its patent law with an eye toward ramping up legal protections for drug manufacturers, building on the country's efforts to bolster its intellectual property system. The country is establishing a new system for brand-name manufacturers and generics makers to resolve patent disputes under the changes, which take effect June 1. China also will allow extensions of patent terms for such things as delays at the patent office.

Changes to the litigation system could provide more incentives for large drug companies to enter the Chinese market by boosting procedural protections, attorneys say. Drugmakers have been skeptical in the past about their ability to protect brand-name products against unfair competition in China.

The changes to the system for drug patents are part of a "general trajectory of trying to align Chinese IP laws with international standards," Mark Deming, an intellectual property attorney and shareholder at Polsinelli PC in Chicago, said. China will establish a patent linkage system resembling the framework established by the Hatch-Waxman Act of 1984, which created the modern U.S. regulatory framework. It will provide a process for branded companies to challenge copycat medicines early, which could reshape patent litigation in China. There will also be a platform for registering patent information, similar to the U.S. Orange Book. Additionally, China is raising the amount of statutory damages available in all patent disputes, and will allow courts to award punitive damages of up to five times the amount won at trial for willful infringement. Courts in the U.S. can triple a damages award for willful infringement.

Under the new Chinese system, brand-name drug makers will be able to sue before a generic launches its product. Companies often have been left playing catch-up after the generic's launch. Even if the branded company wins, attorneys said there can be market impacts and significant price consequences. The new system also provides generics with an opportunity to challenge the validity of drug patents during the approval process. That could take some of the risk out of the equation before a generic goes to market, attorneys said.

https://news.bloomberglaw.com

Pre-tax additional deductions for R&D expenses

On April 7, 2021, China's Ministry of Finance (MOF) and State Taxation Administration (STA) jointly released the *Announcement on Further Improving the Policy for Pre-Tax Additional Deductions for R&D Expenses* (MOF STA Announcement [2021] No.13). The announcement, with retrospective effect from January 1, 2021, increases the ratio of additional deduction on manufacturing firms' R&D expenses from 75% to 100%.

According to the announcement, for R&D expenses actually incurred by manufacturing firms:

- If they have not formed intangible assets, nor have they not been included into the current profits and losses, such expenses can be additionally deducted before tax at 100% of the actual deductions.
- If they have formed intangible assets, they can be amortized before tax at 200% of the actual cost of intangible assets.

For example, if an enterprise spent RMB 1 million (approx. US$153,000) of R&D expenses and such expenses did not form intangible asset and was not included in the current period's profit or loss, a total of RMB 2 million (approx. US$305,000) is allowed to be deducted from the enterprise' taxable income. If the RMB 1 million expenditure formed intangible assets, the pre-tax amortization can be made based on the costs of RMB 2 million.

As the higher pre-tax deductions mean lower corporate income tax (CIT) to be paid by manufacturing firms, this policy is designed to boost enterprises' R&D input, incentivize business innovation, and advance industrial upgrading.

This policy is expected to reduce corporate taxes by another RMB 80 billion (approx. US$12 billion) this year, on top of the RMB 360 billion (approx. US$55 billion) tax cuts last year. In general, enterprises are entitled to enjoy the additional deductions of R&D expenses when completing their annual financial CIT settlement by May 30, the second year. However, under the new policy, manufacturing firms can opt to benefit from the additional deduction of R&D expenses on a semi-annual basis.

The *Announcement [2021] No.13* stipulates that when an enterprise declares the CIT for the third quarter (pre-paid quarterly) or for the month of September (pre-paid monthly) of the current year, it can choose to deduct the additional deductions of the R&D expenses incurred in the first half of the current year. This reform allows enterprises to benefit from the tax incentive in advance when prepaying the CIT, thereby further encouraging enterprises to increase their R&D spending.

To enjoy this preferential policy, an eligible firm must have manufacturing as their main business and the main business revenue must account for more than 50% of its total revenue. In addition, it must fall under the scope of the manufacturing industry determined by the *Industrial Classification for National Economic Activities (GB/T 4574-2017)* or any updated scope released by the relevant government department.

China has been rolling out tax privileges for R&D activities in manufacturing industry to promote the deep integration of traditional manufacturing and information technology and advance the country's industrial upgrading. In recent years, the ratios of the additional deduction for R&D expenses of manufacturing firms have been raised from 50% and 75% to the current 100%. Besides, the government also introduced a relaxed policy for the refund of end-of-period value-added tax (VAT) credit for certain advanced manufacturing taxpayers.

https://www.china-briefing.com

Commercialization rate of invention patents

According to the 2020 China Patent Investigation Report, the 2020 yearly commercialization rate is 34.7%. The rates throughout the entire 13th Five-Year Plan (2016–2020) sit firmly above 30% while the rates of companies are even higher at above 40%.

The Patent Transfer and Transformation Index reaches 54.7 in 2020, up 3.6 points from 2019. Nearly 80% of companies have clear expectations for the future revenue generated by their patents, 49.5% of which expect that their revenue derived from materializing their patents will increase in the next year; 45.5% expect such revenue to stay flat, and only the remaining 5.0% foresees a decline, suggesting most Chinese corporate patentees see their patent-generating revenue going nowhere but upward.

The Report also illustrates China's enhancement in patent protection. On the one hand, the proportion of Chinese patentees experiencing infringements is dropping, down 3.7% from 2015 to 10.8% in 2020. On the other hand, patentees have a more prepared mind to enforce their rights. In addition, 73.9% of Chinese corporate patentees took measures to protect their rights after being infringed, up 11.1% from 2015, clearly sending a message that right owners are more proactive in defending their belongings.

The Report shows that during the 13th Five-Year period, 7.3% of patent infringement court cases ended up with over 1 million yuan in damages, whether from court order, mediation, or settlement, 4.4% higher than that during the 12th Five-Year period (2011–2015).

The Report also illustrates new changes in innovation activities: patentees themselves tend to invest more in R&D and join hands in innovation. In 2020, 16.5% of China's valid invention patents received R&D investments of more than 1 million yuan, up 4.4% year-on-year while 43.4% of valid invention patents received R&D investments below 100,000 yuan, down 1.2%, obviously suggesting companies are more generous in infusing more capital to R&D. Nearly 80% of Chinese corporate patentees had worked with others in innovation; 52.1% of corporate patentees had worked with their upstream or downstream customers on innovative projects; 34.9% with companies in the same industry; 27.5% with universities or research institutes, whose most frequent patrons were national-level high-tech companies, reaching 40.5%, 1.9 times more likely than that of non-high-tech enterprises. Cooperation has become a significant option of companies' innovation.

https://www.mondaq.com

INDIA

S&T-led SMEs selected for joint R&D and technology transfer

Three Indian S&T-led small-to-medium enterprises/Startups have been selected to undertake joint R&D and technology transfer projects under the India-Russia Joint Technology Assessment and Accelerated Commercialization Program. Two of the selected companies—Prantae Solutions and Jayon Implants are being funded under joint R&D Projects, and the third company, Ananya Technologies, has been funded for technology adoption from Russia.

Prantae Solutions is being funded for the development of a platform for rapid point of care diagnosis of Rheumatoid Arthritis (RA) by a technique called multiplex immunofluorescence analysis based on disposable cartridges. The company aims to create a portable Point-of-Care technology for rapid identification of RA to circumvent the difficulties associated with ELISA-based serological diagnosis.

Support for Jayon Implants will help in the development of prosthetic technologies and manufacturing ceramic endoprostheses for hand and foot joints, adjacent joints, large joints, as well as dental implants. The key aim of the project is to create and commercialize unique, innova-

tive medical devices for patients with RA, degenerative lesions, injury, and arthrosis of the joints of the upper limbs of a person. Ananya Technologies is being funded for joint development of Integrated Standby Instrument System and associated test equipment with their Russian counterpart.

The India-Russia Joint Technology Assessment and Accelerated Commercialization Program is a joint initiative of the Department of Science & Technology (DST), Govt. of India, and the Foundation for Assistance to Small Innovative Enterprises (FASIE). On the Indian side, the Federation of Indian Chambers of Commerce & Industry (FICCI) is implementing this program on behalf of DST.

https://www.devdiscourse.com

Guidelines cap expenditure on R&D

The DoT, or Department of Telecommunications, notified the guidelines for the production-linked incentive scheme (PLI) for manufacturing telecom and networking products, has capped the expenditure as investment that global companies can make on research and development (R&D), as well as transferring technology.

Leading global companies and EMS (electronics manufacturing services) players have shown an interest in applying for the much-awaited scheme. The threshold investment is a key element that determines the financial incentive that a company will be eligible for under the scheme. As part of the detailed guidelines, only 15% of the expenditure on R&D and 5% of that incurred in transferring technology will be considered investment for determining eligibility under the scheme.

https://www.business-standard.com

JAPAN

Augmented reality collaboration solution

Librestream's Onsight platform enables workforce transformation through industrial use cases like AI Connected Expert, powering the workforce of the future by combining AR, artificial intelligence (AI), and internet of things (IoT) data visualization, enabling automated on-the-job training, reducing cognitive load, and driving operational insights. Since 2019, the Japanese market increasingly adopted Librestream's Onsight platform, with user growth expanding over 300% in that time frame.

As the third-largest economy in the world and fourth-largest in total exports, continuous workforce improvement via technology and innovation is critical to maintaining competitive positioning. The Onsight platform enables efficiency, safety, and resiliency across industries, including those that account for Japan's top exports: cars and vehicle parts ($136B), integrated circuits ($30.7B), machinery with individual functions ($20B), and passenger and cargo ships ($13.7B).

As a device-agnostic company, Librestream's Onsight platform also supports use on smartphones, tablets, computers, and wearables. In Japan, Onsight use on wearables make up 21% of usage cases, compared to 3.4% across the other 183 countries in which Librestream is deployed. This reflects research findings that the APAC region is expected to outgrow all others in wearable usage through 2025 due to factors including the geography's industrial workforce, embrace of smart technology, and aging populations. Librestream recently announced Onsight Connect for Microsoft's HoloLens 2 advanced AR wearable.

https://www.prnewswire.com

MALAYSIA

Accelerating innovation among start-ups

PETROLIAM Nasional Bhd (Petronas) is inviting Malaysian start-ups to participate in the second edition of its technology accelerator programme, Petronas FutureTech 2.0. The programme is aimed at encouraging local innovations and scaling up homegrown technology start-ups to be at par with international standards.

This year, Petronas is teaming up with Telekom Malaysia Bhd (TM) and Sime Darby Plantation Bhd while it continues to partner global venture capital firm, 500 Startups. This collaboration is expected to bring in greater prospects for participating start-ups, as well as to unlock synergies from cross-industry expertise and maximize the programme's value impact on local start-ups.

According to Petronas, the strategic partnership will allow the partnering companies to uncover potentially game-changing technologies and accelerate new ideas that can help transform local industries while enabling the teams to have greater market access for growth. The themes for FutureTech 2.0 are Industrial Revolution 4.0, Specialty Chemicals and Advance Materials, Future of Energy, Digital Transformation and Retail Innovation.

FutureTech 2.0 seeks to build on the success of its inaugural batch 2 years ago, where the programme funded two start-ups from the first cohort—robotics and automation for agriculture technology start-up Braintree Technologies Sdn Bhd and sustainable energy start-up SOLS Energy Sdn Bhd. Shortlisted start-ups in FutureTech 2.0 will undergo an intensive 12-week virtual programme from September, which includes masterclasses, workshops, and coaching from 500 Startups' mentors, as well as C-suite and experts from Petronas, TM, and Sime Darby Plantation.

https://themalaysianreserve.com

Innovation exchange programme

The Malaysia Digital Economy Corporation (MDEC) has announced the launch of MDEC Innovation Exchange (MIX), a programme it said is designed to accelerate the digitalization of the nation's economy. In a statement, MDEC said that MIX is part of the agency's corporate innovation efforts aimed at empowering large corporates with value-added digital transformation via local innovations and bringing together established corporates and world-class local technology players.

MDEC said MIX acts as the link between corporates and high caliber local tech start-ups and scale-ups. This enables organizations to realize their asset value, understand their pain points, and

pervasively deploy and utilize digital and data technologies, it claimed.

MDEC will provide the bridge between corporates and startups via the following steps of engagement:

- **Design Thinking:** MDEC will help participating corporates to identify crucial problem statements and pain points within their respective organizations. The agency will then advise the corporates on the right solutions required for their digital transformation;
- **Exploration & Networking:** MDEC will connect the corporates to a pool of over 800 tech startups and scale-ups that can provide solutions or proofs of concept (POCs). The agency will do this by curating a list of relevant solution providers based on the corporate's problem statements;
- **Partnerships & Market Access:** MDEC will co-create programmes with accelerators, venture builders, and VC communities to unearth and highlight the best technology solutions for potential collaborations, including funding, mentorship, business deals, and acquisitions;
- **Empowering Talents:** MDEC will help participating corporates with the hiring of digitally savvy talents through initiatives such as MyDigitalWorkforce Work in Tech (MYWiT) and the Premier Digital Tech Institutions (PDTI). The agency will also assist the corporates in the upskilling of existing staff; and
- **CSR Programmes:** Participating corporates will be able to collaborate with MDEC on programmes and initiatives such as SayaDigital, eBerkat, and the Global Online Workforce (GLOW) to support underprivileged communities in Malaysia.

https://www.digitalnewsasia.com

PHILIPPINES

Patent mining to support R&D, tech transfer

The Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development of the Department of Science and Technology (DOST-PCAARRD) has rolled out the patent mining program for selected commodities to influence changes in research and development (R&D) and technology transfer prioritization in the agriculture, aquatic and natural resources (AANR) sector. The "Patent Mining Program for Selected AANR Commodities through Strengthened IP-TBM Offices" involves 17 participating state universities and colleges (SUCs) and research and development institutes (RDIs). The SUCs and RDIs in the program were previously involved in the two batches of the Intellectual Property and Technology Business Management (IP-TBM) program supported by the DOST-PCAARRD.

The program will discover emerging agricultural technologies and influence the development of priority R&D programs through patent mining. The process highly relies on patent literature, which contains valuable information that can guide organizations in planning for targeted R&D investments and determining early IP management strategies. These tools may help advocate changes in R&D and technology transfer and in crafting new science and technology (S&T) plans for the AANR sector.

To successfully carry out these initiatives, the program will capacitate the project teams through the 1st DOST-PCAARRD Patent Mining Mentorship Series, a series of training activities in partnership with the Intellectual Property Office of the Philippines (IPOPHL). Mentors from IPOPHL will guide the project teams as they proceed with the development of their patent mining reports.

The program will also harness and strengthen the capacities of IP-TBM offices through patent landscaping and mining, discover emerging agri-aqua technological trends and recommend priority R&D programs through patent mining, develop or enhance the IP policies and technology transfer protocols of other SUCs to harmonize IP management and technology transfer activities, and develop a web-based management information system for the real-time monitoring of IP filings of the IP-TBM network.

With the accomplishment of the IP-TBM network in IP management and technology commercialization, this program will also continue such initiatives by targeting the filing of 170 IP applications and execution of 17 commercialization contracts within the 2-year project duration. Linkages with various agencies will also be enhanced to support activities on IP protection and management, as well as technology transfer and commercialization. The program will also extend its policy development support to PCAARRD's partners in the regional consortia that are not members yet of the IP-TBM network.

https://businessmirror.com.ph

Helping small firms apply for international patents

The intellectual property office said it plans to assist small businesses applying for international patents under a partnership with the Philippine Chamber of Commerce and Industry (PCCI). The PCCI and the Intellectual Property Office of the Philippines (IPOPHL) signed a memorandum of agreement Monday to work on training business representatives and promoting the country's intellectual property (IP) assets.

The Madrid system manages trademark registrations worldwide through a streamlined process. Under the agreement, IPOPHL will also help market IP assets from PCCI members and help them commercialize their products. The Philippines' largest business group in turn will promote IPOPHL programs that incentivize small businesses to protect their IP. The two organizations committed to create mentorship opportunities and to showcase incubated technologies in various events.

IP filings rose 21% in the first 4 months of the year to 15,028 as businesses started to recover from the effects of the pandemic. Filings declined by 12% in 2020, with inventors and creatives delaying applications due to subdued business activity during the lockdown declared to contain coronavirus disease 2019 (COVID-19).

https://www.bworldonline.com

REPUBLIC OF KOREA

R&D tax breaks to bolster semiconductor industry

The Republic of Korea signaled its intention to heavily boost its semiconductor industry with an announcement on May 13 that it

will offer up to 50% tax credits on research and development (R&D) investment and up to 20% on facilities investments to help private companies there to reach total investment of KRW 510 trillion (USD 452 billion) in memory chips by the year 2030. The R&D incentive marks a 10 percentage point increase from the current maximum 40% credit for R&D investment.

As part of the plan, the Ministry of Trade, Industry and Energy announced other tax breaks, finance, and infrastructure changes to aid chipmakers' competitiveness. Small and medium-sized companies will be eligible to receive up to a 50% R&D credit, but the upper limit for large companies is 40%, according to the plan. The credits can apply from the middle of this year for investments made through 2024. The 10–20% credits for corporate facilities investments is a noteworthy increase, as the maximum credit is currently just 3%.

https://mnetax.com

Patents in artificial intelligence

The Republic of Korea ranks fourth in terms of the number of patents registered in the artificial intelligence sector, but an index showing the impact of the patents shows that the quality of patents from South Korea fell relatively short, according to a report. The report from Clarivate Analytics and KAIST Center for Innovation Strategy and Policy says that the number of patents that South Korea registered in the AI field has reached 6,317 between 2010 and 2019, the fourth highest among the 10 countries included in the report. The report analyzed around 147,000 patents registered by 10 countries, including China, the US, Japan, Korea, Germany, Taiwan, the UK, Canada, France, and India.

China was ranked first with 81,236 registered patents, accounting for around 60% of all patents registered by the 10 countries during the period. The US followed China with 24,708 patents, and Japan followed with 6,754 patents. The report, however, noted that the quality of South Korean patents in the AI sector were relatively poor, when compared with those held by the US and Canada.

According to the report's combined patent impact index—an analytic measure that the report used to assess how many useful patents each country holds—Republic of Korea holds around only 8% of the top 10's most useful patents. The CPI index for South Korea is lower than the average of the 10 countries included in the report, 14%. In terms of CPI, the US was ranked first with 43%, followed by Canada with 26%.

http://www.koreaherald.com

SINGAPORE

COVID-19 research collaboration

Two COVID-19 research collaboration proposals, initiated by Singapore in 2020, during its chairmanship of COSTI, were officially endorsed at the COSTI-79 and IAMMSTI-11. Both proposals arose from the outcomes of the ASEAN COSTI Forum on COVID-19, initiated and organized by Singapore in October 2020. With the Forum's broad themes of Prevention, Detection, and Therapeutics. Member states shared their collective national experience in dealing with the pandemic and brainstormed ideas for regional cooperation in science and technology which could strengthen ASEAN's technological capabilities against COVID-19.

IAMMSTI-11 and COSTI-79 endorsed a proposal on adding analysis value to genomic surveillance, co-led by Singapore and Malaysia through Singapore's Bioinformatics Institute (BII) and A*STAR Infectious Disease Labs (ID Labs), research institutes under the Agency for Science, Technology and Research (A*STAR), and Malaysia's Institute for Biotechnology (NIBM). The R&D partnership aims to provide accurate and up-to-date genomic information on virus strains detected in the region, leveraging the Global Initiative on Sharing All Influenza Data (GISAI) platform—an international data initiative for sharing of virus genomes, including the coronavirus causing COVID-19, to enable rapid and open access to virus information. This proposed partnership leverages existing biotechnology and bioinformatics capabilities in ASEAN and builds on top of existing national genome sequencing efforts.

The Philippines and Singapore are co-leading a regional study to assess the levels of immunity within ASEAN communities at different stages, including before vaccination and the longevity of immunity conferred through vaccination. The study will look into the effectiveness of seroconversion of vaccines, which refers to the development of specific antibodies in the blood serum as a result of a COVID-19 infection or vaccination. This research partnership also taps on the networks fostered through the ASEAN Diagnostics (Dx) Initiative, expanding on the list of priority diseases and pivoting to help meet the challenges of the current pandemic.

https://www.biospectrumasia.com

THAILAND

Long-term R&D outlook

Thailand's long-term R&D outlook remains positive NXPO pledges confidence with post-Covid measures. The research & development (R&D) investment survey undertaken by the Office of National Higher Education Science Research and Innovation Policy Council (NXPO) and the National Research Council of Thailand (NRCT) in 2019, found that Thailand spent 193,072 million baht on research & development, equivalent to 1.14% of GDP with 5.9% growth year-on-year. Of this, 23% (43,828 million baht) came from the government sector while 77% (149,244 million baht) was spent by the private sector. The top three industries with the most R&D investment were food, petroleum, and finance & insurance. Government spending primarily involved infrastructure and frontier research topics, including quantum technology, space science & technology, high energy physics, and molecular biology. In addition, the survey found that Thailand has 166,788 full-time equivalent personnel on R&D in 2019, equivalent to 25 out of 10,000 people, up 4.6% from the previous year.

https://www.bangkokpost.com

AFRICA

SOUTH AFRICA

Cloud, AI to improve food security

Startup, Omniolytics, has turned to IBM to help transform poultry farming through digital platforms that use sensors and IBM Watson running in the IBM Cloud. Omniolytics develops smart farming solutions for emerging and commercial poultry farmers. The local poultry industry today has a number challenges ranging from the quality and origins of feeds, high feed prices, and the recurrence of avian influenza and disease outbreaks such as listeriosis and salmonellosis.

Working with IBM, Omniolytics has developed a new approach that uses Internet of Things (IoT) technologies to collect data on the environmental conditions of production facilities and day-to-day management activities and processes of poultry to improve animal health, mitigate losses, and assist producers in improving production efficiency, helping address food security concerns. The suite of solutions uses IBM Watson and machine learning capabilities to identify and learn the typical behaviour of birds—and leads to improved management practices. Farmers are then able to receive a more complete picture of the well-being of their flocks delivered on IBM Cloud identifying processes and environmental deviations which could point to a potential problem.

https://it-online.co.za

ASIA-PACIFIC

AUSTRALIA

IoT turns agri waste into renewable energy

Melbourne-based renewable energy company, AgBioEn, is using a combination of IoT devices, drones, and telemetry as part of an AUD 2 billion initiative to turn agricultural waste into renewable fuels. The company plans to take waste from high-yielding, sustainably grown crops and then process it to produce renewable diesel, bio-jet fuel, LPG, heat (for on-farm glasshouses), food-grade liquefied CO_2, and a soil nutrient that can be plowed back to grow more crops.

Working with La Trobe University and Microsoft partner LAB3, AgBioEn is running a series of on-farm trials, growing different crops under different conditions. It has used IoT sensors and devices to monitor the health and growth of the crops with telemetry and drone data held in an Azure Cloud Edge Computing Platform. Data analytics tools and dashboards are available for La Trobe researchers and farmers that partner with the company. Crop trials will continue for the next 3–4 years, while AgBioEn will complete its fuel manufacturing facility design this year, with construction scheduled to start early next year with fuel produced from 2023.

LAB3 has helped design the crop testing system, which sees data from farm-based sensors and drones uploaded via LoRaWan networks into an Azure IoT Hub. Stream analytics performs an initial analysis of the stored data in an Azure Data Lake and available for analysis through Azure Cosmos DB.

https://www.cdotrends.com

Recycling robot for soft plastic waste

Working alongside industry partners as part of a federal government Cooperative Research Centre Project grant, researchers from the Centre for IoT and Telecommunications at the University of Sydney are developing a unique method to increase recycling of soft plastics—by creating a smart, automated robotic system that uses robotics and Artificial Intelligence (AI) to sort recyclable waste.

The researchers are working with waste management companies, IQRenew and CurbCycle, technology developers Licella, Mike Ritchie and Associates, and Resource Recovery Design to develop the system. It will be integrated into IQ Renew's material recovery facility as part of CurbCycle's soft plastic recovery program, an Australian initiative that involves the household collection of recyclables that are segregated into bags prior to placing them into their kerbside recycling bin.

After being separated from other waste, the soft plastics will be used for various purposes, including advanced recycling into oils and other valuable chemicals using patented Catalytic Hydrothermal Reactor technology (Cat-HTR™) created by Licella Holdings.

https://www.eurekalert.org

CHINA

AI-powered drug discovery framework

Ping An Insurance (Group) Company of China has reported that its researchers have come up with a deep-learning framework for drug discovery. The researchers created a new AI-driven framework for drug discovery called MPG that learns molecular representations from large volumes of unlabeled molecules. They also made their own graph neural networks (GNN) model called MolGNet for modeling molecular graphs.

Ping An said drug discovery can take between 10 and 15 years. AI technologies have been employed to speed up the process, particularly in molecule drug design, drug–drug interaction and drug–target interaction predictions. Yet, molecular designing remained a challenge given the dearth of labeled data for training datasets. To this end, the research team worked with GNN technology, a model that can be pre-trained with unlabeled data instead of relying on labeled data. In their research, the team crafted a self-supervised pre-training strategy named Pairwise Half-graph Discrimination. It found that after pre-training the MolGNet on 11 million unlabeled molecules, it captured "meaningful" patterns of molecules to produce an interpretable representation.

"The pre-trained MolGNet can be fine-tuned with just one additional output layer to create state-of-the-art models for a wide range of drug discovery tasks, including molecular properties prediction, drug-drug interaction and drug-target interaction, on 14 benchmark datasets," the researchers said in their study's abstract. They also said their own GNN model has the potential to become an "advanced

molecular encoder in the drug discovery pipeline."

https://www.mobihealthnews.com

Multi-modal AI

When Open AI's GPT-3 model made its debut in May of 2020, its performance was widely considered to be the literal state of the art. Capable of generating text indiscernible from human-crafted prose, GPT-3 set a new standard in deep learning. But oh what a difference a year makes. Researchers from the Beijing Academy of Artificial Intelligence recently announced the release of their own generative deep-learning model, Wu Dao, a mammoth AI seemingly capable of doing everything GPT-3 can do, and more.

First off, Wu Dao is flat out enormous. It's been trained on 1.75 trillion parameters (essentially, the model's self-selected coefficients) which is a full 10 times larger than the 175 billion GPT-3 was trained on and 150 billion parameters larger than Google's Switch Transformers. In order to train a model on this many parameters and do so quickly—Wu Dao 2.0 arrived just 3 months after version 1.0's release in March—the BAAI researchers first developed an open-source learning system akin to Google's Mixture of Experts, dubbed FastMoE. This system, which is operable on PyTorch, enabled the model to be trained both on clusters of supercomputers and conventional GPUs. This gave FastMoE more flexibility than Google's system since FastMoE doesn't require proprietary hardware like Google's TPUs and can therefore run on off-the-shelf hardware—supercomputing clusters notwithstanding.

With all that computing power comes a whole bunch of capabilities. Unlike most deep-learning models which perform a single task—write copy, generate deep fakes, recognize faces, win at Go—Wu Dao is multi-modal, similar in theory to Facebook's anti-hatespeech AI or Google›s recently released MUM. BAAI researchers demonstrated Wu Dao's abilities to perform natural language processing, text generation, image recognition, and image generation tasks during the lab's annual conference. The model can not only write essays, poems, and couplets in traditional Chinese, it can both generate alt text based off of a static image and generate nearly photorealistic images based on natural language descriptions. Wu Dao also showed off its ability to power virtual idols (with a little help from Microsoft-spinoff XiaoIce) and predict the 3D structures of proteins like AlphaFold.

https://www.engadget.com

AI platform to sort garbage

A team of researchers participating in Huawei's Cloud Garbage Classification Challenge created the aptly named GarbageNet, an AI platform for sorting different types of refuse.

As per the research team's paper:

"We present a novel incremental learning framework, GarbageNet, to address the aforementioned challenges. Firstly, weakly-supervised transfer learning guarantees the capacity of feature extractor. Secondly, for new categories of garbages, GarbageNet embeds them as anchors for reference and classifies the test samples by finding their nearest neighbors in the latent space. Thirdly, an attentive mixup of training data is utilized for suppressing the negative effect of mislabeled data."

GarbageNet can't work alone; it's a brain looking for a body. If the team can either develop their own robots or pair with a company that specializes in mechanical sorting equipment, this could go a long way toward solving our trash problems.

https://thenextweb.com

INDIA

IoT-based device for silk supply chain

Karnataka-based silk agritech startup ReshaMandi is helping to bring different strands of the industry together through IoT and other app-based services. "The silk supply chain always had a problem of not knowing exactly what they are producing in terms of quality. Silk [mulberry] farmers cannot understand the price fluctuations for their cocoons, while reelers who function like cartels, using arbitrary testing methods, can be biased against a product from certain regions. We are trying to change this by using quality as the benchmark for not just pricing, but also production," says Mayank Tiwari, founder and CEO of the silk agritech startup ReshaMandi, based in Bengaluru.

Tiwari co-founded ReshaMandi with Saurabh Agarwal and Utkarsh Apoorva in April last year to digitize sericulture production from farming, thread processing (reeler units) to fabric weavers, and business organizations with platforms based on AI and IoT.

The startup initially helped to solve the logistics problems faced by sericulture farmers and reelers due to the lockdown's transport restrictions. Over the past year, its app-based services have grown to include cocoon sourcing and grading, farmer advisories on mulberry cultivation, disease detection in *chawki* (young silkworms), and fair price marketing. It has also tied up with Bengaluru-based agritech startup Fasal, in an innovative precision farming project that aims to save water resources while increasing the mulberry leaf yield. To speed up the process, ReshaMandi ensures that cocoon grading results are available within a day. By removing the geographical details, the startup tags the cocoon lots by their tested quality scores, which guarantees a fair price.

At the farming level, ReshaMandi offers two IoT devices, one to monitor the soil's carbon and moisture content, and the other to maintain ideal air quality, temperature, and humidity levels in the rearing shed. While the app is free to use, the devices are available on monthly subscription.

The devices are connected with an app installed on a farmer's smartphone (for Android 5.0 and up). The in-house developed app is available on Google Play Store as "ReshaMandi, The New Silk Route." Sensors installed in the field and rearing sheds enable ReshaMandi to send textual advice through the phone, with follow-up calls if required.

https://www.thehindu.com

Automated rainwater harvesting system

Students of the National Institute of Technology Andhra Pradesh (NIT-AP) have devised a unique solution with innovation and technology. Calling themselves Team LinkLer, the group has developed a "Wi-Fi mounted Microcontroller" that integrates sensors for smart harvesting of rainwater and creates a system which does the job without human intervention. This system can automate the process of water storage, reduction in water-borne diseases, and efficient storage. Team LinkLer aims to address the problem of water shortage in Indian cities by deploying Deep Tech such as IoT and machine learning.

The team has developed an end-to-end Software Stack that provides an easy interface to manage and control in-house water resources. The system monitors wastewater and supply systems such as rainfall recorded, water remaining in the storage tank, water quality index, and water supply in a given area. The students have also designed an underground storage tank with a material capable of holding the water on a long-term basis. The treatment process is monitored on a feedback IoT system.

The system strives to bring autonomy in the entire rainwater harvesting process and overall water utility in one's home. They integrate tank depth sensors for available water quantity in the main and secondary tank, and use weather patterns for rainfall estimates using machine learning. Further, estimation of storage from rainwater in the additional tank is done in coordination with the main water supply source as well.

There are two versions of this system. One comes with a mechanical tank setup, while the other integrates the microcontroller and flow meter/sensor into the existing supply. The product's concern is to make users aware of their water usage pattern and make the management process hassle-free. The fact of more "information-based water usage" can drive our concern toward proper addressal of the rising water crisis, the team says.

https://www.thebetterindia.com

IoT device to record real-time ambient temperature

Indian Institute of Technology in Punjab's Ropar has developed a first-of-its-kind IoT device—AmbiTag. The institute stated that the device records real-time ambient temperature during the transportation of perishable products, body organs, and blood, vaccines, etc. AmbiTag is a USB-shaped device that continuously records the temperature of its immediate surroundings from –40°C to 80°C in any time zone for a full 90 days on a single charge.

Most of the similar devices available in the international market record data only for a duration of 30–60 days. AmbiTag has a range of inbuilt features to customize logging intervals, time zone, and alarms, said Dr. Suman Kumar, the coordinator of the IoT Systems Domain at the Agriculture and Water Technology Development Hub (AWaDH). He said AmbiTag is a certified device priced below ₹1,000 to ensure the broader use of the device in different applications. "It generates an alert when the temperature goes beyond a pre-set limit. The recorded data can be retrieved in user-defined format by connecting the USB with any computer."

"The AmbiTag temperature data log advises the user whether the transported item is usable or the cold chain has been compromised during the transportation. This information is particularly critical for vaccines, organs, and blood transportation in the Indian scenario."

"AmbiTag in India is developed by the researchers at the IIT Ropar Technology Innovation Hub - AWaDH and its startup ScratchNest. The ScratchNest is an IoT technology startup founded by four IIT Ropar students. AmbiTag is waterproof and monitors ambient temperature during the transportation of vaccines, including Covid-19, medicines, blood samples, food and dairy products, meat products, and animal semen. So far, such devices are being imported by India in a massive quantity from other countries, such as; Singapore, Hong Kong, Ireland, and China."

https://www.thehindu.com

Blockchain-based healthcare systems

Indian Institute of Technology Madras researchers have developed "BlockTrack," a first-of-its-kind blockchain-based secure medical data and information exchange system for a mobile phone-based application, which is currently being field-tested at the institute's hospital. A release said BlockTrack aims to securely digitize healthcare information systems while ensuring protection of sensitive personal information and medical records by decentralizing the control and ownership of patient data, through a blockchain-based innovation. The BlockTrack innovation is now protected through a provisional IP filed with the Indian Patent Office.

The Android version has been developed separately for patients and doctors. It opens up universal and transferable healthcare information management with a strong emphasis on data privacy and tracking the spread of infectious diseases across geographies. It allows the interoperability of systems from multiple hospitals, institutes, and healthcare organizations. The patient can choose to visit any healthcare facility which is on BlockTrack's blockchain network without any concerns about duplication of records or re-registrations, said the release.

BlockTrack is developed by a team led by Prabhu Rajagopal, Lead Faculty for Remote Diagnostics, Center for Nondestructive Evaluation (CNDE), Department of Mechanical Engineering, IIT Madras. This is one of the first implementations of blockchain technology for securing Healthcare Data Management Systems and we see immense impact this approach can make in securely digitizing and maintaining unique patient records across the country and indeed across the world eventually.

https://www.newindianexpress.com

REPUBLIC OF KOREA

Cardiovascular event prediction model

The Korea Institute of Machinery and Materials (KIMM), said its researchers have

developed a cardiovascular event prediction model that enhances the speed and accuracy of disease diagnosis. Researchers led by Dr. Jong-won Park, head of the institute's Department of Reliability Assessment, collaborated with the cardiology research group at Daejeon St. Mary's Hospital. KIMM said in a statement the research team integrated the big data deep-learning technology used in checking the reliability of mechanical parts and equipment into ultrasound imaging equipment.

According to KIMM, the new technology utilizes a graphics processing unit to achieve a diagnosis time of 30 minutes with 80% accuracy. Using AI deep learning, the researchers came up with the model through automated analysis of aortic atherosclerotic plaque. The research institute said they were "successful in confirming the effectiveness of such methods."

In their study, the research team adopted a fresh approach toward creating a deep-learning model that can be deployed to classify aortic plaque and measure plaque thickness. They applied standard machine learning techniques, such as autoencoder and U-Net models, to differentiate ultrasound images of the aortic wall, which was identified to confirm the conditions of any aortic atherosclerotic plaque—a risk factor for stroke. KIMM noted that the researchers plan to modify the deep-learning model to improve the accuracy of aortic plaque analysis. They also intend to expand the technology to be used along with imaging data for spotting faults and failures in building virtual engineering platforms for manufacturing future transportation equipment parts.

https://www.mobihealthnews.com

AI technology to visualize location and size of sound source

Researchers have developed AI technology that can accurately and quickly visualize the location and size of sound sources. It is useful in tracking the location of disaster survivors, gas spills, and leaks. An empirical test will be conducted in 2022 to search for missing people with a drone equipped with high-performance microphones.

The technology developed by researchers from the Korea Research Institute of Standards and Science (KRISS) and Pohang University of Science and Technology (POSTECH) is 10 times more accurate than previous technologies and the time of arithmetic operation is about one-tenth.

"We will carry out continuous research so that technology can be commercialized and bring innovation to existing markets," Chang Ji-ho, a KRISS researcher, said in a statement released by POSTECH. In defense, the technology can be used to find the location of enemy firearms. POSTECH said that deep-learning algorithms can accurately distinguish the location and size of individual sound sources even under unfavorable conditions where many sounds are mixed and visualize them like a map for easy location.

Tracking the location of sound sources through unmanned aerial vehicles such as drones is not so precise and performance degradation is inevitable due to noise. Because tracking technology developed by the joint research team provides more than 10 times more accurate information than before, it can be used in adverse conditions with noise. Researchers installed 56 speakers in a spherical form in a laboratory to implement various acoustic data. POSTECH said the new technology would contribute to the success of various drone missions such as reconnaissance, transportation, and rescue.

https://www.ajudaily.com

VIET NAM

IoT solutions for rural areas

Kerlink is teaming up with Vietnamese IoT startup Cloud Energy in building new solutions to meet demand for IoT services in rural areas around Ho Chi Minh City (HCMC), expanding on their earlier collaboration on smart-building and energy-management projects in the city of nearly 9 million people. The two companies recently developed and deployed a fully wireless LoRaWAN network to monitor and manage a 900-kWp solar-power installation on a mushroom farm 80 km from the city. The installation of the wireless solar-power system was chosen by NG Investment for its superior advantages: stability of data reading, ability to connect to different inverter brands, and the cost savings on investment and maintenance.

The IoT upgrade included Kerlink's long-range, low-power Wirnet iStation gateways and its Wanesy Management Center to operate and manage the new system, and Cloud Energy's advanced LoRaWAN-based meter and devices for data management, optimized to meet the rigorous requirements of utility scaling. The system is expected to reduce the owners' operation and maintenance costs by 30% annually compared to the previous system. New installations are expected to shave 30% off the cost of a new wired monitoring system.

Cloud Energy uses advanced technologies and developing tailored IoT solutions for its markets in smart utilities management, smart buildings, and smart cities. Based in HCMC, the company provides advanced wireless solutions, including wireless mobile routers and cloud management platforms, optimized to meet the rigorous requirements of utility scaling to provide a best-in-class solar monitoring for energy efficient solutions.

https://futureiot.tech

EUROPE

BELGIUM

Stroke care with AI

Clinicians are using AI to help triage patients they suspect may have had a stroke. Aidoc, a provider of AI-powered tools for medical imaging, and icometrix, a Belgian imaging firm, have teamed up to provide an advanced end-to-end AI stroke package for patients.

The package includes icometrix's FDA-cleared CT analysis tool and Aidoc's FDA-cleared AI stroke solution which detect bleeding inside the skull and if a stroke has happened. Aidoc's algorithms analyze medical images directly after the patient is scanned, before notifying physicians within the imaging workflow. It is customizable and provides cutting-edge AI-

powered care coordination with real-time sharing, viewing, and chatting.

"Aidoc's care coordination suite facilitates rapid triage and communication of patients with suspected stroke, alerting physicians and speeding up access to lifesaving treatment" explains Ariella Shoham, Vice President of Marketing at Aidoc. "The solution is always-on, always running behind the scenes without requiring physician activation. Suspected stroke patients are automatically flagged directly after the scan is performed and a notification is sent simultaneously to team members including neurosurgeons, stroke teams, radiologists and emergency department physicians" she adds.

https://healthcareglobal.com

POLAND

Smart city blockchain solution

Orange and technology company Smartkey, are partnering to deliver blockchain technology that will manage access control, smart bikes, utilities, and other elements of smart cities. Firstly, the two will extend Smartkey's "Rescue without Barriers" pilot, which enables escue services in Olsztyn, Poland use Smartkey to gain immediate access to every secure district and building in the area, using blockchain, reducing response times.

"Smart devices are not a new idea. Already over 2 million M2M cards from Orange work, among others, in such devices throughout Poland," said Sebastian Grabowski, director of IoT and advanced technologies at Orange. "However, even a wide range of such devices does not create a network in itself, just as a collection of houses does not create a city. We also need an infrastructure that connects IoT technology with the end user, and this is what blockchain provides."

Together, this will be deployed to more than 80 cities across Poland which uses Orange's IoT solutions integrated with the Live Objects IoT platform. The Live Objects platform is already being used to manage a number of city services, including remote reading of water meters or street lighting control. The integration of the Live Objects platform enables the ability to register devices with an Orange SIM card in the blockchain network and to generate and distribute Smart NFT access keys in the SmartKey blockchain network. The specificity of blockchain technology based on decentralized applications (dApps) and Orange network security standards prevent unauthorized use of the "virtual key."

https://www.capacitymedia.com

UK

AI to monitor water quality

AI that enhances remote monitoring of water bodies—highlighting quality shifts due to climate change or pollution—has been developed by researchers at the University of Stirling. A new algorithm—known as the "meta-learning" method—analyzes data directly from satellite sensors, making it easier for coastal zone, environmental and industry managers to monitor issues such as harmful algal blooms (HABs) and possible toxicity in shellfish and finfish.

Lead author Mortimer Werther, a PhD Researcher in Biological and Environmental Sciences at Stirling's Faculty of Natural Sciences, said: "Currently, satellite-mounted sensors, such as the Ocean and Land Instrument (OLCI), measure phytoplankton concentrations using an optical pigment called chlorophyll-a. However, retrieving chlorophyll-a across the diverse nature of global waters is methodologically challenging. "We have developed a method that bypasses the chlorophyll-a retrieval and enables us to estimate water health status directly from the signal measured at the remote sensor."

"This research, funded by the European Union's Horizon 2020 programme, is the first demonstration that trophic status of complex inland and nearshore waters can be learnt directly by machine learning algorithms from OLCI reflectance measurements. Our algorithm can produce estimates for all trophic states on imagery acquired by OLCI over global water bodies.

"Our method outperforms a comparable state-of-the-art approach by 5-12% on average across the entire spectrum of trophic states, as it also eliminates the need to choose the right algorithm for water observation. It estimates trophic status with over 90% accuracy for highly affected eutrophic and hypereutrophic waters."

https://eurekalert.org

NORTH AMERICA

USA

AI-powered dermatology tool

At Google's recent I/O event, Google announced its new AI-powered dermatology tool for consumers. The app allows consumers to use their phone's camera to capture images of their skin, hair, or nail concern from different angles. The app will then guide the user through a series of questions to better understand the users' skin type, how long they have had the issue, and if any other symptoms are present.

Google's AI dermatologist tool will help address key barriers in access to care for consumers and help them take an empowered role in their care. This tool may help:

1. Lower the cost of care for consumers. On average, a dermatologist visit costs consumers $150. Google's AI dermatologist tool offers a starting point for consumers and makes skincare advice more accessible for people who cannot afford traditional options.
2. Increase access to dermatological care. Over 2 billion people globally suffer from dermatologic issues, but there is a shortage of specialists. Although dermatologist density has increased from an estimated 1.9 specialists per 100,000 individuals in 1970 to 3.4 in 2017, the recommended density of 4.0 specialists per 100,000 people for adequate dermatologic care has not been met, and the gap between access in rural and urban areas is growing.
3. Improve care outcomes with earlier diagnosis. Through the tool, users can collect data that may lead to an earlier diagnosis by prompting users to see a clinician. Google's AI dermatologist tool allows users to capture their condition in real time, which is key when patients face an average wait time

of 18 to 33 days. As Dr. John Maitland told Forrester in an interview, "We often use the photographs that people have on their phones. The rashes may have changed or gone away. [If] they can show us photos when they first got it, we can see the progression."

4. Enable consumers to make informed decisions about their healthcare. Google's tool can give users the information they need to make an informed decision about the next steps—whether that is more research or making an appointment. The AI model analyzes the data and pictures you provide against its knowledge of 288 conditions to give a list of possible matching conditions that users can research further.

https://www.cdotrends.com

AI to monitor remote seabird colonies

Scientists at Duke University and the Wildlife Conservation Society (WCS) used a deep-learning algorithm—a form of AI—to analyze more than 10,000 drone images of mixed colonies of seabirds in the Falkland Islands off Argentina's coast.

The deep-learning algorithm correctly identified and counted the albatrosses with 97% accuracy and the penguins with 87%. All told, the automated counts were within 5% of human counts about 90% of the time. "Using drone surveys and deep learning gives us an alternative that is remarkably accurate, less disruptive and significantly easier. One person, or a small team, can do it, and the equipment you need to do it isn't all that costly or complicated," said Madeline C. Hayes, a remote sensing analyst at the Duke University Marine Lab, who led the study.

To conduct the new surveys, WCS scientists used an off-the-shelf consumer drone to collect more than 10,000 individual photos, which Hayes converted into a large-scale composite visual using image-processing software. She then analyzed the image using a convolutional neural network (CNN), a type of AI that employs a deep-learning algorithm to analyze an image and differentiate and count the objects it "sees" in it—in this case, two different species of sea birds. These counts were added together to create comprehensive estimates of the total number of birds found in colonies.

https://www.sciencedaily.com

IoT communicators at 5G speeds

Researchers at the Georgia Institute of Technology, Nokia Bell Labs, and Heriot-Watt University have found a low-cost way for backscatter radios to support high-throughput communication and 5G-speed Gb/sec data transfer using only a single transistor when previously it required expensive and multiple stacked transistors.

Employing a unique modulation approach in the 5G 24/28 Gigahertz (GHz) bandwidth, the researchers have shown that these passive devices can transfer data safely and robustly from virtually any environment. The findings were reported earlier this month in the journal *Nature Electronics*.

Traditionally, mmWave communications, called the extremely high-frequency band, is considered "the last mile" for broadband, with directive point-to-point and point-to-multipoint wireless links. This spectrum band offers many advantages, including wide available GHz bandwidth, which enables very large communication rates, and the ability to implement electrically large antenna arrays, enabling on-demand beamforming capabilities. However, such mmWave systems depend on high-cost components and systems.

The researchers are the first to use a backscatter radio for gigabit-data rate mmWave communications, while minimizing the front-end complexity to a single high-frequency transistor. Their breakthrough included the modulation as well as adding more intelligence to the signal that is driving the device.

The technology opens up a host of IoT 5G applications, including energy harvesting, which Georgia Tech researchers recently demonstrated using a specialized Rotman lens that collects 5G electromagnetic energy from all directions.

https://www.eurekalert.org

AI strategy enables robots to adapt to real world environments

Artificial intelligence algorithms developed by a team of researchers from UC Berkeley, Facebook and Carnegie Mellon University are equipping legged robots with an enhanced ability to adapt to and navigate unfamiliar terrain in real time.

Their test robot successfully traversed sand, mud, hiking trails, tall grass and dirt piles without falling. It also outperformed alternative systems in adapting to a weighted backpack thrown onto its top or to slippery, oily slopes. When walking down steps and scrambling over piles of cement and pebbles, it achieved 70% and 80% success rates, respectively, still an impressive feat given the lack of simulation calibrations or prior experience with the unstable environments. Not only could the robot adjust to novel circumstances, but it could also do so in fractions of a second rather than in minutes or more. This is critical for practical deployment in the real world.

The RMA system combines a base policy — the algorithm by which the robot determines how to move — with an adaptation module. The base policy uses reinforcement learning to develop controls for sets of extrinsic variables in the environment. This is learned in simulation, but that alone is not enough to prepare the legged robot for the real world because the robot's onboard sensors cannot directly measure all possible variables in the environment. To solve this, the adaptation module directs the robot to teach itself about its surroundings using information based on its own body movements. For example, if a robot senses that its feet are extending farther, it may surmise that the surface it is on is soft and will adapt its next movements accordingly.

The base policy and adaptation module are run asynchronously and at different frequencies, which allows RMA to operate robustly with only a small onboard computer. The RMA project is part of an industry-academic collaboration with the FAIR group and the Berkeley AI Research (BAIR) lab. Before joining the CMU faculty, Pathak was a researcher at FAIR and a visiting researcher at UC Berkeley. Pathak also received his Ph.D. degree in electrical engineering and computer sciences from UC Berkeley.

https://engineering.berkeley.edu

Fourth Industrial Revolution Technologies for Progress in UN SDGs

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Abstract

COVID-19 pandemic has accelerated the development and adoption of fourth industrial revolution technologies, 4IR helps to contain the pandemic, to protect and deliver essential services to billions of people, to learn remotely, to perform work from anywhere, and to restore resilience of economies. 4IR technologies are indispensable in attaining the UN Sustainable Development Goals 2030 by countries as well as by companies. Benefits of 4IR include lower greenhouse gas emissions, reduction of solid waste going into land, incinerators, and oceans, improved healthcare, low-carbon products and services, better jobs, sustainable farming, protecting the environment and biodiversity, and mitigating extreme weathers and rising sea levels. Enthusiasts are already envisioning a fifth industrial revolution, 5IR-facilitated societies. This article presents a discussion of basics, trends, challenges, solutions, and opportunities for inclusive and equitable sustainable development.

Introduction

COVID-19 pandemic has affected all economies and lives of around 7.9 billion people. Pandemic exposed the vulnerabilities of inadequately prepared communities and individuals. United Nations Development Program, UNDP projected that more than 200 million people fall into extreme poverty by 2030 due to COVID-19 effects. This number is in addition to 470 million or 6% of world population estimated to be living in extreme poverty by 2030. More than 1.25 billion students worldwide affected by the lockdowns, and students in the developing countries have limited or no access to online learning and thus growing up with no learning. Low-income countries are in firefighting mode with daily issues. Hence several countries gone off the track of environmental sustainability goals endorsed by 193 nations at the 2015 Paris agreement. Income and gender inequalities are rising in all countries. High-income nations and large companies are building post-pandemic economic growth and new jobs creation via carbon neutral circular economies. If proactive actions with long-term perspectives are not taken, a good proportion of developing countries as well as small and medium enterprises will be left behind in the emerging future led by green growth and sustainability. In other words, the United Nations 2030 Sustainability Development Goals, SDGs will be missed (Liu and Ramakrishna, 2020). Climate change is the impending challenge, and all nations are underprepared (Tamil Selvan and Ramakrishna, 2021).

This article examines the role of fourth Industrial Revolution, 4IR technologies in building carbon-neutral circular economy for sustainable development (Ramakrishna *et al*, 2020 and Ramakrishna, 2021A, 2021B). Sustainability underpinned by the carbon neutral circular economy is about reduction of carbon (GHG) emissions as well as circular solid waste management to reduce pollution and waste generation, to alleviate resources depletion, to regenerate biodiversity, and to overcome rising sea levels and extreme weathers for the well-being of humans and preserving Earth for the future generations. It aims to deliver quality economic growth, jobs, & living conditions. 4IR technologies are several as indicated in Robotics, automation, internet of things (IoT), artificial intelligence, machine learning, big data analytics, block chain, 5G, cloud computing, nanotechnology, and additive manufacturing often mentioned in the media and national strategies (Figure 1). Augmented reality, digital twins, sensors, wearables, intelligent materials & systems, materials informatics, brain-machine interface, and quantum computing are also 4IR technologies. Information on each of these technologies is vast and growing.

Robotics and Automation

Robots are conceived to assist humans in repetitive and hazardous jobs. They are categorized into manipulators & industrial robots, mobile robots, and humanoid robots based operation, movement, control and sensor. Sensing elements of robots make use of the specialist behaviors of materials such as thermal-sensitive, photosensitive, force-sensitive, piezoelectric, vision, etc. Sensing element produces a useful signal. Signals processed by the controllers and facilitate robot performing certain functionalities. Nanotechnology and advanced electronic hardware chipsets capable of handling complex algorithms contributed to the evolution of controllers to be more precise added with cognitive capabilities. Robots are finding uses in diverse sectors of economy and society to aid in the productivity and sustainability of manufacturing of products as well as delivery of services. Automation of process industry, manufacturing industry, assembly industry, packaging

industry, warehousing, quality control and inspection, and transportation logistics primarily enabled by the mass production of specialist robots and coordinating them via big data analytics, block chaining, machine learning, and artificial intelligence.

Internet of Things (IoT) and Industrial Internet of Things (IIoT)

When several physical objects are connected digitally such a system is known as the Internet of Things (IoT) or Industrial Internet of Things (IIoT). More than 50 billion physical objects are digitally connected with cost-effective and energy efficient sensors. Many more billions of objects and machines will be connected in the coming decades. The ubiquitous connectivity accrues benefits such as information sharing and coordination leading to new functions and services that were previously not feasible, as well as greater device or equipment reliability since their status queried on a regular basis. Such systems are already deployed in the manufacturing industry, autonomous vehicles, traffic management, shipping, power grids, immigration and check points, security services, buildings and construction, solid waste management, precision agriculture and farming, and flood control in canals and water ways, to name a few. This 4IR technology has the ability to make the systems more agile and responsive, reduce equipment downtime and achieve greater efficiencies in operations leading to reduced costs. For example, precision farming will save water, energy, and fertilizers thus leading to lower carbon footprint and resources efficiency. Another example is the manufacturing industry equipped with 4IR technologies, which is also known as digital manufacturing or smart manufacturing or intelligent manufacturing. 4IR technologies will enable all players in the value chain of products at the supply chain, enterprise and shop floor levels to be digitally connected and data analytics-driven, thus achieving intelligent coordination for demand and supply matching, faster time to market, mass customization, and reduction of waste generation.

Digital Twins

Digital twins are virtual replicas of physical devices, systems, and spaces. They leverage 4IR technologies such as IoT, IIoT, big data analytics, artificial intelligence, and computer modeling to run simulations to design and to optimize operational performance thus leading to energy efficiency, decarbonization, and optimized use of resources. They found in a number of sectors such as power plants and power grids, manufacturing plants, automotive industry, healthcare, buildings and construction industry, urban design, and urban systems.

Artificial Intelligence

Artificial intelligence, AI, is the ability of a device or system to perceive its environment or correctly interpret external data, to learn from such data, and flexibly adapt those learnings to take actions that maximize its chance of successfully achieving its goals. AI gained strong foothold in internet search engines, home systems, social media, gaming industries, security, finance, and commerce. AI coupled with other 4IR technologies employed to increase energy efficiency, to facilitate carbon trading, and to realize the circular economy of products and services (Jose et al., 2020).

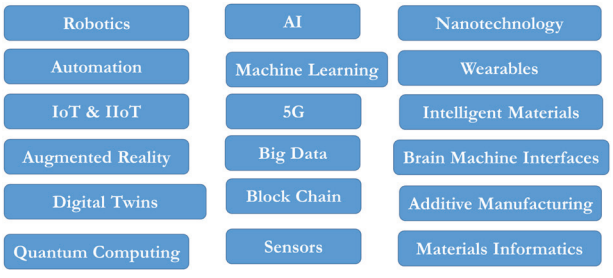

Figure 1: A short list of fourth industrial revolution, 4IR technologies

Machine Learning and Deep Learning

Computer algorithms are evolving toward Artificial Intelligence instilling with the machines with the cognitive ability by the use of data known as machine learning, ML and Deep Learning, DL. ML uses sample/historical/training data to build a model so as to predict or make decisions based on the real-time data. ML is suited to model both big as well as limited data, for example in the manufacturing industry dealing with real measurements (Khayyam et al., 2020). Machine learning and AI are finding applications in agriculture, environment monitoring, health, climate change mitigation measures, smart and clean energy, smart and green cities, smart traffic management, and autonomous transportation, to name a few. DL or deep neural network learning can learn unsupervised, utilizing unstructured, unlabeled data even at higher frequencies in real time.

Block chain Technology

Block chain technology is a decentralized, distributed ledger that records the provenance of a digital asset. By inherent design, the data on a block chain is secure and tamper proof. In other words, the digital ledger of transactions duplicated and distributed across networks of computer systems that support block chain. Hence, block chain is finding uses in certification, authentication, and records safekeeping in diverse sectors in addition to circular economy, which is an important concept of sustainability. Circular economy emphasizes three R's, i.e., reducing materials and waste, reusing products, and recycling materials. Block chain is helpful in ensuring traceability of materials and transparency of transactions. Carbon offsets and carbon credits trading, carbon tokenization would benefit from the advantages offered by block chain technology.

Data Analytics

Quality and reliable data is necessary for making sound sustainability decisions. 4IR trend is to perform real-time data collection and analyzing dynamically for faster and effective decision-making. Software

companies provide platforms for big data processing. Hyper-scale data centers support them. However, these data centers are huge energy hogs. The International Energy Agency estimates that the sector currently uses around 1% of the world's electricity. This figure could hit double-digits by 2030, making related emissions a problem. Sustainability credentials of data centers (Manganelli et al., 2021) are evaluated via indicators such as power usage effectiveness (PUE), carbon usage effectiveness (CUE), on-site energy fraction (OEF), and on-site energy matching (OEM), energy reuse factor (ERF), and water usage effectiveness (WUE). Accordingly, new data centers with improved sustainability performance will be built in countries around the world.

Data analytics coupled with other 4IR technologies such as sensors, 5G, and block chain labeling, and eco-friendly product designs facilitate transition toward zero-waste manufacturing and carbon neutral societies with low-carbon products and low-carbon services. In other words, reducing the amount of solid waste sent to the landfills or incinerators.

Sensors, Processors, and 5G Networks

Ubiquitous digitalization is contingent on the availability of robust, power efficient and cost-effective smart sensors, faster processors, and high-speed wireless networking interfaces. For this purpose nanotechnology, quantum science, and atomic scale precision engineering of atoms enable design and fabrication of advanced sensors. Self-powered and environmentally friendly sensors, electronic skins, and molecular labeling for traceability are few such examples. More over a variety of processors from small low-end cores for sensors and actuators to more compact and power efficient for robots and intelligent devices to highest performance cores for servers. They designed to process more efficiently using algorithms and data processing arrays with low energy requirements. 5G network provides with gigabit bandwidth with low latency connectivity to enable the flow of low to high bandwidth data seamlessly in real time.

Nanotechnology

Nanotechnology methods enable building of materials and devices on the scale of atoms and molecules. A nanometer is one-billionth of a meter, and 100,000 nanometers is the thickness of paper. Nanotechnology harnesses enhanced materials characteristics such as color, thermal conductivity, electrical conductivity, quantum entanglement, and reactivity at such length scales. Application of Nanotechnology in decarbonization span across

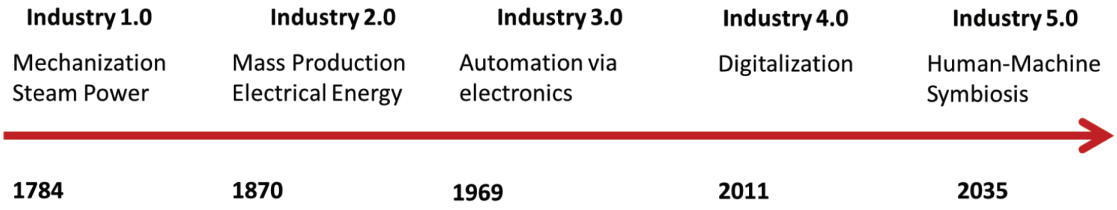

Figure 2: Industrial Revolutions

UN SDG	Sectors	Robotics & Automation	IoT, IIoT	Digital Twins	AI, Machine Learning	Block chain	Data Analytics	Sensors & 5G	Nanotechnology	Additive Mfg, 3D Printing
1	Family income	☺☺	☺☺	☺☺	☺☺	☺☺	☺☺	☺☺	☺☺	☺☺
2	Food	☺☺	☺☺☺	☺☺	☺☺☺	☺☺☺	☺☺☺	☺☺☺	☺☺☺☺	☺
3	Health	☺☺☺	☺☺☺	☺☺☺	☺☺☺	☺☺☺	☺☺☺	☺☺☺	☺☺☺	☺☺☺
4	Education	☺☺	☺☺☺☺	☺☺☺	☺☺☺☺	☺☺	☺☺☺☺	☺☺☺☺	☺☺☺	☺☺☺
5	Gender equality	☺☺	☺☺	☺☺	☺☺	☺☺	☺☺	☺☺	☺☺	☺☺
6	Water and Sanitation	☺☺	☺☺☺☺	☺☺	☺☺	☺	☺☺☺☺	☺☺☺	☺☺☺☺	☺
7	Energy	☺☺	☺☺☺	☺☺☺☺	☺☺☺	☺	☺☺☺☺	☺☺	☺☺☺	☺
8	Economic Growth	☺☺☺	☺☺	☺☺	☺☺	☺☺☺	☺☺☺☺	☺☺	☺☺	☺
9	Infrastructure	☺☺☺	☺☺☺☺	☺☺☺☺	☺☺☺☺	☺☺	☺☺☺☺	☺☺☺☺	☺☺☺	☺☺
10	Social mobility	☺☺	☺☺	☺☺	☺☺	☺☺	☺☺	☺☺	☺☺	☺☺
11	Urbanization	☺	☺☺☺☺	☺☺☺☺	☺☺	☺☺	☺☺☺☺	☺☺☺	☺☺☺☺	☺
12	Consumption & Production	☺☺☺	☺☺☺	☺☺	☺☺☺	☺☺☺	☺☺☺	☺☺☺	☺☺☺	☺
13	Combating Climate Impact	☺	☺☺	☺☺	☺☺☺	☺☺☺☺	☺☺☺☺	☺☺☺	☺☺☺	☺☺
14	Oceans & Water Resources	☺	☺	☺	☺☺	☺☺	☺☺	☺☺	☺☺☺	☺
15	Terrestrial Ecosystems	☺	☺☺☺	☺☺☺☺	☺☺☺	☺☺☺	☺☺☺☺	☺☺☺☺	☺	☺
16	Peace & Security	☺☺	☺☺	☺	☺☺☺	☺☺☺☺	☺☺☺☺	☺☺☺	☺☺	☺
17	Trade & Commerce	☺☺	☺☺	☺	☺☺☺	☺☺☺☺	☺☺☺☺	☺	☺	☺

Figure 3: Mapping of 4IR technologies on to the UN SDGs and diverse sectors

many sectors. For example, processing and washing of textiles, protection of crops in agriculture, enhancing the yields of aquafarming, longer life packaging of food, wastewater treatment (Ang et al., 2021), solid waste management, cooling the buildings, insulation, renewable energy harvesting and storage, monitoring and sensing of environment, air & water, lighter & stronger materials for mobility, and anti-microbial and anti-viral surfaces.

Additive Manufacturing or 3D Printing

Additive manufacturing or 3D printing involves direct making of products by layer-by-layer disposition of materials using digital data from a 3D model. Process is suited to reduce the resources consumption per product while improving the functionality, integration, and flexibility of product manufacturing. It is also suited to re-manufacture used components to recover value beyond the traditional 3Rs approach, i.e., reuse, recycle, and recover. According to the United Nations Environment Program, UNEP manufacturing is responsible for 20% of global CO2 emissions. COVID-19 highlighted the need for resilient manufacturing within the countries and communities (Teymourian et al., 2021). Additive manufacturing is one of the ways to attain resiliency and sustainability goals in products and services sectors with improved productivity, cost savings, product customization to the markets, resources efficiency, and mitigating manufacturing's negative environmental impact.

To get a sense of 4IR technologies impact on economies and human development, Figure 2 compares them with earlier industrial revolutions. Steam power and mechanization drove the first industrial revolution. Electrical energy and mass production underpinned the second industrial revolution. Electronics led automation facilitated the third industrial revolution. Per capita incomes, quality of infrastructure, living standards, education attainment levels, and improved average life spans in several nations around the world underscore the importance of IR technologies. Hence, it is in the best interests of emerging countries and small and medium enterprises to embrace 4IR technologies for respective contexts and needs.

Building on the success and promise of 4IR, technologists and policy makers envision fifth industrial revolution, 5IR. 5IR will be more toward human–machine collaboration for example a seamless mix of robots and humans. 5IR involves seamless merging of physical world with digital world via advances such as cognitive computing, space computing, brain-machine interfaces, quantum computing, intelligent materials, and beyond 5G network technologies. It aims to transform the relationships between technology and living spaces and habitats of people so that the economic development is more equitable and safe environment for creative activities. Considering the integrative scope of 5IR, Japan calls it as data driven Society 5.0.

Figure 3 attempts to map 4IR technologies on to the UN SDGs and economic sectors. It is clear that diverse 4IR technologies facilitate economic growth and job creations in various sectors while progressing on seventeen UN SDGs. An exhaustive discussion is not possible here due to the space constraints of the article. However, in order to illustrate key take away pointers, a case study of Singapore is described in the following section.

Case study on Singapore

Singapore is an island nation of 720 square kilometers land and a city-state with 5.6 million residents. Despite not endowed with natural resources, and faced with uncertain future at birth as a nation in 1965, Singapore has transformed from a low-income country to a high-income country over the past five decades. Singapore is systematically implementing seventeen UN SDGs with 169 targets and 247 indicators. Singapore made significant strides in water and sanitation (SDG6), healthcare (SDG3), education(SDG4), family income (SGD1), gender equality (SDG5), social mobility (SDG10), and sustainable urbanization (SDG11) with nearly 50% green cover.

Yet, Singapore recognizes its vulnerability to extreme weathers and rising sea levels caused by climate change. Singapore Prime Minister Lee Hsien Loong attended the Earth Day climate summit hosted by the US President Joe Biden. The summit acknowledged that no country tackle the climate change alone. He emphasized the critical role of technological innovations and public as well as private finances in realizing carbon neutral and climate-resilient economies. Singapore is turning to technology to reduce its emissions and mitigate climate change effects. Singapore emitted 53 million tons of CO_2 in 2019, which is around 0.1% of global emissions. Singapore ranks 27th out of 142 countries in terms of emissions per capita, and 126th of 142 countries in terms of CO_2 emissions per dollar GDP. As a responsible nation, Singapore making systematic efforts to control annual CO_2 emissions to less than 65 million tons by 2030, half it by 2050 and reduce it to zero before 2100. Singapore emissions comprise about 60% from industry, 15% from transport, and remaining from the building and household sectors. Ongoing carbon emissions reduction measures include enhancing energy efficiency, ramping up of solar energy adaption, zero-emission buildings, electrification of transport, sustainable urban farming, transition toward zero waste economy, and reforestation. Also exploring the potential of green hydrogen, importing renewable electricity via regional power grid, and carbon capture utilization and storage technologies in addition to carbon offsets and carbon trading. SG Green Plan 2030 is a whole-of-nation effort for climate action, sustainable development and decarbonization of economy (Carrière et al., 2020; Rezvani Ghomi et al., 2021). Herein, the role of 4IRs in realizing UN SDGs is elaborated. Singapore is one of the most advanced countries in adapting latest and emerging technologies. For example, Singapore in fact demonstrated to the world as a role model in using tracing app and Bluetooth tokens to manage, control and combat the community spread of COVID-19 in Singapore. Singapore made notable progress with SDG1, i.e., end poverty in all its forms, SDG5, i.e., gender

equality and empower all women and girls, and SDG10, i.e., reduce inequality.

Food (SGD2)

SDG2 is to end hunger, achieve food security and promote sustainable agriculture. Only 1% of Singapore's land used for agriculture and hence most of its food is imported. COVID-19 disruptions to supply chains underscored the food security. Singapore embarked on urban farming to meet its 30% of nutrition needs by 2030. Technological innovations are employed for sustainable urban food production. Indoor multi-tier farming automation and precision agriculture via sensors and IoT; hydraulic engineering and 24/7 monitoring for quality, preventive and on demand maintenance; drone, nanotechnology and AI enabled micronutrients delivery; energy efficiency by implementing green energy conversion and storage technology and infrastructure; water efficiency; nanotechnology advances enabled durable food packaging (Bigdeloo et al., 2021); recycling of resources; web based apps matching the demand and supply and avoid wastage are few examples. In addition, science-led feed and nutrients customization for higher yields. In aquaculture, to maximize production, 4IR technologies would be useful to find a sweet spot where fish fed optimally without causing deterioration of oxygen levels in water, and ensuring quality of water and surrounding environment in terms of harmful bacteria, viruses and pathogens. Singapore is also facilitating lab grown, plant based meat alternatives or synthetic meat industry. Such novel food production leverages 4IR in cell culturing, culture medium, and coloring, texture, structure and scaled up manufacturing, and safety evaluation. They are associated with lower greenhouse gas emissions and agriculture land needs, while improving resources efficiency, antibiotic resistance and mitigating zoonotic diseases.

Health (SDG3)

SDG3 is about ensuring healthy lives and ensure well-being for all, at all ages. Singapore life expectancy is among the highest in the world, and the high quality healthcare is affordable to all. Due to aging demographics, going forward, Singapore needs to provide expanded eldercare services. Innovative technologies including robotics, AI, IoT, telemedicine, personalized medicine, minimally invasive surgeries, stem cells, regenerative medicine, synthetic biology, nanomedicine, neural interfaces, electroceuticals and mind-inspired technologies to be developed with Singapore population mix in mind. More science advances and bioengineering and biomedical technology innovations will prepare Singapore for future epidemics, low fertility rates, mental health issues, life style diseases and other healthcare burdens.

Education (SDG4)

SDG4 is about ensuring inclusive and equitable quality education and promote lifelong learning opportunities for all. COVID-19 has accelerated digitalization of education at all levels. Going forward, blended learning comprising online learning as well as in-person learning will be a mainstream approach. Rapidly changing jobs market as well as lifelong learning attitudes place emphasis on reskilling and acquiring updated knowledge. 4IR innovations to be adapted to improve interactions between the lecturers and students, and among the students taking full advantage of intellectual university community experience, capstone projects involving students from different time zones and industry partners, assessment tools and methods, and conducting laboratory based subjects too. Moreover, sustainability thinking to be infused into the learning of children, adults, business leaders, and policy makers. Singapore schools, colleges and universities are proactively embracing these necessary changes.

Water and Sanitation (SDG6)

SDG6 is ensuring availability and sustainable management of water and sanitation for all. Higher energy efficient and cost-effective innovative technologies are needed to maximize the yield on every drop of rain that falls on Singapore, desalination of seawater, and circular water or zero wastage of water. Sanitation further enhanced via deep tunnel sewerage system, DTSS to meet the future demands of wastewater collection, treatment, reclamation and disposal. A network of wireless sensors or smart water grid will function as a real-time platform to monitor water flows and minimize water leaks. Improved engineering solutions in terms of drainage systems, pumps, and barrages are necessary for managing heavy rain events, storm water floods, and rising sea levels. Singapore converts solid waste into energy. For example by mixing greasy waste with used water sludge and digesting them together produced biogas, which then converted into electricity. Such an approach makes the solid waste management process more sustainable and viable.

Energy (SDG7)

SDG7 is about ensuring access to reliable, affordable, sustainable and modern energy for all. The World Economic Forum (WEF) ranks Singapore 21st globally in its Energy Transition Index (ETI) 2021. This reflects Singapore progress toward a more inclusive, sustainable, and affordable and secured energy system. Singapore relies heavily on pollutive natural gas to meet its electricity and energy needs. To shift toward greener sources, Singapore is ramping up solar power capacity from 260 MW to 2 GW between now and 2030, amounting to an increase from less than 1% to 4% of electricity demand. Floating solar PV farms and roof top solar farms are creative solutions but need further engineering innovations to mitigate associated heat island effects and potential leachates. 4IR technologies such as sensors, IoT, big data analytics and digital twins are necessary to remotely monitor the electricity generation and to make accurate forecasts. Robotics and automation are helpful to align the solar modules to the sun directions. AI and machine learning are useful in assess defects in the solar panels and take proactive preventive maintenance steps. Nanotechnology is helpful to keep the solar modules free from dust accumulation as well as enhance the efficiencies of solar photovoltaics. Further engineer-

ing advances needed to cut the price of solar energy in half by 2030. In parallel, Singapore may capture carbon emissions from power plants and industries and store it permanently in subterranean reservoirs such as saline aquifers, depleted oil and gas reservoirs or depleted coal seams. Carbon Capture and Storage, CCS solutions require engineering innovations in terms of cost efficient capture technologies, transportation and pumping into the reservoirs with long-term safety and environmentally robust ways.

Hydrogen is perceived to be a clean fuel and energy source of the future. 'Green hydrogen' is manufactured by using renewable electricity for the electrolysis of water. Whereas the 'blue hydrogen' or industrial hydrogen is produced from either natural gas via methane steam reforming or from coal via coal gasification. Both processes produce CO_2 emissions and aforementioned CCS technology used to capture emissions. The blue hydrogen is 50% cheaper than the green hydrogen. Hydrogen economy requires infrastructure and engineering solutions in terms of cost-effective production, safe storage, and fuel cells technology. Innovations are needed to lower the cost of clean hydrogen by 80% by 2030, to be competitive with natural gas.

Economic Growth (SDG8)

SDG8 is about sustained and inclusive economic growth, full and productive employment and decent work for all. Sustainable tourism is beneficial to economic growth as well as earth friendly progress of Singapore. Recreation and leisure activities reimagined with the aid of 4IR technologies. Interactive three-dimensional models of Singapore landscapes created using augmented reality, mixed reality, image processing, GPS, digital twins and virtual reality supported by the Smart Nation program of Singapore. A sustainable tourism industry involves integration of sustainable hotels with green transportation and waste management in local circular economy. Integrated waste management by Alba Company involves smart waste bins, RFID tagging, mobile phone apps for uploading of photos of waste deposited by the residents, big data analytics, and web enabled platforms for earing carbon credits and trade them for incentives. Monitory Authority of Singapore has set up a two billion US dollar green fund to promote environmentally sustainable projects in Singapore and overseas. It will support the development of carbon trading and services, sustainability consultancies and environmental risk management. Self-reporting on Environmental, Social and Governance, ESG is encouraged by the investors. This means, Environmental - effects of company's operations on environment such as greenhouse gas emissions, waste and pollution and resource depletion; Social- company's ability to deal with workforce and society such as working conditions, employee relations and diversity, and ties with local communities; and Governance- corporate governance of a company which includes considerations such as broad diversity and transparency. ESG skeptics point out issues such as a) lack of common methodology, b) varying metrics, c) data gaps, and d) reliability and transparency of information and processes. There is an opportunity to increase investors as well as public confidence in ESG declarations by the companies and green-themed funds. 4IR technologies will make the ESG ratings processes more robust, dynamic and precise. Block chain, machine learning, AI and big data will enable accurate and third-party verifiable tracking of information, facts and assets. Singapore Stock Exchange backed Climate Impact Exchange, CIX aims to offer platforms and products for global trading of carbon credits. CIX is a joint venture funded by DBS bank, Temasek Holdings, Standard Chartered bank, and the Singapore Exchange. Carbon abatement or carbon-offset projects include renewable energy enterprises, projects to save rainforests and mangroves. 4IR technologies enable the verifiability of carbon offsets.

Infrastructure (SDG9)

SDG9 is about building resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation. Singapore has built excellent airport, marine shipping port, and land transportation systems. Airline industry is poised to transform with 4IR technologies, alternative fuels, lightweight materials, electrical power, and fuel cell technologies. Digitalization of trade and block chaining of documentation aimed at speeding up the marine commerce. COVID-19 pandemic adaptation accelerated digital transformation facilitated by big data, AI and 5G, and created a strong demand for hyperscale data centers. Green data centers are being envisioned with higher energy efficiency or lower power usage effectiveness (PUE) by leveraging engineering innovations in cooling systems, configurations, and materials substitution suitable for tropics.

Urbanization (SDG11)

SDG11 is to make cities and human settlements inclusive, safe, resilient and sustainable. Land Transport Authority, LTA is considering integrated infrastructure to allow people to commute across Singapore without the need to use roads. This includes a mix of 1,300 km paths conducive for cycling and walking, 500 km park connectors, and elevated skyparks for pedestrians by 2030. Further promoting and incentivizing greener modes of transportation.

Built environment sector has been leveraging 4IR to build residential homes and commercial buildings, and deep tunnel sewerage systems and transport infrastructure. Companies such as City Developments Limited, Capital Land and Lendlease employ sensors and big data analytics to enhance the green mark rating of the buildings as well as transition toward to zero energy buildings. Drones are used for checking for defects in the facades of tall buildings and skyscrapers. Automated Robots are employed to check for leakages in the deep tunnel sewerage systems, which are several meters below the ground and run for hundreds of kilometers. Singapore acknowledged for pre-fabrication of building components off-site in a factory environment with best industry standards and transport them to site for final assembly. Concrete and glass are commonly used building materials. Recently, timber considered in the construction of buildings. Mass-

engineered timber is a sustainable material or low-carbon material and provides a sense of well-being and warm comfort to the inhabitants. Moving forward, sustainability thinking and solutions incorporated from the project conceptualization and design, through construction, operational maintenance and end-of-life management. Materials selection based on low-carbon materials and longer life with durability. Upcycling of post incineration waste, conversion of captured carbon emissions into concrete, additive manufacturing of building components, and 4IR technologies for tracking, tracing and monitoring to ensure higher circularity of building materials. Building information modeling and digital twins enable data-led engineering and sustainability optimized buildings and infrastructure. Enhanced design and technologies will enable buildings to have net positive impact by operating efficiently, cleanly and friendly to the environment. Interior designers are using mainly recycled and recyclable materials to lower the embedded carbon footprint of buildings and living spaces. These are in addition to water conservation and energy efficient appliances for lighting, air-conditioning and refrigeration supported by IoT sensors and data analytics. Further, Singapore aims to moderate its rising urban temperature via potential solutions such as planting million more trees and cool painting on buildings.

Consumption and Production (SDG12)

Singapore's approach to SDG12 sustainable consumption and production is to become a Zero Waste Nation. 3Rs: Reducing, Reusing and Recycling thinking and cultural change is promoted via policy measures such as extended producer responsibility and state of the art end-of-life management of major waste streams namely e-waste, plastic and packaging waste, and food waste (Patil and Ramakrishna, 2020; Tan et al., 2021). Engineering innovations are needed in several areas for example, low carbon processes and materials, automatic labeling, identification using block chain and AI technology, sorting, processing and upcycling of wastes; and increasing product life and repairability via better designs.

Combating Climate Change and its Impacts (SDG13)

SDG13 is about taking urgent action to combat climate change and its impacts. Singapore committed one hundred billion dollars by 2100 to mitigate rising sea levels and rainstorm floods. Singapore is the first country in Southeast Asia to introduce carbon tax. It is also test bedding electric cars, green buildings, sea barrages and decks, carbon tax, carbon credits, carbon offsets, and carbon trading. They supported by 4IR innovations. Singapore is sensorising water drains and canals, and dams to monitor water levels to dynamically adjust the mitigation measures and to provide early warning signals. To facilitate carbon trading, web-based platforms are created for quality carbon offset projects monitored by 4IR technologies such as AI, IoT and Big Data Analytics.

Conserve and Sustainably Use the Oceans, Seas and Marine Resources (SDG14)

Singapore is cooperating with the International Maritime Organization, IMO which is actively pushing for decarbonization, and thus signaling transition from the conventional marine fuels to zero-carbon types such as hydrogen, ammonia and methanol so as to cut the marine transportation industry's greenhouse gas emissions by half by 2050 and net-zero emissions by 2100. Moreover, digitalization of shipping is taking place with the adoption of 4IR technologies such as block chain, machine learning, and AI. For example, the Maritime and Port Authority of Singapore (MPA) launched digitalPORT@SG™ in 2019. It facilitates a one-stop clearance platform for all vessel-related transactions via streamlining 16 different vessel, immigration and port health clearance forms into a single submission. This saves the maritime industry an estimated 100,000 person-hours each year. In the future, it will be further developed as a Just-In-Time (JIT) Planning and Coordination Platform for diverse port users such as ship owners and agents, terminal operators and marine service providers. 4IR technologies will help to shorten the turnaround time of ships calling at the Ports thus enhancing port's efficiency and reduce business costs.

Terrestrial Ecosystems (SDG15)

SDG15 is to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and biodiversity loss. Singapore aims to have 400 kilometers of park connectors, 180 kilometers of Nature Ways and 200 hectares of skyrise greenery by 2030. Reforestation and conservation of natural carbon sinks such as rain forests are popular among the business leaders and public. About 9,165ha of land or 12.6% of Singapore's total land area may be suitable for urban reforestation, which can capture about 0.31% of Singapore's total emissions. Singapore aims to be a City in a Garden. As of 2017, there were 100 hectares of skyrise greenery in Singapore, and plans are underway to double it by 2030. Singapore is employing 4IR technologies to monitor its seven millions trees. Singapore aims to add another million trees by 2030. For example, Light Detection and Ranging (Lidar) technology to scan and inspect trees via Remote Tree Measurement System (RTMS) software to interpret the data. Global navigation satellite system for determining exact location of trees as far as one hundred meters away. Such information is automatically uploaded into a central database. 3D models of trees are built for assessment. All these technologies allow arborists to inspect the health of trees remotely, and determine whether they withstand the forces of nature. Thus allowing city living in nature and protecting humans from the damages caused by falling trees under tropical weather conditions.

Peace and Security (SDG16)

Singapore's law enforcement agencies have been adopting 4IR technologies to further integrate operations and strengthen community partnerships. One example is the use of Unmanned Aerial Vehicles (UAVs) and image processing to provide a bird's-eye view of the ground situation and allow officers to make better-informed decisions. Another example is the introduction of automated self-clearance lanes for motorbikes

at land borders. Further infusion of 4IR innovations will enable better management of crisis events and unforeseen incidents.

Partnerships (SDG17)

SDG17 is to strengthen the means of implementation and revitalize the global partnership for sustainable development. Singapore is championing ASEAN Smart Cities Network (ASCN). It is a collaborative platform to facilitate cooperation on smart cities development, catalyze bankable projects within the private sector, and secure funding and support from external partners. Singapore government embarked on Smart Nation program to harness 4IR technologies which includes big data and faster networks to create technology based solutions. Some areas of focus include open data systems and public transport networks. For example, it encompasses hard ware like lampposts with wireless sensors and AI enabled software to process sensor data and video analytics. They are helpful to urban and operational planning, maintenance, and incident response. 4IR technologies track and analyze data related to housing, amenities and public infrastructure. Singapore collaborated UN-Habitat on a capacity-building program in support of the UN's New Urban Agenda. The emphasis of this program is to demonstrate how local challenges overcome by applying sustainable urban system principles, long-term integrated master planning, and public-private partnerships based development.

Way forward and policy recommendations

In order to realize UN SDGs, it is necessary for the economies and societies to rapidly transition toward circular economy led carbon neutral world. Humans should emulate nature.

Earth systems are circular in nature. Whereas the human engineered systems since the first industrial revolution are in essence linear to achieve mass production. Linear systems produce waste and cause pollution (Jose and Ramakrishna, 2021). Hence, the impetus for circular economy led sustainability in recent times. Yet, sustainability gap is evident with every enabler of sustainability. Fast moving consumer goods (FMCG) companies are lagging behind respective recycling targets. Similarly, companies, businesses and service providers are yet to transition from their linear economy approaches to circular economy approaches deeply. It is true with the commerce and trade among communities, regions and countries. Financial institutions as well as investors have only committed a fraction of their resources to the sustainability projects and programs. In other words, the green financing is in the nascent stage. Nations have fallen behind the announced carbon emissions reduction targets. International standards and treaties, and regulators are in the catching up mode. Consumers are in the wait and see mode rather than influencing the businesses via their purchasing decisions. For example, according to the United Nation's environment program, fashion industry is responsible for up to 10% of global carbon emissions. Consumer choices and behaviors will have a major impact on the fashion industry's supply chains, value chains, and end of life management practices, and thus providing necessary impetus to eliminate or substantially reduce the sustainability gap in the textiles and apparel industry sector (Shirvanimoghaddam et al., 2020; Sadeghi et al., 2021).

4IR readiness

High-technology manufacturing found to be associated with lower emissions than medium-technology manufacturing and low-technology manufacturing (Avenyo and Tregenna, 2021). Such findings suggest that a shift toward more technology-intensive manufacturing may be a more environmentally sustainable industrialization path. Nations and companies to self-assess 4IR readiness and emulate the best practices elsewhere. This will allow them not to miss the green growth opportunities in the coming years and decades. Moreover, this enables them to safe guard against the potential climate change effects, and to perform their respective responsibilities to mitigate extreme weathers, pollution, and biodiversity loss. Knowledge of 4IR technologies in realizing UN SDGs is necessary for nurturing future ready graduates (Ramakrishna, 2021). According to the International Labour Organization, about half of 1.6 billion total workforce are in the informal sector and badly affected by the pandemic. According to the World Bank estimates, transition to low-carbon and circular economies will create trillions of dollars of economic growth and tens of millions of new jobs. In order to seize the opportunities, SMEs and MMEs to quickly absorb the importance of sustainability and embrace sustainability growth opportunities and leverage schemes and incentives provided by the governments, financial institutions and investors. They also should leverage scalable opportunities beyond the home country.

Sustainability Governance Structures

In order to progress on sustainability vision, companies need to align their environmental, social and governance (ESG) aspects and take stock of them regularly. To signal strong alignment, companies to consider appointing Chief Sustainability Officer, CSO. For example, in Singapore the listed companies such as City Developments Limited, CapitaLand, Wilmar International, and United Overseas Bank started appointing CSOs since 2011. Certain other companies are setting up dedicated sustainability committee in respective corporate boards to assess ESG performance and produce annual reports for tracking. For example, Singapore exchange listed companies ComfortDelGro Corporation, SBS Transit Ltd and VICOM Ltd have instituted respective governing board sustainability committees. Independent studies suggest that companies with good ESG performance also performed well in terms of value creation and financial growth. This has been the experience also in USA and European countries. Realizing the importance, Singapore Stock Exchange started encouraging companies to make annual ESG sustainability reporting since 2016. It is in the interest of all stakeholders, companies to consider ESG in all the strategic decisions ranging from daily operations to long-term investments.

Conclusions

The United Nations adopted 17 UN SDGs in 2015 to end poverty and to protect planet Earth for the well-being of current as well as future generations. UN SGDs are interrelated, and hence an action in one SDG will affect the outcomes in other SDGs. Technological advancements, financial resources, creativity, and commitment from all of society are necessary to achieve social, economic and environmental sustainability. The tasks of decarbonization of economies and mitigating climate change are essential in achieving UN SDGs. Earlier technologies fall short in enabling necessary transition to carbon neutrality or decarbonization of economy. 4IR innovations enable the desired shift toward circular economy, which is more environmentally sustainable industrialization and development path. Nations and companies to self-assess 4IR readiness and emulate the best practices elsewhere. This will allow them not miss the green growth opportunities in the coming years and decades. Moreover, this enables them to safe guard against the potential climate change effects, and to perform their responsibilities to mitigate extreme weather, pollution, and biodiversity loss for the well-being and progress of humans.

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Industry 4.0 - Way Forward for Integrated Manufacturing

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Abstract

Developments in technology and understanding of how things work have revolutionized industry across many parts of the world. To the extent that the first machine—the steam engine—is all but obsolete now. Over three stages, three industrial revolutions have taken place, and we are at the beginning of the fourth, called Industry 4.0. This paper describes the overall scenarios that have come and gone in industry, how industry has sought to improve cost, quality, and speed by improving methods of production. "Integrated Manufacturing" and "Integrated Organizations" have been promoted by the likes of the Malcolm Baldrige performance excellence models, which have made many Fortune 500 organizations achieve the TBL (triple bottom line) objectives, which promote sustainability. The paper describes is some details the core concepts of an "integrated organization," and how IOT, AI, ML etc. will further drive "integration," so that the achievements of TBL objectives of companies will become faster and reach very high levels.

Introduction

Since the early 1800s industrial way of life has occupied the thoughts and energies of countries. Inventors, scientists, businessmen, and politicians have been involved in developing methods to promote industrial production whose primary purpose was to mass-produce goods so that they can reach larger and larger markets and consumers. In the process, an economy largely dependent on the wealth generated by such activities provided for the appearance of the "welfare state." Countries in the west led the creation of wealth through industry, and ensured that large parts of their population could improve their standards of living. Over the years, cost pressures, new technologies, new products together have created an enormous explosion in the types and numbers of goods produced, and the ways in which these have been put into the market. We have seen three "industrial revolutions" already, including the computer age, followed by the latest, "Industry 4.0" which is defining the new rules for integrated manufacturing. Together with Internet of Things, Artificial Intelligence, Machine Learning, and advancements in production technologies, the world is now at the cusp of the next "industrial revolution." This will create the "integrated manufacturing" units of tomorrow, which will provide a platform for sustainable development, which is the ultimate goal.

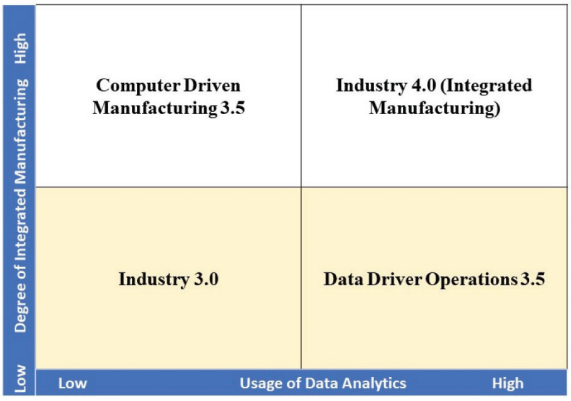
The four quadrants of progress

Industry 4.0 is arriving soon in India. The initial signs are beginning to blossom. Global industry has moved from 1.0 to 3.0 in about 250 years, and now, from 3.0 to 4.0 is set to happen. While Industry 1.0 lasted for about 150 years, Industry 2.0 lasted 70 years, and Industry 3.0 has lasted all of 50 years, till date. However, Industry 3.0 has already become Industry 3.5, due to the increasing role played by internet, cell phones, telecom interconnectivity, and data transmission and processing/analysis. Big Data and Data Analytics have started to shake the foundations of Industry 3.0, to advance it to Industry 3.5, and now, these and other progressives will propel us forward into the next era (see Figure 1).

Industry 3.0 was dominated by Information Technology (IT). While Industry 2.0 was the engineers delight, Industry 3.0 became the computer engineers fiefdom, with advancements in IT leading to growth, productivity, new products, improved market interactions, speedy feedbacks, all leading to the practice of "closed loop" manufacturing. Such an approach suited the Plan–Do–Check–Act (PDCA) methodology, which had come to dominate industrial thinking in this phase of industrial development. While PDCA became the backbone of competition, beginning 1950, after the solid foundational work done by Dr Deming, Dr Juran, Dr Ishikawa, Dr Crosby, Dr Shewhart, and others, it was the advent of Industry 3.0 in 1970s which gave a great push to "world class" manufacturing (see, for example, Artemis et al., 1990).

World class manufacturing

World class manufacturing was a terminology coined after the declaration of the Malcolm Baldrige model in 1987 (nist.gov/Baldrige). The idea was to create world class companies through the mechanism of business excellence, whose basic premise was to practice 11 core values. These core values were identified as: Visionary leadership, Customer-centered excellence, Valuing people, Organizational learning and agility, Focus on success, Managing for innovation, Management by fact, Societal contributions, Ethics and transparency,



(Source: Author)

Figure 1: Way Forward From Industry 3.0

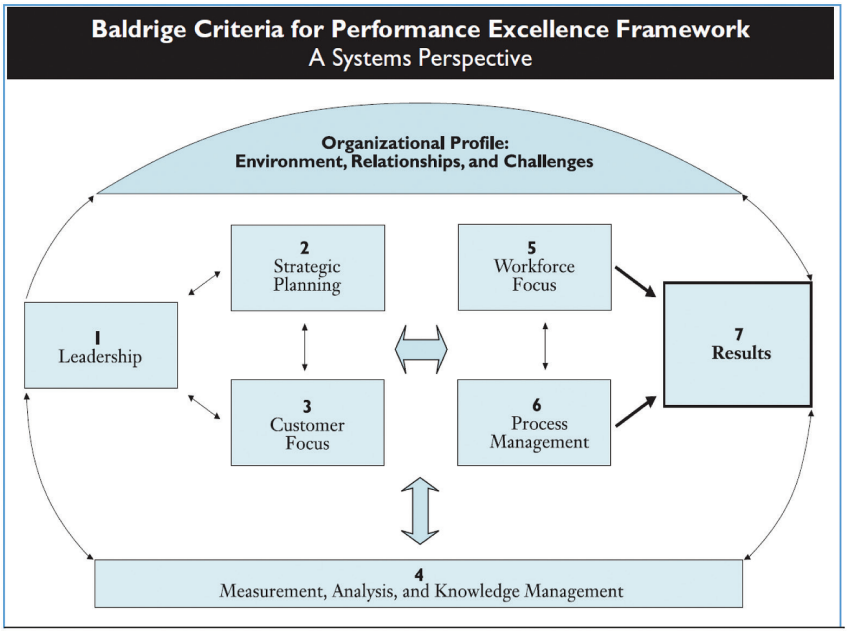


Figure 2: Framework for the Malcolm Baldrige Model for performance excellence

Systems perspective, Delivering value and results. Adopting these core values, companies were able to develop an "integrated organization" over time, which led to all round, holistic, responsive, and proactive excellence. Knowledge Management and Information and Analysis formed the foundation of the excellence model, as shown in Figure 2 below:

The measurement and analysis part was strengthened considerably with the advent of IT into the processes which governed the day-to-day management of companies. "Mass IT usage," signifying the extensive use of IT in all areas of work in an organization, led to speedy information transfer, quick analysis, more frequent, customized reports generation which then were used for decision making. The practice of the core values intensified due to the "Mass IT Usage," which, in turn, led to the creation of "Integrated Organizations." Such integrated organizations were responsive, efficient, proactive and functioned on the basis of well-defined methodologies as prescribed by ISO and other relevant systems standards. The pinnacle of the excellence movement was achieved through Industry 3.0 by around 2000 (see, for example, Muthuraman and Jayaraman, 2014)

Sometime in 1994, the triple bottom line (TBL) concept was enunciated, and, subsequently, criteria for evaluating how organizations addressed the TBL were included in the Baldrige Model. This inclusion increased the scope of work for creating "world class" organizations. Whereas, earlier, the intention to create world class organizations was limited to their economic activities, the TBL concept called for the creation of a socially responsible and environmentally friendly organization, in addition to their being successful in the economic marketplace. Addressing all three would lead to sustainability, both in economic and societal spheres. Thus, the TBL made possible truly holistic excellence in organizations, with the goal of sustainability being supreme. While organizations used Operations Strategies to achieve sustainable business competitiveness in the marketplace, the TBL put additional requirements on Operations Strategies to become holistic (R. Jayaraman, paper presented at a conference in Vishakhapatnam, 2019)

TBL, World class manufacturing, and Industry 4.0

While Industry 3.0 was adequate for creating economically successful organizations, the TBL demands put an additional strain on organizational profits and profitability. Costs incurred on CSR and environmental friendliness could not be recovered, partially or fully, from customers, who were already looking for better value propositions. Increasing prices was out of the question, and companies had to find new value propositions through other means. That's when Industry 4.0 was resorted to.

Since technology had become ubiquitous, and IT had gained wide usage, and experience gained, the next development was the learning of abilities to utilize the IT-generated data, information, and automation, to

improve company operations, in a systematic way, on a huge scale never imagined before. One of the first few companies to benefit from Industry 4.0 were the eCommerce organizations like Amazon, Flipkart, FedEx, UPS, and others, who used the internet and the worldwide webs to create a virtual marketplace. With heightened connectivity, with a 24*7 internet, the global village became a reality. Many companies could do 24*7 work using telecom-supported connectivity, software-driven networks, and newly developed software programs to process voluminous POS (Point of Sale) data, to aid decision making and profit making. As shown in Figure 1, there were two possible directions to move forward from Industry 3.0. One, use more IT through Artificial intelligence (AI), machine learning, automation, interconnected machine networks to greatly improve manufacturing efficiencies.

The improvement is achieved in many ways. AI controls can be pre-programmed, using algorithms developed through experiences and theoretical frameworks, thus becoming "intelligent controllers," many times replacing human interventions, and, which will "never make a mistake, never flag in performance rate, and make on-line, real-time corrections as needed, determined through feedback, to keep the output profiles constant." Such manufacturing systems make for low cost, high volume combinatories, very useful in competitive markets. AI enables connecting several machines to each other, thereby creating "intelligent networks," which can become self-driven factories. Human interventions can shift to other areas, such as, AI design, maintenance, developments, and continuous improvements. Designing "networked factories" will become a hallmark of Industry 4.0.

The other way is to go in for "data-driven operations," which essentially means that, capture data from various machines, from the marketplace, from vendors etc., and use data analytic tools to derive inferences and conclusions, and use them in the processes to obtain improvements and responsiveness. This method does not necessarily make use of networked machines, AI-driven equipment, which, at least to begin with, can involve long efforts and high costs. However, closed loop efficiencies can be achieved through data analytics, establishing appropriate connectivity, and then reprogramming the IT driving the machines. In single machine instances, or self-controlled devices, closed looping can be done without resort to AI. A sensor-controller mechanism should do the job, as is already being done by many climate control devices, such as, air conditioners.

In both of these alternatives, the Figure 1 shows that the next step would be "integrated manufacturing," which uses features from both the alternatives, AI-driven machines, and POS (Point of Sales) and other data-driven decisions, and algorithms to improve and integrate. Only such a combination will lead ultimately to a responsive and proactive TBL sustainable business. A description of what the "integrated manufacturing" could mean in future organizations is given in Jayaraman et al. (2018).

Big Data analytics and Industry 4.0

While data analytics was used in Industry 3.0, Big Data Analytics has changed the scenario. Higher data processing speeds, advancements in hardware like clouds, high storage devices, high-speed data transmission media like 4G, have enabled data crunchers to collect and analyze data like never before. Figure 3 shows the current scenario of the adoption of Big Data Analytics in industry.

Figure 3 clearly shows that, in the long term, high data analytics usage is the way forward, any other path will lead to "death." The "survive" quadrant is valid only in the short term. This is mainly because Big Data Analytics takes a different view of business, as opposed to the current,

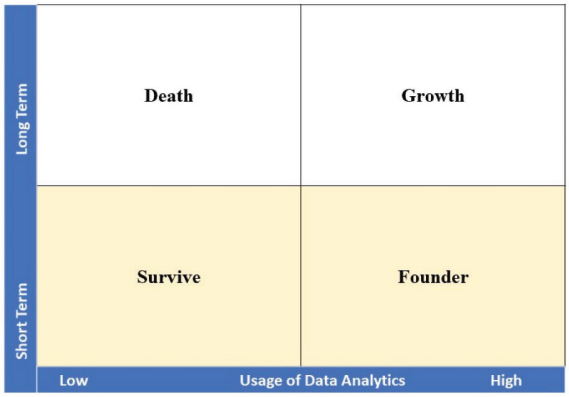


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Figure 3: The Big Data Analytics Imperative in Industry 4.0

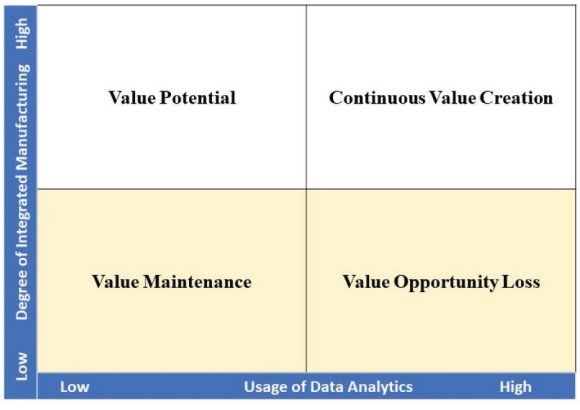

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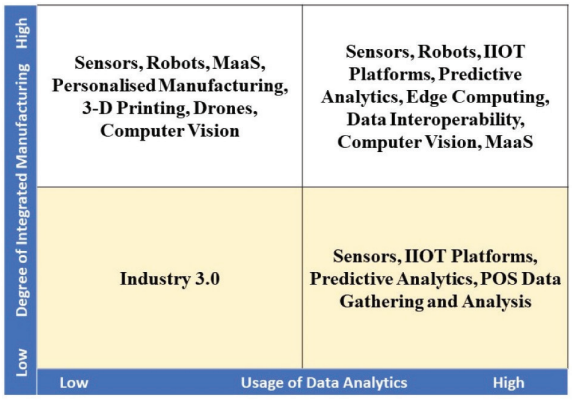
Figure 4: Value Creation and Data Analytics

Industry 3.0 view. The word "integration" acquires a new meaning in Industry 4.0. The combination of several data capture points, speedy transmission of all such data, collation and analysis using powerful algorithms developed specifically for the purpose, AI-driven closed loop responsive machines, all make for a "mass customization" reality, which has been missing in Industry 3.0. In fact, many companies have tried and failed in their mass customization efforts using Industry 3.0 basis. Inadequate data collection, inadequacy of algorithms to analyze, lack of speedy transmission and, ultimately, a complete lack of a responsive networked machine structure to make use of the decisions from data analytic tools speedily and integrally, have made Industry 3.0 unsuitable for mass customization. However, the future will surely be driven by mass customization, and companies must respond to this demand.

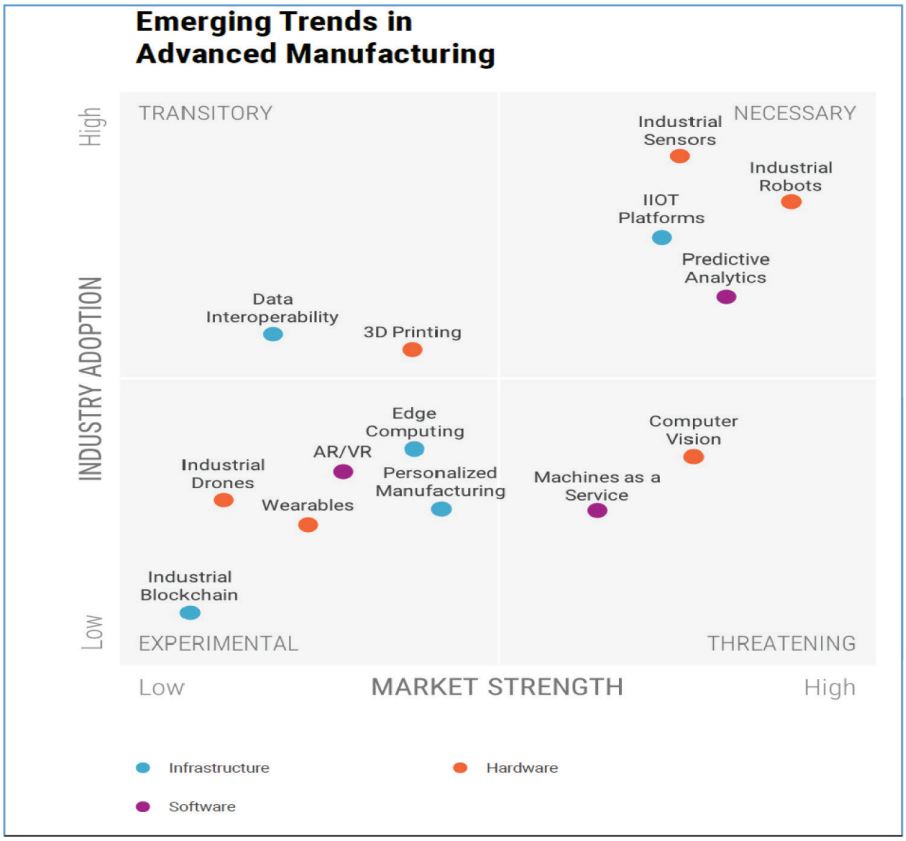


(Source: Author)

Figure 5: Data Analytics and Integrated Manufacturing

Integrated manufacturing, Big Data Analytics, and Industry 4.0

The ultimate goal of excellence in holistic manufacturing, is "integrated manufacturing." Such manufacturing is takt time-driven, responsive, self-adjusting, and able to meet mass customization needs. Right since inception of the Baldrige model, many companies have tried to create value using "integrated manufac-



(Source: https://www.cbinsights.com/) CB Insights (undated)

Figure 6: Emerging trends in Industry 4.0

turing," many achieved a good degree of success, but, as mentioned earlier, the TBL changed the goal post. Just like the Bharat I, Bharat II etc. series of specifications shift the goal post to drive auto companies to achieve higher and sustainability promoting standards, TBL has acted as a driver of continuous value creation, to achieve the objective of creating a livable planet. In India, many corporate houses have used the concept of TBL to drive down effluents, improve quality of air, serve communities, and contribute to social obligations. The government's introduction of the "Corporate Social Responsibility" tax (CSR tax) has enabled organizations to channelize their energies in a focused manner to achieve TBL and sustainability goals. Companies like Tata Steel already had a variety of CSR activities, like Tata Steel town (Jamshedpur), Tata Motors contributes actively to villages in and around Jamshedpur and Pune, NTPC and SAIL run several townships, TVS group, HCL, Infosys, and Wipro run foundations to conduct CSR activities. Apart from being economically profitable, these and other companies in India have also addressed the other two pillars of TBL also.

Industry 4.0 is poised to further contribute to this effort, and data analytics is a key pillar of Industry 4.0. Figure 4 shows that integrated manufacturing and data analytics go hand in hand, and, in case any one of them is deficient, value creation is hampered. Here, value creation is used in the sense of an organization delivering TBL compliant outputs.

Figure 5 also conveys the same theme, but with the addition of some of the details of data analytics.

Integrated manufacturing is the essence of Industry 4.0. TBL compliance can be achieved only through integrated manufacturing. Big Data Analytics (or Data Analytics) is a key piece in this scenario; it drives, and, in turn, is driven by the needs of integrated manufacturing. Already, considerable advancements have been made in both these areas. However, the gaps in AI, machine learning, IIOT, and development of new business models which can "carry the load of the TBL requirements" and still remain profitable, are evolving. The benefits due to the new developments in computer and related technologies will surely provide a channel for making Industry 4.0 happen. The current status is shown in Figure 6 below:

Conclusion

It is evident that Industry 4.0 will eventually be ushered in by all organizations, for several important reasons. One, the required technology elements are available and use of these will provide low-cost, large variety products in small batches to address mass-customized products. Second, the big data ability will enable organizations to collect and analyze information and data efficiently and usefully. Third, applications development will lead to apps, which can be directly downloaded without expensive R&D by individual organizations. Speed of new products introduction, larger variety, catering to individual customer likes and dislikes will become possible. Waste will reduce considerably due to the highly responsive equipment which will be controlled by high-speed computers linked through clouds. This will enable simultaneous manufacturing, zero-defect production, and tailored product and service regimes. All these developments which will be possible through integrated manufacturing foretell of a pleasanter way of life in the years ahead.

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Global Technology Governance Report 2021:

Harnessing Fourth Industrial Revolution Technologies in a COVID-19 World

An essential consideration for government, business and civil society is how technologies are harnessed and regulated to accelerate growth, encourage innovation and build resiliency in the wake of COVID-19. How governments and other stakeholders approach the governance of technologies will play an important role in how we reset society, the economy and the business environment.

This World Economic Forum (WEF) report examines some of the most important applications of Fourth Industrial Revolution technologies if we are to thrive in a post-pandemic world and the governance challenges that should be addressed for these technologies to reach their potential. The technology areas it focuses on are artificial intelligence, blockchain, internet of things, mobility and drones and unmanned air systems.

For more information, access:

http://www3.weforum.org/docs/WEF_Global_Technology_Governance_2020.pdf

A Roadmap for Decarbonization of Singapore and its Implications for ASEAN

Opportunities for 4IR Technologies and Sustainable Development

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Abstract

This article presents a roadmap to decarbonize Singapore's energy consumption sectors. Central to this roadmap is a carbon capture and storage (CCS) project involving centralized post-combustion carbon capture, CO_2 transportation by existing pipelines or tankers, establishing a regional CCS corridor, and hydrogen production with CCS. Applications of fourth industrial revolution technologies will be important for the success of this project. They include efficient carbon capture using nanotechnology, autonomous vessels for CO_2 shipment, digital twin and additive manufacturing for pipeline maintenance and repairs, and characterization of reservoirs for CO_2 storage using big data, artificial intelligence, and machine learning, among others. Potential benefits of this project to ASEAN will include shared financing, cost reduction by leveraging economy of scale, preserving regional oil and gas industries, a quicker energy transition, and creation of new growth industries such as CCS and hydrogen. Engineers and scientists in ASEAN need to be prepared for this challenge.

Nexus between decarbonization, sustainable development, and 4IR technologies

Climate change is an existential problem facing humanity. At least eight of the 17 sustainable development goals (SDG) set by the United Nations have to do with combating climate change (Ramakrishna, 2021). They include SDG6 (clean water), SDG7 (clean energy), SDG11 (sustainable cities), SDG12 (responsible consumption and production), SDG13 (climate action), SDG14 (life below water), SDG15 (life on land), and SDG17 (partnership). Consequently, global decarbonization to combat climate change is one of the biggest engineering efforts ever in human history. In general, there are four switches to transition from an unsustainable high-carbon-intensity economy to a sustainable low-carbon-intensity economy. They are renewable energies, CCS, hydrogen, and adoption of a circular economy (Lau et al., 2021). In each of these four areas, 4IR technologies will play a key role. In this article we will focus on the use of 4IR technologies for CCS and its benefits to ASEAN countries.

Singapore's CO_2 emission profile

In 2017, Singapore emitted 52 million tons of CO_2 which was 0.1% of global emission (NCCS, 2021a). Singapore ranks 27th out of 142 nations in terms of per capita CO_2 emission and 126th in terms of CO_2 emission per dollar GDP. As a signatory to the Paris Agreement, Singapore has pledged to achieve peak CO_2 emission of less than 65 million tons by 2030, half it by 2050 and reduce it to zero before 2100 (NCCS, 2021b). Out of Singapore's total CO_2 emission, 46% comes from industry, 39% from power generation, 13% from transport, and 2% from buildings and other sectors. Ongoing measures to reduce CO_2 emission include improving energy efficiency, increased use of solar photovoltaic energy, zero-emission buildings, electrification of transport, sustainable urban farming, adoption of a circular economy, and reforestation. Possible future measures will include importing green hydrogen, importing renewable electricity via regional power grid, and carbon capture and utilization.

One unique feature of Singapore's CO_2 emission is that it is heavily concentrated in Jurong Island, a small island in the southwest of Singapore (Wikipedia, 2021). About 71% of Singapore's power plants, 69% of refineries and practically all chemical plants are located in Jurong Island which has an area of only 32 km^2. Jurong Island is home to some of the largest refineries and petrochemical complexes in Southeast Asia. Its refineries process 1.5 million barrels of crude oil per day turning crude oil into gasoline, kerosene, and jet fuel sold domestically and abroad. Jurong Island's chemical plants rank among the top 10 in the world and produce lubricants, resins, polymers, plastics, and fuel additives. In 2015, Jurong Island contributed to S$81 billions or one-third of Singapore's total manufacturing output (EDB, 2021). Due to this concentration of industries, 54% of Singapore's total CO_2 emission, or 27 million tons per year, come from Jurong Island. This creates an unique opportunity for centralized carbon cap-

ture and processing.

Centralized post-combustion carbon capture and processing

Due to a high concentration of large CO_2 emitters in Jurong Island, it is possible to direct flue gas from multiple industrial plants to a central location for carbon capture and compression. Post-combustion carbon capture technology can be used to capture CO_2 from several flue gas streams with varying CO_2 concentration. Flue gas from power plants has a CO_2 concentration of 10-20% whereas that from petrochemical plants can be as high as 80% or more. These streams can be fed into a absorber column where CO_2 will be absorbed by liquid solvents such as amines, NaOH, KOH, or ammonia. The solvent can be regenerated by stripping the CO_2 out of the liquid by steam, allowing it to be recycled to the absorber column while producing a concentrated CO_2 stream. In addition to chemical solvents, solid absorbents, membrane, or a combination of them may also be used for post-combustion CO_2 capture. After being captured, CO_2 can be compressed and cooled to liquid or supercritical form. Although post-combustion carbon capture can be retrofitted into existing industrial plants, it is cheaper to build a single centralized plant to capture CO_2 from multiple sources. Our roadmap calls for building a plant that has the capacity of capturing 5 Mtpa of CO_2 which is on par with the largest post-combustion carbon capture plants in the world (Global CCS Institute, 2020). By integrating CO_2 capture, liquefaction, and temporary storage into a single centralized plant, more reduction in capital investment can be achieved. Centralized post-combustion carbon capture is only possible due to Singapore's unique CO_2 emission profile. A centralized post-combustion CO_2 capture plant in Jurong Island capable of processing several million tons of CO_2 per year will a first of its kind in the world.

A Regional CCS Corridor

An important part of Singapore's decarbonization roadmap is a detailed CO_2 source-sink mapping exercise to identify large industrial CO_2 sources and subsurface reservoirs for permanent CO_2 storage (Li et al., 2021). Initially, such a source-sink mapping exercise should identify CO_2 sources and sinks within a 1,000-km radius from Singapore. Besides Jurong Island in Singapore, large stationary CO_2 sources within this area include power plants, refineries, and factories in Sumatra Island of Indonesia and Peninsula Malaysia. It is interesting to note that four (North Sumatra, Riau, Lampung, South Sumatra) of the top provinces for CO_2 emission in Indonesia are located in the Sumatra Island.

Major CO_2 sinks are subsurface layers of porous media (reservoirs) which include saline aquifers as well as depleted or partially depleted oil and gas reservoirs (Lau et al., 2021). They are formed by the deposition of eroded materials (sediment) and precipitation of chemicals and organic debris within a water environment. Over geological time, continuous sedimentation will produce stacked reservoirs in the basin. For CO_2 storage, three types of reservoirs are particularly important. They are saline aquifers, oil reservoirs, and gas reservoirs. For oil and gas reservoirs to exist, five factors must be present. They are the existence of a porous layer to provide the pore space for water, oil or gas to accumulate, an impermeable caprock (seal) to prevent leakage of hydrocarbon to a shallower layer, a structural or stratigraphic trap to prevent lateral migration of hydrocarbon, a source rock for the conversion of organic matter into hydrocarbon, and a migration path from the source rock to the reservoir. Three factors must be present for the existence of an aquifer. They are the presence of a porous layer to provide the pore space for water to accumulate, the presence of an impermeability base layer (underburden) preventing water to flow into deeper strata, and the presence of trap to prevent lateral migration of water. Aquifers are further classified into two types: confined and unconfined. A confined aquifer has an impermeable caprock (seal) to prevent upward migration of water. An unconfined aquifer has no such caprock. The existence oil and gas reservoirs in a sedimentary basin are usually well studied by oil companies in their exploration and production of oil and gas. However, the existence of aquifers is generally poorly studied. It has been estimated that there is ample pore space in subsurface reservoirs in the world's sedimentary basins to store more than two and a half centuries of anthropogenic CO_2 emissions (Lau et al., 2021).

There are eight major sedimentary basins within a 1,000-km radius from Singapore (Figure 1). They are the North Sumatra, Central Sumatra, South Sumatra, Northwest Java, East Natuna, West Natuna, Penyu, and Malay basins. The first six basins are in Indonesia whereas the last two are in Malaysia. There are many oil and gas reservoirs of varying degree of depletion in these eight sedimentary basins. Our preliminary estimates show that the total CO_2 storage capacity in these seven basins exceeds 100 Gt of which 90% resides in saline aquifers and the remaining in oil and gas reservoirs (ADB, 2013; Hedriana et al., 2017). It should be noted that injection of CO_2 into an oil or gas reservoir may lead to production of incremental oil or gas by processes known as enhanced oil recovery (EOR) or enhanced gas recovery (EGR) due to total or partial miscibility of the CO_2 with the oil or gas condensate in the reservoir (Li et al., 2021). This makes the economics of CO_2 EOR or EGR more attractive than pure geological storage of CO_2 in a saline aquifer.

A detailed regional source-sink mapping will involve ranking by CO_2 emission sources by amount and CO_2 concentration. Likewise, CO_2 sinks are ranked by storage capacity, reservoir type, and readiness for CO_2 storage. Mapping of potential sources to potential sinks is done based on factors such as distance, capacity, and readiness (Li et al., 2021).

CO_2 transportation via pipeline or marine vessel

CO_2 is usually transported either in supercritical form by pipelines or in liquid form by marine vessels (Al Baroudi et al., 2021). In pipeline transport, the pipeline is usu-

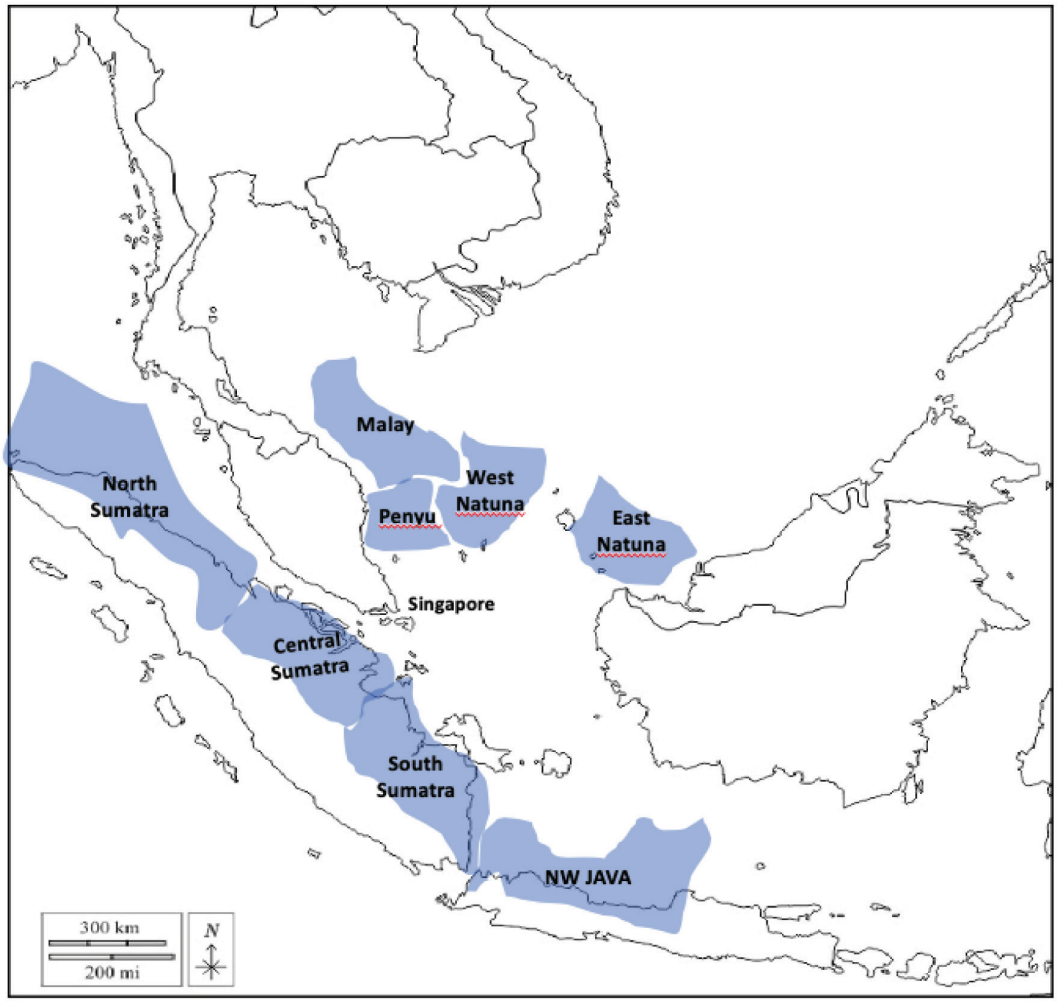

Figure1: Major sedimentary basins with 1,000 km distance from Singapore to be considered for permanent storage of CO_2

ally pressurized to above 10.3 MPa to ensure CO_2 is in supercritical form with a density close to 800 kg/m^3. There are two existing pipelines supplying natural gas to Singapore from Indonesia. One of them is a 654-km-long West Natuna-Singapore pipeline that supplies natural gas from the Indonesia's West Natuna gas field to Jurong Island. The gas delivery contract for this pipeline will end in 2022 and it is not certain whether it will be renewed. The second is the 470-km-long South Sumatra-Singapore pipeline that supplies natural gas from Indonesia's Suban gas field in South Sumatra to Singapore. This pipeline will cease to operate by 2023 when the existing gas contract ends. Indonesia plans to use the gas for domestic consumption. If one or both of these pipelines cease to be used for natural gas delivery, they may be used instead for shipping CO_2 from Singapore to subsurface reservoirs in either the South Sumatra or West Natuna Basin for permanent CO_2 storage. In addition, Singapore's gas transmission network is connected to Petronas' Peninsula Gas Utilization Pipeline. This network was used to supply natural gas from Malaysia to Singapore. These existing natural gas pipelines may be used to transport industrial CO_2 from Singapore to Indonesian or Malaysian subsurface reservoirs for permanent storage. In such a scenario, shipment of CO_2 from Singapore will be relatively inexpensive as no or limited new pipeline needs to be constructed. For transportation of CO_2 over long distances where existing pipelines are unavailable, marine shipment can be used. Currently, small quantities (capacity of 1,000 m^3) of liquefied CO_2 are being transported by ships by the food and beverage, and chemical industries. Marine shipment of large quantities of CO_2 can be done by LPG tankers with capacity of 100,000 m3 (80,000 tons) of liquid CO_2. The existing LNG terminal in Jurong Island may be modified to handle offloading of liquid CO_2. As Singapore is a hub for ship building, modifying LPG tankers or building new tankers for liquid CO_2 shipment in Singapore's shipyards is feasible.

CCS as an enabler of a hydrogen economy

The fourth step of the roadmap is to use CCS as an enabler of a hydrogen economy

(Lau, 2021a, 2021b). It is to build a steam methane reforming (SMR) plant in Jurong Island to produce hydrogen from natural gas (Lau and Ramakrishna, 2021). This is done by mixing steam with natural gas to a high temperature in the presence of a catalyst. This process converts natural gas into hydrogen and CO_2. The hydrogen may be sold as a clean energy carrier for use in hydrogen fuel cell vehicles, as well as heating and as feedstock for industrial use. The produced CO_2 can be removed by CCS. This process will allow Singapore to be a producer of hydrogen for domestic consumption and export. Already, countries like Japan and South Korea are planning to import hydrogen from overseas and include it in the future energy mix. It is estimated that the global market for industrial hydrogen will increase from the current 87 million tons to over 200 million tons in 2030. There is much for Singapore to benefit if it can become a regional hub for exporting hydrogen. CCS will be a key enabling technology for this to happen. New industries such as CCS and hydrogen may well become one of the new growth engines for the Singapore economy.

Decarbonization timeline

Table 1 gives the decarbonization timeline based on our roadmap. The CO_2 emission rate in 2019 was historical whereas those in 2050 and 2100 are projected. The assumptions are Singapore will half its 2017 CO_2 emission by 2050 and reduce it to only 10% of its 2019 value by 2100 or sooner. Total elimination of CO_2 emission is probably too expensive. Consequently, we use 10% of current emission as the goal.

Also shown in Table 1 are the ways to achieve CO_2 mitigation in various sectors of the economy.

In the power sector, the chief migration method is by post-combustion carbon capture. Secondary methods will include importing electricity from the regional power grid and increased use of solar photovoltaic (PV).

In the road transport sector, the chief method is to replace internal combustion engine (ICE) passenger cars by electric vehicles (EV) and long-haul ICE vehicles by hydrogen fuel cell vehicles (HFCV). For the marine transport sector, the migration method is to replace fossil-fuel based fuels by hydrogen or biofuels. For the aviation transport sector, the mitigation method is to replace current fossil-fuel based jet fuel with biofuels. Singapore already has one of the biggest biofuel refineries in the world with a capacity of 1.3 Mtpa (The Chemical Engineer, 2019).

The refining sector is the heaviest emitter of CO_2 in Singapore. The chief CO_2 mitigation method is to reduce the output of Singapore's refineries. Shell has recently announced cutting the capacity of its Bukom refinery from 500,000 bbl/d to 300,000 bbl/d by July 2021 (Argusmedia, 2021). On the other hand, ExxonMobil has plans to expand the capacity of its largest refinery in Jurong Island from 592,000 bbl/d by another 48,000 bbl/d (The Straits Times, 2020). The overall reduction in refinery capacity in Singapore will reduce CO_2 emission in this sector. Post-combustion carbon capture will still be the mainstay of CO_2 mitigation for refineries. Another suggestion is to gradually replace crude oil refining by hydrogen production using SMR of natural gas and using CCS to remove the emitted CO_2. This will require a structural change in the overall refining industry in Jurong Island. However, it will align with the overall goal of transitioning from a fossil fuel based economy to a low-carbon-intensity economy.

Post-combustion carbon capture will continue to be the main CO_2 mitigation method for the petrochemical business in Jurong Island. As for the building and other sectors, the introduction of low or zero-emission building, of which Singapore already has one, and adoption of a circular economy to reduce demand for high-carbon-intensity material will be important CO_2 mitigation methods.

If we make the assumption that CO_2 emission in Singapore has already peaked at around 53 Mtpa today, then achieving 90% reduction in CO_2 emission will require a reduction of 48 Mtpa. One possible scenario for achieving this is given in Figure 2 wherein 59% of the reduction will be achieved by CCS, 24% by reducing refinery output and industry restructuring,

Table 1: Current and projected CO_2 emission from Singapore based on roadmap

Sector	CO_2 emission (Mtpa)			CO_2 mitigation methods
	2017	2050	2100 or sooner	
Power	19.16	9.58	1.92	(1) post-combustion CCS, (2) import electricity from regional grid, (3) more solar photovoltaic
Refinery	22.32	11.16	2.23	(2) reduced refinery capacity, (3) post-combustion CCS, (3) substituting crude refining by hydrogen production with CCS
Petrochemical	2.91	1.46	0.29	(1) post-combustion CCS
Transport	6.71	3.35	0.67	(1) Less internal combustion engine vehicles, (2) electric vehicles, (3) hydrogen fuel cell vehicles, (4) biofuels for aviation, (5) hydrogen and biofuel for marine vessels
Building & others	0.99	0.49	0.10	(1) zero-emission buildings, (2) adoption of circular economy
Total	52.09	26.04	5.21	

and 12% by fueling transport by electricity, hydrogen, and biofuels. Achieving this will require ramping up CCS from zero to 28 Mtpa between now and 2100 or sooner. This is feasible if a ASEAN open access CCS corridor is established in the next decade. Other scenarios, for example using CO_2 to produce building materials and chemicals, are possible. However, regardless of which scenario is chosen, CCS will be the major contributor to Singapore's decarbonization.

"Southern Lights" project

In this roadmap we propose a "Southern Lights" project wherein industrial CO_2 from Singapore will be transported to a nearby country for permanent storage in a subsurface reservoir through the establishment of a ASEAN CCS corridor (Lau and Ramakrishna, 2021). Figure 3 illustrates the concept behind the project. Industrial CO_2 from Singapore is transported by marine vessels or pipelines to a host country. This CO_2 together with CO_2 from the host country will be temporarily stored in an onshore facility. CO_2 from this facility will be piped to either an onshore or offshore reservoir for geological storage in a saline aquifer, EOR in an oil reservoir or EGR in a gas reservoir. The choice of the target reservoir will be the result of a detailed CO_2 source-sink mapping exercise. This project will be the first cross-border CCS project in ASEAN and will involve multiple companies and governments.

The name "Southern Lights" is inspired by a similar "Northern Lights" CCS project sanctioned by the Norwegian government in

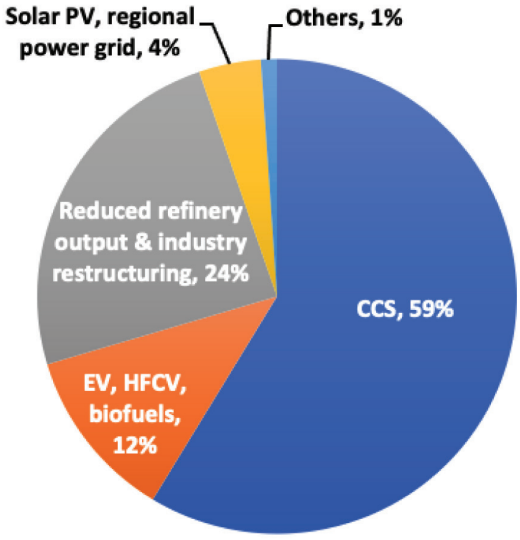

Figure 2: Relative contributions to 90% reduction in Singapore's CO_2 emission from 2019 level

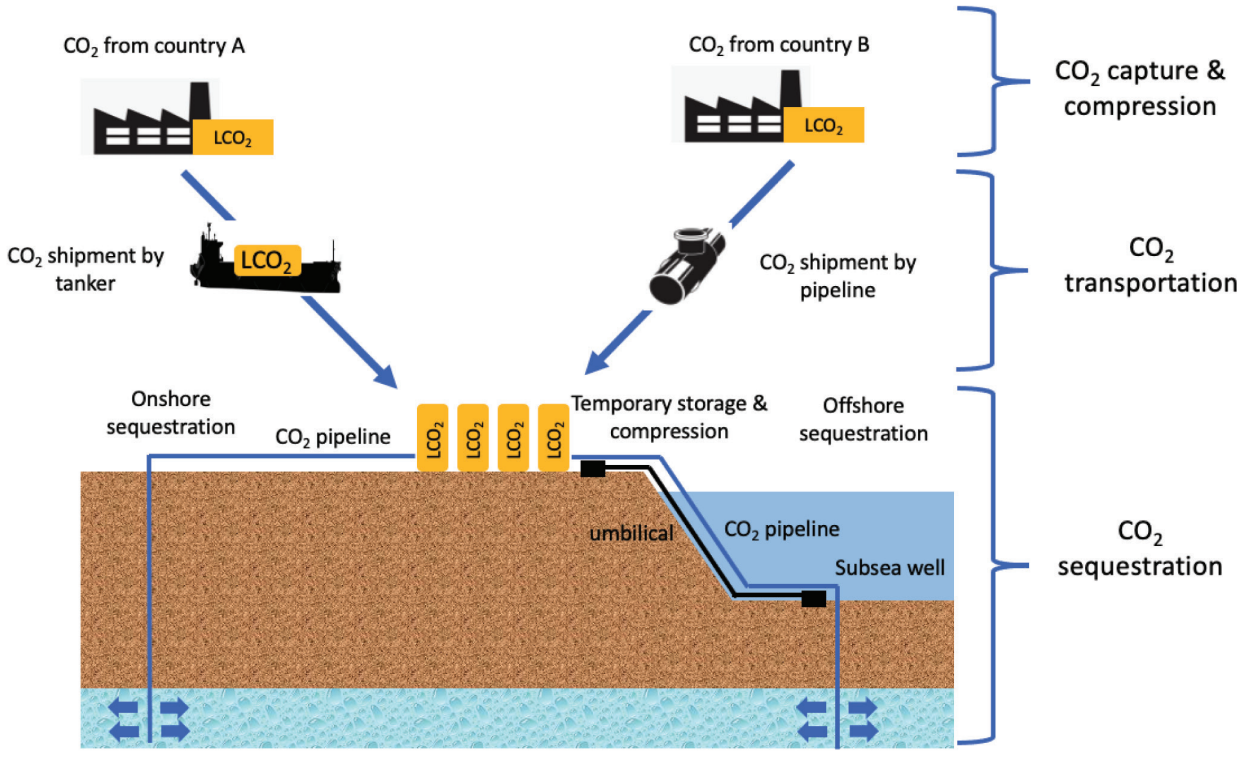

Figure 3: Southern Lights: A cross-border ASEAN CCS project

Table 2: Work for different phases of Southern Light project

Project component	Identify Phase	Feasibility Phase	Select Phase	Define Phase	Execute Phase	Operate Phase
CO_2 capture	Identify suitable CO_2 sources in Singapore for post-combustion carbon capture	Identify CO_2 capture technologies, plant locations, capture volume over time.	Select CO_2 capture technology and location for carbon capture plant in Singapore and host country	Perform detailed design of carbon capture plant in Singapore and host country.	Construct carbon capture plant in Singapore and host country.	Operate carbon capture plant as designed.
CO_2 transport	Determine CO_2 transport options from Singapore and host country.	Assess local and international regulations controlling movement of CO_2 across borders. Determine showstopper.	Select mode of CO_2 transport from Singapore and host country to target reservoir.	Detailed design of CO_2 storage facility in host country. Define specification of CO_2 tankers or pipelines.	Build CO_2 tankers and/or pipelines	Deliver CO_2 through pipelines or tankers as planned.
CO_2 storage	Perform regional CO_2 source-sink mapping within 1,000-km radius from Singapore	Assess storage capacity of target reservoirs by numerical simulations. Assess injectivity and number of wells needed. Investigate risk of CO_2 leakage.	Select the best target reservoir for CO_2 storage.	Perform detailed design of drilling, construction, and operation of wells.	Construct and test CO_2 injection wells. Install CO_2 monitoring equipment.	Operate CO_2 injection wells and optimize injectivity based on well and reservoir data.

September 2020 (Equinor, 2019). Costing 2.7 billion dollars, the Northern Lights project will capture 0.8 million tons per year of CO_2 from a cement factory and a waste-to-energy power plant in the southwest of Norway. The captured CO_2 will be shipped by tankers over approximately 1,000 km to the west coast of Norway for temporary storage. From there, the CO_2 will be piped to one or two subsea wells where it will be injected into a saline aquifer for permanent storage. The project will be operational by 2024 and will expand to 5 million tons of CO_2 per year. There are also plans to accept CO_2 from other European countries in future.

Table 2 illustrates the major technical work components in the different phases of the project. Commercial, financial, social, and governmental aspects of the project are not included. Many learnings from the Northern Lights project in Norway should be captured to shorten the learning curve. Following the best practice used by petroleum industry, the Southern Lights project will be divided into six phases: identify, feasibility, select, define, execute, and operate (Lau, 2008). In the Identify Phase, data are assessed to determine if the project is worth pursuing. If the answer is positive, then the project goes into the Feasibility Phase where all available options to pursue the project will be identified and evaluated. In the Select Phase, the optimal project concept is selected for detailed design. In the Define Phase, detailed engineering design of the project will be performed to provide the basis of design for the project. Also final investment decision will be made at the end of this phase. In the Execute Phase, construction begins and the assets are installed. In the Operate Phase the assets are operated to achieve permanent CO_2 storage as planned.

Benefits to ASEAN

The following are some potential benefits of the Southern Lights project to participating ASEAN countries. It is expected this project will cost several billion dollars and the project will last two to three decades. As the project will involve at least Singapore and a host country for CO_2 storage, its cost will be shared by both governments. Initially, construction of the carbon capture plants will be capital expensive. However, part of the cost of these plants can come from a carbon tax. At present, Singapore has a carbon tax of S$5/ton which may be increased to S$10 to $15/ton by 2030. This revenue can be used to partially finance the construction of the carbon capture plant in Singapore. Other countries may also use a carbon tax to raise finances for CCS projects. In addition, financing through international agencies such as the Asian Development Bank or the Asian Infrastructure Investment Bank may be worth considering.

Another benefit of the Southern Lights project is to reduce CCS cost by the estab-

Table 3: Nexus between decarbonization and 4IR technologies

Decarbonization technology	Technology subcategory	Examples of 41R technology	Reference
Post-combustion carbon capture	Chemical solvent	Materials informatics to identify new solvents	Rajan (2013)
	Solid sorbent	Solid sorbet using nanotechnology	Fryxell and Cao (2017)
	Membrane	New membrane using nanotechnology	Mueller et al. (2012)
	Absorber and stripper	Smart sensors to improve efficiency	Fryxell and Cao (2017)
CO_2 transport	CO_2 pipeline	Smart sensors to monitor flowrate, corrosion and leakage with real-time data transmission using IoT	Algarni and Zwawi (2019)
		Digital twin to schedule maintenance	Xue and Gai (2020)
		Additive manufacturing for repair and applying coating	Pathak and Saha (2017)
		Weather and metocean prediction using big data, AI, machine learning	Liu et al. (2020)
	Liquid CO_2 tanker	Zero-emission vessel using hydrogen or biofuels	de-Troya et al. (2016)
		Digital twin of key equipment in tanker	Bondarenko and Fukuda (2020)
		Autonomous tanker	Bassam et al. (2019)
CO_2 storage	Characterization of subsurface reservoir	AI and big data for seismic data processing	Pandey et al. (2020)
		Data analytics for seismic data interpretation	
		AI and data analytics for well log interpretation	
	Reservoir engineering	Quantum computing for geophysics	Moradi et al. (2018)
		Quantum computing for reservoir simulation	Ottaviani et al. (2019)
		Nanotechnology for wettability alteration of reservoir	Li et al. (2019)
		Nanotechnology for increasing heat transfer for geothermal heat mining by CO_2	Yang et al. (2005)
	Field operation	Intelligent wells to control CO_2 injection and production of water and hydrocarbon	Lau (2008)
		Smart field technologies (4D seismic, intelligent wells) with real time history matching using quantum computing	Engberg et al. (2014)
		Smart sensor to detect downhole seismic activity	van Dok et al. (2016)
	Post-injection CO_2 plume monitoring	Smart sensor to monitor CO_2 plume movement	Bathellier and Czernichow (1997)
Hydrogen production	Catalyst	Improved catalyst for SMR using nanotechnology	Rodriguez et al. (2004)
	Membrane reactor	Improved membrane using nanotechnology	Mueller et al. (2012)
	Plant efficiency	Smart sensors to enhance plant efficiency	Mukhopadhyay and Gupta (2008)

lishment of a regional CCS corridor. This corridor has a shared CO_2 collection and transportation network which will reduce CO_2 transportation cost for participating countries. If existing natural gas pipelines and oilfield infrastructure such as storage facilities and wells are used, further cost reduction can be achieved. Many ASEAN countries have substantial oilfield infrastructure which may be usable for future CCS projects. In addition, the large-scale removal of CO_2 by CCS will play an important role in preserving many industries in ASEAN countries, such as oil and gas, coal mining, marine, and offshore. This is important for sustaining the economies of ASEAN in the post pandemic era.

Another purpose of the Southern Lights project is to accelerate the transition to a hydrogen economy in participating countries. As a clean energy carrier, hydrogen is one of four important levers of the ongoing energy transition (Lau et al., 2021). If CCS on a large scale in ASEAN is proven by the Southern Lights project, it can be the basis for the production of hydrogen from either natural gas or coal. By using coal gasification or SMR, coal and natural gas can be converted to hydrogen and CO_2. If the emitted CO_2 is removed by CCS, then ASEAN countries can produce "blue" hydrogen for both domestic consumption and export. Already, countries including Japan and South Korea have announced their intention to import hydrogen and include it in their future energy mix. By upgrading coal and natural gas to hydrogen and getting rid of the emitted CO_2 by CCS, ASEAN countries like Singapore, Indonesia, and Malaysia may transition to a hydrogen economy much faster than buying hydrogen from other countries. There is much to gain for ASEAN countries to become exporters of this valuable commodity. A key part of the Southern Lights project is for Singapore to build a hydrogen plant next to its post-combustion carbon capture plant in Jurong Island. This will be a demonstration project for combining hydrogen production with CCS in ASEAN.

As ASEAN countries recover from the COVID-19 pandemic, they need new growth engines. This is especially important because of the decline of the oil and gas, and marine and offshore industries caused by the collapse of oil price since 2014. A successful CCS demonstration project like Southern Lights will revive not only these industries but also provide impetus for new growth industries such as CCS and hydrogen.

Challenges to the project

According to the Global CCS Institute there are only 28 large-scale CCS in operation in 2020 (Global CCS Institute, 2020). Together they store 41 Mtpa of CO_2 and 38 more are being planned with a capacity of 76 Mtpa. However, even countries that implement CCS project only store less than 1% of their emitted CO_2. This slow pace of CCS implementation is concerning and is due to many reasons (Lau et al., 2021). First is the lack of carbon pricing. Outside of northern Europe and U.S.A., most countries have low or no carbon tax or credit. Within ASEAN, Singapore is the only country with an established carbon tax although Malaysia is considering imposing one. Consequently, there is little incentive for companies to conduct CO_2 geological storage projects. A high enough carbon tax will create a strong incentive for CCS. However, the level of carbon tax is sensitive to energy price and cost of capital which varies from country to country. In addition, a consistent and predictable national energy policy will go a long way toward encouraging companies to invest in CCS. Subsidy for low carbon technologies, such as CCS, electric or hydrogen fuel cell vehicles, is beneficial to investment in these technologies. Lack of CCS regulations is also a potential challenge. Cross-border CO_2 movement is controlled by the London Protocol and Basel Convention (Dixon et al., 2015). However, ASEAN countries are not signatories to them. Therefore, both national and international laws need to be passed to govern the movement of CO_2 in ASEAN, its disposal and monitoring in subsurface reservoirs. Long-term liability of CO_2 disposal and whether it can be transferred from the operator to the state after a certain period of time also needs to be addressed. Permitting of CO_2 disposal also needs to be streamlined to avoid long delay. In additional, public awareness of CCS is low in ASEAN. Support for CCS can be increased if economic benefits, such as creation of new industries and new employment opportunities, are clearly articulated. Public engagement by trusted experts is needed to raise awareness on the benefits of CCS. Trusted experts should include those from institutes of higher learning, technology practitioners, and government officials. In addition, a lack of local expertise can be a barrier to a large-scale CCS project. Therefore, transfer of knowledge from foreign technology providers to local companies should be an important element of a CCS project. In addition, research collaboration between institutes of higher learnings and local and foreign technology providers will facilitate technology transfer and creation of local expertise in ASEAN. Implementation of a large-scale CCS project can be facilitated by a public-private partnership (PPP) which brings multiple industries, government agencies, and investors together. A stable, cooperative framework that lasts for two to three decades will be needed for a project like Southern Lights. This framework should encourage sharing of risks and rewards, and protection from political risks of governments changing their minds. A PPP may be a better vehicle to achieve this than a purely commercial partnership.

Decarbonization and fourth industrial revolution technologies

As one of the biggest engineering challenges ever for humanity, global decarbonization is an sustainable development issue which has a strong connection to many 4IR technologies. Table 3 gives an incomplete list of 4IR technologies that will likely be used in the decarbonization of Singapore.

Post-combustion carbon capture will likely utilize 4IR technologies such as materials informatics, nanotechnology, and smart sensors for improved plant efficiency. Nanotechnology is one of the 4IR technologies which has captured worldwide attention and has found many applica-

tions (Lau et al., 2017). CO_2 transport through pipelines will likely utilize smart sensors with internet of things (IoT), digital twin and additive manufacturing. CO_2 transport by tankers will likely involve big data, artificial intelligence (AI), machine learning, and quantum computing for weather and metocean prediction. In addition, digital twin can be used to monitor ship equipment for preventive maintenance. Other 4IR technologies may include zero-emission and autonomous ships. Subsurface CO_2 storage will likely use big data, AI, machine learning, and quantum computing for seismic and well log data processing and interpretation and numerical reservoir simulations. Hydrogen production will likely use nanotechnology for new catalysts and reactor design and smart sensors for improved plant efficiency. Indeed the list will go on and on.

Research and development on some of these 4IR technologies have already been conducted in Singapore. Singapore's government-supported Advanced Remanufacturing Technology Centre (ARTC) has been conducting research in additive manufacturing since its establishment in 2017. The Technology Centre for Offshore and Marine Singapore (TCOMS) was launched jointly by Singapore's Agency for Science, Technology and Research (A*STAR) and the National University of Singapore (NUS) in 2016 to conduct advanced research in marine technologies including the use of digital twin and autonomous vessels. Since 2016 NUS researchers, supported by the Petroleum Engineering Professorship programme of Singapore's Economic Development Board (EDB), have been conducting research on the use of nanotechnology for enhanced oil recovery and new stainless steel-carbon nanotube composites for downhole tools. Other research areas include use of AI, machine learning, big data and data analytics in the processing and interpretation of seismic data for reservoir characterization.

Conclusions

Herein, we have presented a roadmap for decarbonization of Singapore which will allow the country to half its current CO_2 emission by 2050 and reduce it to only 10% or less before the end of the century. The chief elements of this roadmap include decarbonizing Singapore's power and petrochemical sectors by post-combustion carbon capture, decarbonizing the transport sector by switching to electric and hydrogen fuel cell vehicles, using hydrogen fuel for marine vessels and biofuels for aviation. In the industrial sector, both reduction in Singapore's refining output and restructuring of the refining industry to hydrogen production are suggested. In addition, adoption of a circular economy will reduce demand for energy and high-carbon-content materials.

It is proposed that the majority of CO_2 mitigation (about 60%) will be provided by post-combustion CCS technologies. To this end, implementation of a Southern Lights CCS project is proposed. This project will include centralized post-combustion carbon capture in Singapore, establishing a regional CCS corridor, shipment of CO_2 from Singapore and other regional sources via existing natural gas pipelines or liquid CO_2 tankers to a target location for permanent storage, and building a SMR hydrogen plant in Singapore and removing the emitted CO_2 by CCS. This project will be ASEAN's first cross-border CCS project. Potential benefits will include shared financing, reduced cost of decarbonization by leveraging economy of scale, preserving regional oil and gas industries, enabling a quicker transition to a hydrogen economy, and creation of regional growth industries such as CCS and hydrogen.

Many challenges to the implementation of this CCS project exist. Solutions to them will include public engagement on CCS, establishing a PPP for project financing, management, and execution, formulating consistent energy policies by participating governments and international cooperation for transfer of knowledge to local entities.

A number of 4IR technologies will also play a key role in the success of this project. Research and development on some of them have already being conducted in Singapore. Working together, ASEAN countries can benefit from harnessing many 4IR technologies to implement a regional CCS project which may become the catalyst for sustainable development in the region.

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Centre for the Fourth Industrial Revolution of the World Economic Forum

The Centre for the Fourth Industrial Revolution of World Economic Forum is a hub for global, multistakeholder co-operation to accelerate the benefits of science and technology. With Centres in 13 countries around the world, the C4IR Network is working with government, business, academia and civil society to develop, prototype and test pioneering collaborations and governance models to ensure the benefits of technology are maximised, and the risks accounted for. The Centre is co-designing and piloting policy frameworks and governance protocols across six areas of focus.

As the world undergoes a great reset, our ability to harness and disseminate the new technologies of the Fourth Industrial Revolution (4IR) will play a key role in ensuring our recovery from the pandemic and the avoidance of the future crises.

The possibilities of new 4IR technologies, deployed appropriately, should be used as the baseline to reinvent the way we operate in the new context: everything from government services, education and healthcare, to the way business interacts and provides value to its customers.

However, if not directed with purpose, the 4IR has the potential to exacerbate inequality. Human-centricity, Inclusion and Trust must be key principles guiding action - we must take proactive steps to ensure technology adoption does not heighten abuse of power, bias, wealth disparities, exclusion and loss of livelihoods. Whilst technology comes with risks, such as cybersecurity or fraud, it can also provide vast opportunity, such as enhancing education systems, reducing corruption in supply chains or accelerating the adoption of clean energy.

Affiliate Centres selected to join the Centre for the Fourth Industrial Revolution Network can access and share research and analysis across our Centres and portfolio areas. Combined with emerging technology policy initiatives managed locally, Affiliate Centres will play a vital role in helping to shape the development of national Fourth Industrial Revolution strategies and public-private initiatives.

Organizations eligible to join the C4IR Network as Affiliates include governmental offices, advisory commissions or related research bodies, academic institutes or universities, non-profit organizations or business associations. Affiliates will actively engage with their host government in the policy design and piloting activities.

For more information access:

https://www.weforum.org/centre-for-the-fourth-industrial-revolution

Tech Events

2021

Sep 14–16 Virtual
3rd International Congress on Water Desalination, Application of Advanced Technologies in Unconventional Water Treatment for Zones under Water Stress
Contact: Faculty of Engineering,
University of Sistan and Baluchestan,
Zahedan, Iran. P.O. Box: 98135-987
Tel: +98-54-31136490, Fax: +98-54-33447092
E-mail: UWTC@usb.ac.ir
http://seminars.usb.ac.ir/uwtc

Sep 29–30 Ulaanbaatar, Mongolia
International New Energy Summit 2021
Contact: Ms. Alyssa Pek
E-mail: alyssa.pek@gwec.net
https://gwec.net/international-new-energy-summit-2021/

Oct 14–16 Bangkok, Thailand
ASEAN Sustainable Energy Week 2021
Contact: Ms. Jittraporn Kulwanich
Tel: +66 2036 0500 ext. 244 & 235, Fax: +66 2036 0588
E-mail: jittraporn.k@informa.com, asew-th@informa.com
https://www.asew-expo.com/2021/en/index.asp

Oct 18–19 Virtual
7th International Conference on Low Carbon Asia & Beyond
Contact: UTM Low Carbon Asia Research,
Universiti Teknologi Malaysia,
81310 Johor Bahru, Johor, Malaysia
E-mail: secretariat@iclcaconf.com
https://iclcaconf.com/

Oct 20–21 Singapore
Big Data & AI World
Contact: Ms. Joyce Luk
Conference Producer
Tel: +852 2972 0627
E-mail: joyce.luk@closerstillmedia.com
https://www.bigdataworldasia.com/

Oct 25–29 Virtual
Solar World Congress 2021
Contact: International Solar Energy Society e. V. ISES
Wiesentalstr. 50
79115 Freiburg, Germany
Tel: +49 761 459 06 0, Fax: +49 761 459 06 99
https://www.ises.org/

Nov 6–8 Phuket, Thailand
2021 6th Asia Conference on Environment and Sustainable Development (ACESD 2021)
Contact: Nancy Liu
Conference Secretary
Tel: +86-28-86512185
E-mail: acesd@iacsitp.com
http://www.acesd.org/

Nov 9–10 Ho Chi Minh City, Viet Nam
ASEAN Wind Energy 2021
Contact: Jay Hsu
Tel: +86 186 0171 2917
E-mail: Jay@leader-associates.com
https://www.aseanwindenergy.com/

Nov 9–11 Kuala Lumpur, Malaysia
ASEAN Solar Expo
Contact: Ms. Esther Lim
Mob: 6012-302 5216
E-mail: Esther.lim@informa.com
https://www.super8asean.com/

Nov 16–18 (Virtual)
2021 Asia-Pacific Agri-Food Innovation Summit
Contact: Rachel Mackie
Business Development Manager
Rethink Events Ltd, 1st Floor, Huntingdon House,
20a North Street, Brighton, BN1 1EB, UK
Tel: +44 (0)1273 789989
E-mail: rachel.mackie@rethinkevents.com
https://agrifoodinnovation.com/

Nov 17–19 (virtual)
3th Asian Conference on Machine Learning (ACML 2021)
Contact: Secretariat
E-mail: acml21-conf@googlegroups.com
http://www.acml-conf.org/2021/

Nov 26–28 Shenzhen, China
2021 6th International Conference on Renewable Energy and Conservation (ICREC 2021)
Contact: Ms. Rachel Cao
Conference Secretary
Tel: +86-13880104217
E-mail: icrec_conf@163.com
http://www.icrec.org/

Nov 30–Dec 2 Virtual
Second Annual Asia-Pacific Hydrogen Summit
Contact: Rob Arthur
Tel: +44 20 7978 0095
E-mail: AsiaHydrogen@sustainableenergycouncil.com
https://asia-hydrogen-summit.com/

Dec 1–3 Bangkok, Thailand
2021 4th Asia Conference on Machine Learning and Computing
Contact: Cherry Chan
Conference Secretary
Tel: +86-28-86512185
E-mail: acmlc@iacsitp.com
http://acmlc.org/

Dec 5–8 Brisbane, Australia
2021 Innovative Smart Grid Technologies Conference Asia (ISGT Asia 2021)
Contact: Arinex Pty Ltd
ABN.28 000 386 676
S3, The Precinct 12 Browning Street
West End, QLD 4101, Australia
Tel: +61 7 3226 2800
E-mail: isgt2021@arinex.com.au
https://ieee-isgt-asia.org/

2022

Mar 9–11 New Delhi, India
IIoT India 2022
Contact: Pinak Gupta
Mobile: (91) 9910112272
E-mail: pinak.gupta@singex.com
http://iiotindia.co.in/

Mar 18–20 Guangzhou, China
2022 6th International Conference on Sustainable Development and Green Buildings (ICSDGB 2022)
Contact: Ms. Yury Yu
Tel: +852-30506939 (HK)
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E-mail: icsdgb@apise.org
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Tech Ventures & Opportunities

Business Coach

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Startup support in Bangladesh

IDEA Bangladesh

https://idea.gov.bd

Venture capital investments spur innovation, create employment, and make a significant contribution to economic growth. With our population growing, globalization rapidly changing the international business climate, and sometimes making it uncertain, a culture of innovation can provide its own energy for Bangladesh by affording us opportunities for our young entrepreneurs. Where done correctly, the impact of government intervention in fostering an innovation economy has successfully created venture capital ecosystems in many countries. The government of Bangladesh hopes to replicate similar success by founding Startup Bangladesh that will catapult its young generation of entrepreneurs to the next level who can accelerate the pace of innovation and lead the economy to a self-sustained path to growth. With this in mind Startup Bangladesh aims to pursue the following goals: Create an accelerator and its accompanying ecosystem of entrepreneurs, investors, mentors, advisors to promote Bangladesh as a global hub for tech entrepreneurship.

- Actively collaborate with entrepreneurs, industry, academia, financial institutions, and government to stimulate innovation.
- Create the appropriate business, operational, and regulatory frameworks to support bold dreams.

Through iDEA Accelerator, the government will nurture innovative ideas in the areas of Education, Agriculture, Health, Financial Services, eCommerce, eGovernance, Environment, Transport, and Infrastructure. Evaluate concepts based on potential impact, execution strategy, and public benefit.

Mentoring

iDEA provides mentoring to its portfolio startups. iDEA has a pool of expert mentors. The mentor's pool consists of national and international industry leaders, university professors, angel investors, successful entrepreneurs, and specific field experts.

Academic programs

The iDEA academy provides different courses to train up entrepreneurs working in different industries. The academy provides long-term and short-term courses in different levels considering entrepreneur's need. Workshops and training programs are also arranged regularly.

Networking

As the central hub of the startup ecosystem of Bangladesh, iDEA collaborates with national and international stakeholders who are working with startups. Startup Circle is created to foster the collaboration among the member organization. Match-making sessions between startups and investors are arranged regularly.

Legal and IP support

iDEA guides and helps startups to protect their legal and intellectual property rights. If needed the startups can also seek supports from Startup Circle members.

Coworking space

iDEA has a great coworking space for startups. 51 desks have been furnished for the startups. Startups can also use the meetings rooms and other facilities created by the project.

Funding

iDEA provides Bangabandhu Innovation Grant (BIG) to startups. Pre-seed or idea-stage startups can apply for the BIG which is up to 10 Lakhs BDT in iDEA. Seed and growth-stage startups can apply for investment that will be funded from Startup Bangladesh Limited venture capital company. Seed and growth-stage startups can apply to Startup Bangladesh Limited.

Lab support

Startup Bangladesh – iDEA has created a state-of-the-art lab facility for the startups. Startups can test their product or service and get expert opinion.

Investment promotion criteria in Thailand

Thailand Board of Investment, Thailand
https://www.boi.go.th/

1. In order to develop competitiveness in the agricultural, industrial, and service sectors, projects submitted for BOI promotion must have the following qualifications:

1.1 The value-added of the project must not be less than 20% of revenues, except for projects in agriculture and agricultural products, electronic products and parts, and coil centers, all of which must have value-added of at least 10% of revenues.

1.2 Modern production processes must be used.

1.3 New machinery must be used. In case of imported used machinery, the criteria for consideration will be classified into 3 cases, as follows:

General Case

Factory Relocation Case

Other Cases

Remarks

- Relocation of factory refers to the relocation of the production line either partially or in its entirely from a foreign country where the machinery to be used in the project belongs to affiliates or related companies.

- Machinery Performance Certificate refers to a certificate issued by a trusted institute that grants a machinery performance certificate, which includes a certified report on reconditioned machinery together with detailed documentation of the reconditioning. The inspection of certified machinery and equipment shall include a full test run of the machinery to evaluate its capacity and functionality, as prescribed by requirements of the testing procedure. An environmental impact report, a safety standards check, and an energy consumption report must be compiled in accordance with the acceptable criteria. A certified report must identify 6 significant details, as follows:

1) Details on reconditioning and an analysis of the remaining lifecycle of the machinery;

2) Year of manufacture;

3) Test-run results;

4) An environmental impact report, safety standards check, and an energy consumption report;

5) Appropriate price estimation (the price estimation certificate can be submitted separately);

6) Inspection report with date and place of inspection.

Note: * Planes in the Air Transportation Services project must be no more than 14 years old. (Please see condition under activity 7.3.4)

1.4 Projects that have investment capital of 10 million baht or more (excluding cost of land and working capital) must obtain ISO 9000 or ISO 14000 certification or similar international standard certification within 2 years from the full operation start-up date, otherwise the corporate income tax exemption shall be reduced by 1 year.

1.5 For a concession project and the privatization of a state enterprise project, the Board's criteria shall be based on the Cabinet's decisions dated May 25, 1998, and November 30, 2004, as follows:

(1) An investment project of state enterprise according to the 1999 State Enterprise Corporatization Act shall not be entitled to investment promotion.

(2) For Build-Transfer-Operate or Build-Operate-Transfer projects, the state agency that owns the project must submit its project to the Board for consideration prior to any invitation to bid, and bidders shall be informed of any promotional privilege entitled to them, prior to the bidding.

(3) For Build-Own-Operate projects, including those leased to or managed by the private sector, which in return pays rent to the state, the Board shall use normal criteria for investment promotion.

(4) For the privatization of state enterprises according to the 1999 State Enterprise Corporatization Act, in case of expansion after the privatization, only the expansion investment shall be eligible for promotion.

2. Environmental protection

2.1 Adequate and efficient guidelines and measures to protect environmental quality and to reduce environmental impact must be installed. The Board will give special consideration to the location and pollution treatment of a project with potential environmental impact.

2.2 Projects or activities with type and size that are required to submit environmental impact assessment reports must comply with related environmental laws and regulations or Cabinet resolutions.

3. Minimum capital investment and project feasibility

3.1 The minimum capital investment requirement of each project is 1 million baht (excluding cost of land and working capital) unless specified otherwise on the list of activities eligible for investment promotion that is attached to this announcement.

3.2 For newly established projects, the debt-to-equity ratio must not exceed 3 to 1. Expansion projects shall be considered on a case-by-case basis.

3.3 For project with an investment value over 750 million baht (excluding cost of land and working capital) the project's feasibility study must be submitted with details as specified by the Board.

(Source: Announcement of the Board of Investment No. 2 /2557)

Petty patent registration in Thailand

Department of Intellectual Property, Thailand
http://www.ipthailand.go.th/

Consideration criteria

1. Invention applied for the patent should be characterized as follows;
   1.1 The invention shall be a new creation.
   1.2 The invention can be used for industrial applicability.
   1.3 The following inventions shall not be protected by the Patent Act.
      (1) Microorganism and any component of the microorganism naturally-existing in animal, plant or extract from animal or plant;
      (2) Scientific or mathematical principles and theories;
      (3) Database for computer functions;
      (4) Method of diagnosis, treatment or care of human and animal diseases;
      (5) The invention that contradicts public order, morality, health or welfare;
2. To apply for a petty patent, the applicant shall submit supporting documents as follows;
   (1) Title of the invention
   (2) Describe features and objectives of the invention
   (3) Invention details. The invention shall be described in details completely, concisely and clearly, with which an ordinary person specialized in the relevant technical field can create such invention.
   (4) Claim
   (5) Other documents stipulated in the Ministerial Regulation

Conditions of application submission

1. To receive a petty patent, the applicant shall submit the form as determined by the Director-General.

The petty patent application shall be accompanied with invention details, claim and summary of invention. If necessary, the applicant shall provide drawing(s) as supporting documents of the application for the better understanding of the invention.

If the invention applied for the patent is involved with a new microorganism, the invention details shall mean the certificate of bio-organism deposit and/or document describing its features or properties issued by an institution for bio-organism deposit. In this regard, the Department of Intellectual Property shall announce the list of institutions from time to time.

2. Authorization
   2.1 In case the applicant of the petty patent does not reside in the Kingdom of Thailand, he shall authorize the patent agent/patent attorney registered with the Director-General of the Department of Intellectual Property to act on his behalf. In this regard, the power of attorney shall be presented to the Director-General in accordance with the following regulations;
      (1) If the authorization is done outside the Kingdom of Thailand, the signatures in the authorization letter or power of attorney shall be certified by the authorized official of the Thai embassy or consulate or Director of the office of the Ministry of Commerce located in the country where the principal or power grantor resides, or the person authorized to act on behalf of the said officials or the person authorized to certify the signature according to the law in that country, or
      (2) In case the authorization is done in the Kingdom of Thailand, the applicant shall submit a copy of passport or temporary residence certificate of the principal or power grantor, or any evidence indicating that at the time the authorization was made, the principal or power grantor was in Thailand.
   2.2 The Power of Attorney shall be attached with the revenue stamp of 30 Baht/patent agent/patent attorney/application.

Proceeding according to the official's instruction

1. In case that the official finds a correctable defect in the application, the official shall notify the applicant or his patent agent/patent attorney for the correction. The applicant shall finish the correction within 90 days from or since the notification reception date. After such period, without the correction of the applicant shall be deemed to have abandoned the application according to Section 27, except the Director-General extends the period for correction as deemed appropriate due to any necessity.
2. After the applicant corrected the application, the applicant shall submit the corrected application and the fee to the Department of Intellectual Property or the provincial office of the Ministry of Commerce. The corrected application shall enter the consideration and initial inspection processes respectively, similarly to the re-submission of the application.
3. In case of application submission via the website or internet/E-

patent filing system of the Department of Intellectual Property, the inspecting official shall check the completeness of information and details in the patent/petty patent application, request or other applications based on information and details appearing in the e-patent filing system. In this regard, the applicant shall present the application and supporting documents to the Department of Intellectual Property within 15 days of application number reception date and patent/petty patent application filing date via internet. The inspection of application submitted via internet shall be in accordance with the Notification of the Department of Intellectual Property Re: Principles and conditions for submission of patent/petty patent application, requests or other applications via internet.

4. In case the application is correct or the correction is completed, the official shall notify the applicant to pay the registration and publication fees within 60 days from or since the notification date. If the applicant does not pay the fees after the second notification, the applicant shall be deemed to have abandoned the application. As for the publication, the registration application shall be announced in the petty patent publication book.
5. After the publication, any interested person can request the inspection against the petty patent application whether it complies with the laws within 1 year of the publication date. After 1 year the examination shall complete the consideration. If the applied patent does not comply with the laws, it will be revoked.
6. In case of the application revocation, the appeal can be submitted to the official in accordance with the laws.

Notes

1. The working process starts after the inspection of the documents is completed, as specified in the manual of the public service.
2. In case the application or documentary evidence is not correct or incomplete, the official shall record the defect of the document or indicate the required additional documentary evidence (Record of conditions on application reception). The applicant shall correct the document and/or submit the additional document within 90 days of the application filing date. If the applicant fails to submit all additional documents within the specific period of time, the applicant shall be deemed to have abandoned the application for petty patent. The official shall return the application to the applicant and inform the reason of the return and his appeal right.
3. Any person fee paid to the Department of Intellectual Property shall not be refunded in all cases, except
   (1) The law stipulates that the fee must be refunded, or
   (2) The applicant double-paid or overpaid the fee, by which the faulty payment resulted from the mistake of the state official, not the payer. In this regard, the Department of Intellectual Property shall consider the refund case by case.
4. In case the applicant is required to submit many additional documentary evidences, the applicant shall submit all additional documentary evidences in the same time.
5. In case the applicant submits the copy of the documentary evidence, the applicant shall certify the copy of the documentary evidence.
6. In case the applicant submits the document in foreign language, the applicant shall submit the document with Thai translation and the correct translation certification of the translator.
7. In case the applicant or the authorized patent agent/patent attorney does not submit the application by himself, and granted power to the other person to submit the application, the application submitter shall present a sub power of attorney or temporary power of attorney, so that he is eligible to submit the application and sign in the record of conditions on application reception. If it appears that the application and the documentary evidence is not correct or incomplete, and the application submitter is not authorized to sign on the said record, the official shall not receive the application.
8. The working period does not include the time period when the applicant follows the official's examination or corrects the application, or the period of temporary suspension of registration.
9. The applicant is entitled to convert application to change the protection category (i.e. from petty patent to patent) prior to the issuance or prior to the publication, as the case may be. In this regard, the date of request for the change is deemed as the first day of the protection period.

Relevant laws

1. The Ministerial Regulation No.21 (B.E. 2542) issued by virtue of the Patent Act B.E. 2522 (Dated 24 September 1999).
2. The Ministerial Regulation No.22 (B.E. 2542) issued by virtue of the Patent Act B.E. 2522 (Dated 24 September 1999).
3. The Patent Act B.E. 2522 as amended by the Patent Act (No. 2) B.E. 2535 and the Patent Act (No. 3) B.E. 2542

Registration of technology transfer arrangements in Philippines

Intellectual Property Office of the Philippines

https://www.ipophil.gov.ph

Rule 6. Registration Procedure. The Bureau shall act on requests for registration of technology transfer arrangements based on the following procedure:

6.1. Filing. All requests pertaining to technology transfer arrangements shall be filed with the Bureau and duly stamped "Received" with the date, time, and name of the receiving officer upon receipt.

6.2. Notice of Additional Requirements. Should the Bureau find that the applicant has submitted incomplete or insufficient information and requirements, the Bureau shall issue a Notice of Additional Requirements to the applicant within three (3) working days from the filing of the request requiring the applicant to submit the additional requirements. The applicant shall complete the requirements within fifteen (15) working days from receipt of the Notice of Additional Requirements. Should the applicant not be able to comply with the requirements within the aforesaid period, applicant may request for an extension of another fifteen (15) working days and pay the corresponding fee. Otherwise, the file shall be archived and shall only be retrieved upon submission of the complete requirements and payment of the Document Retrieval Fee. (revised Rule 8)

6.3. Filing Date. Upon receipt of all the requirements as contained in the Notice of Additional Requirements, the Bureau shall issue a Notice of Filing Date within three (3) working days from such receipt. The Filing Date shall be the date when the Bureau has satisfactorily received all the requirements. This date is also the date when evaluation of the request shall commence. (revised Rule 7)

6.4. Decision. The Bureau Director shall decide on the request within twenty (20) working days from the Filing Date. (revised Rules 13, 18, 22, and 24) A favorable Decision shall cause the corresponding Certificates to be issued. Otherwise, appropriate Notices shall be issued to applicant.

6.4.1. Notice of Findings and Notice to Comply. Should any provision of the agreement violate any of the Prohibited Clauses or Mandatory Provisions of the IP Code, the Bureau shall issue a notice to the parties informing them of the violation and requiring them to comply. (revised Rules 20, 22, and 25)

6.5. Issuance of Certificate. Upon the applicant's satisfactory response to the findings and subsequent compliance with the IP Code provisions, and/or after a favorable Decision by the Bureau Director, the Bureau shall issue the appropriate certificate within seven (7) days from receipt of the duly executed and notarized agreement and payment of the required fees for the following as requested: (revised Rules 14, 19, and 21)

a. Certificate of Registration - A certification that a technology transfer arrangement has been granted certain exemption/s from the requirements of Sections 87 and/or 88 of the IP Code;

b. Certificate of Compliance - A certification that the technology transfer arrangement does not violate any of the Prohibited Clauses and conforms to all the Mandatory Provisions of the IP Code;

c. Certificate of Clearance - A certification that a trademark license agreement covered by Section 150 of the IP Code has been cleared for recordal with the Bureau of Trademarks.

6.6 Entry in the Certificate Registry Book. After the issuance of a certificate, the Bureau shall enter in the Certificate Registry Book the following:

a. Title of the technology transfer arrangement;

b. The parties thereto;

c. Its registration number;

d. The date of registration; and

e. The corresponding type of certificate as enumerated in Rule 6.5 above.

Other information needed by the agency for statistical purposes may likewise be recorded, in accordance with the provisions of the law. (revised Rule 15)

6.7. Publication. The Bureau shall publish in the IPO Gazette all agreements that are granted exemption, registered, or cancelled. The publication shall contain the names of the parties, title, and subject of the agreement, the specific exemption/s granted, if any, and the date of cancellation, if such was the case. (revised Rule 33)

Rule 7. General Provisions

7.1. Applicants. Any party to a technology transfer arrangement or his duly authorized representative may file with the Bureau an application for Certificate of Registration, Certificate of Compliance, or Certificate of Clearance (as distinguished under Rule 6.5). Parties may also jointly file such Applications. (revised Rules 5 and 21)

7.2. Requirements. The basic requirements for any request to be filed with the Bureau pertaining to a technology transfer arrangement shall be as follows:

a. Letter request;

b. Copies of the technology transfer arrangement;

c. The duly filled-out sworn application form which shall include a verified statement from the applicant that the agreement is not subject of any judicial, administrative, or other proceeding; and

d. Requisite Fees.

Requests for Exemption shall also be accompanied with specifics on the exemption/s being requested and the justification for the exemption/so

In case of Requests for Preliminary Review, the applicant may submit either a draft or a duly executed and notarized agreement.

Other documents may be required by the Bureau to support and establish the merits of a request. (revised Rules 4 and 21)

7.3. Amendments. Minor changes on a technology transfer arrangement, such as addition or deletion of products, increase or decrease in royalty rates and other commercial terms, etc. which do not violate the requirements of Sections 87 and 88 of the IP Code, will not affect the findings of the Bureau and will not necessitate another round of review. Such requests for annotation shall be acted upon by the Bureau within three (3) working days from receipt of all the requirements which may include the surrender of a previously issued certificate covering the technology transfer arrangement. (revised Rule 35(b))

7.4. Issuance and Validity of the Certificates. There will not be issued any perpetual certificates and in no case shall any of these certificates exceed the life of the Technology Transfer Arrangement.

Technology Transfer Arrangements which had expired shall not be issued certifications anew unless aforesaid technology transfer arrangement had been renewed or extended in due course.

Only one (1) original Certificate shall be issued to the applicant and the Bureau will maintain only one (1) original duplicate for file. Requests for additional original copies will not be granted. However, an applicant may request for certified true copies of the original duplicate on file.

a. Maximum Validity of the Certificate of Registration and Certificate of Compliance. The Certificates of Registration and Certificate of Compliance to be issued by the Bureau, as the case may be, may carry a maximum validity of ten (10) years from the date of effectivity of the technology transfer arrangement or from the date of issuance of the certificate, whichever is earlier.

b. Maximum Validity of the Certificate of Clearance. The Certificate of Clearance to be issued by the Bureau on account of Trademark License Agreements for recordal with the Bureau of Trademarks, may carry a maximum validity of ten (10) years but may not exceed the expiration of the Trademark registration itself, as appearing in the Trademark Registration certificate.

7.5. Cancellation of Registration. Automatic cancellation of registration shall be made upon receipt by the Bureau of a duplicate original or certified true copy of the registered technology transfer arrangement containing amendments or modifications that violate the Prohibited Clauses and Mandatory Provisions of the IP Code without approval of the Bureau. (Rule 16)

The Bureau may also cancel the registration of the technology transfer arrangement if, after evaluation, the Bureau has established that the justification for the grant of an exemption submitted by the applicant does not exist or has ceased to exist.

Such action will be made only after the parties in whose names the certificate of registration was issued are given an opportunity to be heard. (Rule 16)

In both cases, the parties shall be required to surrender the certificate provided that the surrender of the certificate shall not be a pre-requisite to the cancellation of the registration. (Rule 16)

(Source: IPOPHL Memorandum Circular No. 2020-002, Revised Rules and Regulations on Voluntary Licensing)

Medicines Patent Pool

The Medicines Patent Pool (MPP) is a United Nations-backed public health organization working to increase access to, and facilitate the development of, life-saving medicines for low- and middle-income countries. Through its innovative business model, MPP partners with civil society, governments, international organizations, industry, patient groups and other stakeholders, to prioritize and license needed medicines and pool intellectual property to encourage generic manufacture and the development of new formulations.

MPP's mandate is to accelerate access to affordable quality treatments for people living with HIV, hepatitis C and tuberculosis, as well as HIV-associated co-morbidities. Since 2018, MPP has expanded its mandate to other patented essential medicines on the World Health Organization (WHO)'s Model List of Essential Medicines (EML) as well as medicines with strong potential for future inclusion on the EML.

To date, MPP has signed agreements with ten patent holders for thirteen HIV antiretrovirals, one HIV technology platform, three hepatitis C direct-acting antivirals and a tuberculosis treatment. MPP was founded by Unitaid, which continues to be MPP's main funder. MPP's work on access to essential medicines is also funded by the Swiss Agency for Development and Cooperation (SDC).

For more information, access:

https://medicinespatentpool.org/

Stages of startups and sources of funding in India

Startup India Hub

https://www.startupindia.gov.in/

There are multiple sources of funding available for startups. However, the source of funding should typically match the stage of operations of the startup. Please note that raising funds from external sources is a time-consuming process and can easily take over 6 months to convert.

Ideation/pre-seed stage

This the stage where you, the entrepreneur, has an idea and are working on bringing it to life. At this stage, the amount of funds needed is usually small.

Given the fact that you are at such an initial stage in the startup lifecycle, there are very limited and mostly informal channels available for raising funds. Common funding sources utilized by startups in this stage are:

- **Bootstrapping/Self-financing:** Bootstrapping a startup means growing your business with little or no venture capital or outside investment. It means relying on your own savings and revenue to operate and expand. This is the first recourse for most entrepreneurs as there is no pressure to pay back the funds or dilute control of your startup.
- **Friends and family:** This is also a commonly utilized channel of funding by entrepreneurs still in the early stages. The major benefit of this source of investment is that there is an inherent level of trust between the entrepreneurs and the investors
- **Business plan/pitching events:** This is the prize money/grants/financial benefits that is provided by institutes or organizations that conduct business plan competitions and challenges. Even though the quantum of money is not generally large, it is usually enough at idea stage. What makes the difference at these events is having a good business plan.

Validation/seed stage

This is the stage where your startup has a prototype ready and you need to validate the potential demand for your startup's product/service. This is called conducting a "Proof of Concept (PoC)," after which comes the big market launch. To do this, the startup will need to conduct field trials, test the product on a few potential customers, onboard mentors, and build a formal team. Common funding sources utilized by startups in this stage are:

- **Incubators:** Incubators are organizations set-up with the specific goal of assisting entrepreneurs with building and launching their startups. Not only do incubators offer a lot of value-added services (office space, utilities, admin, & legal assistance, etc.), they often also make grants/debt/equity investments
- **Government loan schemes:** The government has initiated a few loan schemes to provide collateral-free debt to aspiring entrepreneurs and help them gain access to low-cost capital. Some such schemes include CGTMSE, MUDRA, and Stand-up India.
- **Angel investors:** Angel investors are individuals who invest their money into high potential startups in return for equity. Reach out to angel networks such as Indian Angel Network, Mumbai Angels, Lead Angels, Chennai Angels, etc. or relevant industrialists for this.
- **Crowd funding:** Crowd funding refers to raising money from a large number of people who each contribute a relatively small amount. This is typically done via online crowd funding platforms.

Early traction/series A stage

This is the stage where your startup's products or services have been launched in the market. Key performance indicators such as customer base, revenue, app downloads, etc. become important at this stage. Funds are raised at this stage to further grow user base, product offerings, expand to new geographies, etc. Common funding sources utilized by startups in this stage are:

- **Venture capital funds:** Venture capital (VC) funds are professionally managed investment funds that invest exclusively in high-growth startups. Each VC fund has its own investment thesis—preferred sectors, stage of startup, and funding amount—which should align with your startup. VCs take startup equity in return for their investments and actively engage in mentorship of their investee startups.
- **Banks/NBFCs:** Formal debt can be raised from banks and NBFCs at this stage as the startup can show market traction and revenue to validate their ability to finance interest payment obligations. This is especially applicable for working capital. Some entrepreneurs might prefer debt over equity as they debt funding does not dilute equity stake.
- **Venture debt funds:** Venture Debt funds are private investment funds that invest money in startups primarily in the form of debt. Debt funds typically invest along with an angel or VC round.

- **TReDs:** To decrease the financing concerns faced by MSMEs in India, RBI introduced the concept of TReDS in 2014, an institutional mechanism for financing trade receivables on a secure digital platform. Trade Receivable Exchanges such as M1xchange, standardizes the process of funding MSMEs via Invoice Discounting. TReDS addresses the gaps in MSME industry as enterprises face challenges in getting their payments on time, thus creating working capital discrepancies. TReDS is a timely and effective solution to drive the MSME sector to the next phase of Indian economy.

Scaling/series B & above stage

At this stage, the startup is experiencing fast rate of market growth and increasing revenues. Common funding sources utilized by startups in this stage are:

- **Venture capital funds:** VC funds with larger ticket size in their investment thesis provide funding for late stage startups. It is recommended to approach these funds only after the startup has generated significant market traction. A pool of VCs may come together and fund a startup as well.

- **Private equity/investment firms:** Private equity/Investment firms generally do not fund startups; however, lately some private equity and investment firms have been providing funds for fast-growing late-stage startups who have maintained a consistent growth record.

Initial public offering

Initial Public Offer (IPO) refers to the event where a startup lists on stock market for the first time. Since the public listing process is elaborate and replete with statutory formalities, it is generally undertaken by startups with an impressive track record of profits and who are growing at a steady pace. One of the benefits of an IPO is that a public listing at times can increase the credibility of the startup and be a good exit opportunity for stakeholders. Any Angel investor, VC, or PE fund may buy out investors of a previous round to get their equity share as well.

COVID-19 mRNA vaccine technology transfer hub

The World Health Organization (WHO) and its partners are seeking to expand the capacity of low- and middle-income countries (LMICs) to produce COVID-19 vaccines and scale up manufacturing to increase global access to these critical tools to bring the pandemic under control. WHO will facilitate the establishment of one (or more, as appropriate) technology transfer hub(s) that will use a hub and spoke model (REF) to transfer a comprehensive technology package and provide appropriate training to interested manufacturers in LMICs. This initiative will initially prioritize the mRNA-vaccine technology but could expand to other technologies in the future.

To support this activity, we are seeking expressions of interest from:

1. Small/middle-sized (public or private) manufacturers of medical products (drugs, vaccines or drug substances) preferably, but not exclusively, in LMICs, which could host a COVID-19 mRNA hub and:
   - o Assemble the technology up to good manufacturing practices-grade pilot lots for clinical trials;
   - o Transfer the appropriate know-how and technology to existing or new manufacturers in LMICs to enable them to develop and produce COVID-19 mRNA vaccines;
2. Owners (public or private) of technology and/or intellectual property rights. These may be academic institutions, pharmaceutical companies, non-governmental organizations or any other entity willing to contribute these to a technology transfer hub, under the auspices of WHO, to enable production of mRNA-based COVID-19 vaccines in LMICs.

For this initial expression of interest, entities may contact:

Martin Friede (friedem@who.int) and Raj Long (rlong@who.int)
World Health Organization

Selected funding programmes in Malaysia

Malaysia Digital Economy Corporation (MDEC) Sdn Bhd

https://mdec.my/

Businesses of all sizes can reach out to and engage with various support initiatives that MDEC currently manages. This includes the different grants that are currently made available for different industry verticals. These market assistance are actively providing the support businesses need to remain sustainable or expand their operations.

Smart Automation Grant (SAG)

This is a specific matching grant for services companies that will help them automate their business processes and move towards digitalization.

The grant will be used solely for the purpose of kickstarting the development and implementation of projects that push the adoption of technologies to automate business operations.

The Development Grant

Development Grant focuses on the development stage of the Project, the stage where it involves idea generation, production design, market research, and marketing analysis. The development stage is defined as a planning phase of the Project.

This includes development of the idea into working script, research and development (R&D) of the concept, business plans, and preparation of documents which are investor-friendly. Applicants with new project/IP/idea within the Eligible Project Categories are encouraged to apply for funding under the Development Grant.

Production Grant

Production Grant focuses on the production stage of the project which involves the activity of creating, assembling, aggregating, and generally producing or generating content.

IP Marketing & Licensing Grant

IP Marketing & Licensing Grant is a financial assistance provided to IP creators with market ready product (s). This includes IP extension, IP registration, development of style guide and other activities related to marketing, promotion, localization, commercialization, licensing, or distribution.

Creative Industry Export Acceleration and Enterprise Development (CREED)

The Creative Industry Export Acceleration and Enterprise Development (CREED) is an end-to-end fund to address long-term industry growth and sustainability. CREED is designed to support established creative content companies with a history of successful IP developed and commercialized.

Global Tech Fund

The Global Tech Fund (GTF) aim is to support the following three focus pillars:

1. Nurturing Global Champions
2. Driving Investments
3. Catalyzing Digital Innovation Ecosystem

GTF targets local scale-up technology companies who are ready to go into their first global market or expand their existing global market presence via technology innovation and commercialization of market-driven product/service. We want to see potential Malaysian unicorn in the making. Local technology companies are welcome to set up Centre of Excellence for the benefit of the ecosystem.

GTF targets foreign technology companies to set up Centre of Excellence to conduct high value technology innovation/R&D activities leading to the development and commercialization of market-driven, innovative product/service for the global market as well as contribute to ecosystem development. (Source from Wikipedia: A centre of excellence (COE) is a shared facility that provides leadership, best practices, research, support and/or training for a focus area.)

- TF supports local and foreign technology companies to:
- Acquire new knowledge and/or
- Develop local talents in the identified technology area/s and/or
- Research and develop new, innovative and market-driven product/service for regional/global customers and/or
- Innovate on existing product/service transformatively for regional/global customers and/or
- Development of new technologies or innovation on existing technologies that will disrupt the market by the introduction of innovative, market-driven product/service and/or
- Establish Centre/s of Excellence to conduct R&D activities leading to development and commercialization of innovative product/service and/or
- Develop the Malaysian ecosystem by conducting ecosystem development initiatives.

Innovation initiatives in Malaysia

Malaysia Innovation Foundation
https://www.yim.my/

The Malaysia Innovation Foundation (YIM) has zeroed in on grassroots innovations—using novel or new ideas that are usually developed in unconventional settings to deal with issues that are often neglected in the context of mainstream solutions. These often adopt a "bottom-up" approach for community empowerment through affordable access, enhanced quality and functionality, access for excluded population.

YIM is implementing initiatives in line with the Government's policy to ensure that the country has high knowledgeable, diverse, creative and innovative human capital to meet the needs of the country by 2050, especially to achieve the Common Prosperity Vision, as well as facing the IR 4.0 boom.

Mainstreaming Grassroots Innovation (MaGRIs)

The MaGRIs program aims to enhance the development and commercialization efforts of grassroots innovation including the provision of capacity building opportunities to local grassroots innovators. The program adds value to innovation products from prototype development to pre-commercialization.

- 1,458 innovations found
- 24 innovations approved
- 15 innovations commercialized
- 12 innovations filed

High Impact Programme 6 (HIP 6)—Inclusive Innovation Inklusif

The HIP 6 program involves financing for entrepreneurs and aims to nurture, identify, adopt, add value as well as develop inclusive innovation products that can benefit the local community especially for the low-income community.

- 2,328 innovations found
- 106 innovations approved
- 756 shortlisted innovations
- 92 innovations filed
- 58 innovations were commercialized with total sales RM14.06 million

The focus areas for this programme are as follows:

- Health
- Education
- Food
- Technology
- Utility Development
- Increased Productivity

Malaysia Social Innovation (MySI)

Enhance the well-being of the community with priority for the B40 through the implementation of innovative locally R&D technology application projects that has been developed and ready to implement.

- Economics
- Green technology
- Eco-friendly
- Health
- Security

Social Impact Matching (SIM) Grant

The Social Impact Matching Grant is an initiative of the Social Enterprise Surge Matching Grant (SE) announced by the YAB Prime Minister in June 2020, as part of the COVID-19 Pandemic Short Term National Economic Generation Plan (GENERATOR).

SIM grants aim to support SE and other social impact businesses in Malaysia to sustain their initiatives/programs, leverage on their ability to raise funds, raise public awareness on social innovation, and improve innovation solutions for social outcomes and/or good environments.

Grassroots Enrichment Program

The Grassroots Enrichment Program is implemented to strengthen and enhance entrepreneurial skills among YIM grassroots innovators. GEP focuses on product development and improvement, enhancing the set of innovator capabilities, and sharing innovation with the community.

Global Design Database

The Global Design Database enables free, simultaneous searches of more than 13,470,000 industrial designs registered under the WIPO-administered Hague System and/or in participating national collections.

For more information, access,

https://www.wipo.int/reference/en/designdb/

Selected provisions of The Philippine Innovation Act

National Economic and Development Authority, Philippines

https://www.neda.gov.ph/

Republic Act (RA) No. 11293 otherwise known as the "Philippine Innovation Act" was signed by President Rodrigo R. Duterte on April 17, 2019. The law mandates the creation of the National Innovation Council (NIC) that will steer the whole-of-government coordination and collaboration and to remove the fragmentation in the country's innovation governance.

The NIC is also tasked to set the direction of the country's innovation goals, priorities, and long-term national strategies through the formulation of the National Innovation Agenda and Strategy Document (NIASD).

Pursuant to Section 28 of the Act, the National Economic and Development Authority (NEDA), in coordination with the Department of Science and Technology (DOST) and the Department of Trade and Industry (DTI), have prepared the Philippine Innovation Act's Implementing Rules and Regulations (IRR).

Rule 11. Inclusive Innovation. The NIC shall develop strategies to promote the participation of different sectors in the creation of new ideas that shall be developed into new and quality products, processes, and services aimed at improving the welfare of low-income and marginalized groups, as defined in Section 3f of these Rules, as well as create livelihood and entrepreneurship opportunities for these sectors.

Rule 12. Micro, Small and Medium Enterprise (MSME) Innovation. The NIC shall develop strategies towards promoting MSME internationalization, digitalization, and participation in the local and global value chains. A comprehensive support program, from incorporation to internationalization, including industry firm-level collaborations, shall be developed by the NIC and implemented by the agencies concerned. These programs shall include coaching and mentoring in the areas of:

(a) design;

(b) technology extension services;

(c) standard business practices in contracting, accounting and project management;

(d) quality control;

(e) standard-setting;

(f) business services such as commercialization market needs assessment, marketing and promotion and management;

(g) patents, and other forms of intellectual property rights; and others.

The Department of Trade and Industry (DTI) shall look for high productivity innovative businesses to help them identify and exploit opportunities in overseas markets. The NIC shall develop metrics for the purposes of assessing the progress of work in these areas.

The NIC shall assign areas of responsibility to implementing agencies according to their mandate to avoid duplication of assistance provided.

For purposes of implementing Section 12 of the Act, these Rules further define the Startup MSME Innovation Development Program.

The MSME Innovation Development Program shall mobilize government agencies to work hand in hand with private organizations and academic institutions to provide technical and/or financial support programs for the development training of entrepreneurs. The Program shall also include the search for high productivity innovative businesses that could help in identifying and exploiting opportunities in overseas markets and provide for appropriate incentives, intellectual property registration, among others, under the Investment Priorities Plan (IPP).

The innovation development program for startups shall be done through the Philippine Startup Development Program as provided under Republic Act No. 11337 or the Innovative Startup Act of the Philippines. The DTI shall lead the development of this comprehensive support program for MSME innovation in coordination with relevant members of the NIC.

The Programs shall also provide for capacity-building for the public sector particularly, those who shall be expected to provide training to startups and MSMEs in order to ensure that the training shall be suitable, updated, and valuable.

The Philippine Statistics Authority (PSA), in coordination with the DTI Bureau of Small and Medium Enterprise Development (DTI-BSMED), shall collect data and ensure the consistency, accessibility and availability of adequate and timely statistics on MSMEs, including startups, by asset size as defined under Republic Act No. 9501 or the Magna Carta for Micro, Small and Medium Enterprises, including other indicators such as but not limited to employment size. Other pertinent information shall also be made available to characterize and track the progress of MSMEs over time. These statistics and information shall be used for development planning and investment programming purposes.

Implementing agencies of programs, projects and activities shall annually report to the NIC the implementation status and challenges, as well as accomplishments vis-à-vis targets approved by the NIC.

Rule 13. Innovation Centers and Business Incubators. The

government, through the NIC, shall encourage and support the establishment of innovation centers and business incubators, in partnership with the private sector, the academe, and research and development institutions towards fostering skills and technology transfer, collaboration on innovation initiatives between small and big businesses, supplier development, access to finance, and creating marketing opportunities.

As used in these Rules, the DTI and the DOST shall collaborate in ensuring complementation of and coherence in programs that provide innovation-related services to MSMEs and innovators. These programs shall build links between tertiary institutions, research institutions, and industry towards creating avenues for knowledge diffusion, capacity building, and commercialization of R&D outputs. Government-Academe-Business research collaborations shall be pursued to foster future innovations.

The NIC may enjoin the participation of other government agencies and institutions such as the Department of Information and Communications Technology (DICT), the Intellectual Property Office of the Philippines (IPOPHL), and Higher Education Institutions (HEIs). The NIC may tap these agencies to provide technical assistance to the DTI and DOST in developing a framework for the implementation, monitoring and evaluation of programs that aim to build links between tertiary institutions, research institutions, and industry towards creating avenues for knowledge diffusion and capacity building.

Rule 14. Regional Innovation and Cluster Policy. The NIC shall integrate in the NIASD strategies to promote regional innovation that shall harness the competitive advantages, as well as existing and potential strengths of regions and provinces. Such strategies shall promote regional development through sound science, technology and innovation programs.

For this purpose, the RDCs shall help coordinate and monitor the implementation of the NIASDs in their respective regions.

The NIC shall adopt cluster policies or strategies as significant components of the country's innovation policy mix. In determining the feasibility and effectiveness of cluster policies in pursuit of innovation goals, other policy streams, such as regional economic development policy, industrial/enterprise policy, higher education policy, among others, shall be considered.

The cluster policies shall be adopted to focus on regional hubs or provinces or sectors such as MSMEs, large firms, spinoffs and startups, academic or educational institutions and research centers, or combinations of these. For this purpose, the NIC shall establish a Cluster Development Program. Funding for this purpose shall be incorporated in the annual General Appropriations Act.

Rule 15. Strategic Research, Development and Extension (RD&E) Programs. The NIC, in consultation with relevant stakeholders, guided by the country's innovation agenda and development goals, shall develop RD&E themes. These themes shall be adopted in the RD&E programs of concerned agencies which will ensure that a higher level of mission orientation in publicly funded research is observed. These themes shall be reviewed periodically as determined by the NIC aligned with priorities identified in the National Innovation Agenda and Strategy Document (NIASD).

For this purpose, the NIC shall:

(a) develop a "relevance criteria" that shall be administered by the agencies concerned in the selection of RD&E programs or projects (e.g. government R&D grants and R&D initiatives to be undertaken by the government, and research papers/ publications, among others) for funding;

(b) conduct periodic review of RD&E themes and the "relevance criteria";

(c) prepare, maintain and update regularly an inventory of academic or educational and RD&E institutions, together with their resources and capacities to undertake these programs and projects which shall provide the strategic intelligence for the generation of public funding and grants for these purposes; and

(d) monitor the implementation of the projects and ensure that they comply with the criteria established for the purpose and meet the objectives for which they were funded. A system for "peer review" may be established for this purpose.

As part of strategies to address the multi-dimensional nature of certain research requirements, the NIC shall:

(a) Establish new and/or strengthen existing centers of research excellence and/or adopt best practices, to bring together multi-sector/stakeholder teams to address multi-disciplinary research agenda;

(b) Establish centers of collaborative research activity between academic and business; and

(c) Mandate pertinent agencies to work with academic or educational and research institutions to provide research infrastructure to support key research areas.

The NIC shall recommend to the Congress of the Philippines the annual proposed level of Gross Expenditure on Research and Development (GERD) based on the NIASD. This recommendation shall be submitted at the beginning of each annual budget cycle.

Rule 16. Innovation Instruments. The government shall employ a range of instruments to achieve the objectives of the Act. These instruments, shall include, but are not limited to:

(a) Technology programs;

(b) Innovation centers;

(c) Innovation networks;

(d) Technology platforms;

(e) Science and Technology Parks (STPs);

(f) Cluster policies, including policy dialogues;

(g) Human capacity building programs; and

(h) Use of patent information, including patent landscape reports.

(Source: https://www.neda.gov.ph/the-philippine-innovation-act/)

Renewable energy parks in Sri Lanka

Sri Lanka Sustainable Energy Authority
http://www.energy.gov.lk

A renewable energy park, or "energy park" is an evolving concept, and the definition still varies; but for the most part, it is an area used and planned for the purpose of clean energy development, like wind and solar generation. This renewable infrastructure can serve as smart and sustainable assets for areas with surplus industrial property. Renewable energy parks not only provide a source of reliable, locally produced clean energy, but they have also contributed to eco-tourism and served as an educational resource to local schools, universities, and business groups.

In the past, energy sites have been one-dimensional with a coal or gas plant producing electricity, for example; whereas, energy parks today can incorporate an assortment of technologies and purposes. For instance, generation can come from solar, wind, biomass, geothermal, nuclear, clean fossil, or hydrogen generation.

Energy Park is a concept initially proposed as an alternative strategy to accelerate wind and solar power development in Sri Lanka. Energy Parks function in the form of a public–private partnership. The main purpose of energy parks is to attract investments for renewable energy development at the optimum economic efficiency.

At present, the involvement of the private sector in wind and solar development is in relative slow progression. The main challenge faced by renewable energy developers is that the project capital costs are comparatively higher in terms of specific costs (USD/kW). This disparity is largely due to the:

- Economy-of-scale effect—10 MW projects compared to the current global trend of project capacities of 50–100 MW
- Lack of scale for competitive bidding—leading equipment suppliers are reluctant to bid for small-scale projects
- Poor engineering infrastructure involving lift and shift equipment for MW-class projects, especially for wind turbines. This situation compels to call for the hiring of such equipment from overseas at considerable additional costs.
- The need to absorb the cost of dedicated power transmission line.

The main elements of the energy park strategy consist of measures that could, directly or indirectly, contribute to reducing the cost of electricity and enabling renewable energy resources emerge as a financially viable source of energy.

- One measure is to increase the scale of wind and solar power projects from the currently allowable 10 MW capacity per project to a 75–100 MW project. A project of this scale is most likely to result in the reduction in the capital cost due to the following reasons:
  - Economy-of-scale effect
  - Increased competition among equipment suppliers
  - Proportionately lower balance-of-plant costs

The reduction of operation and maintenance costs due to the low level of specific manpower and spare parts stocks that has to be maintained.

- Large wind projects are often beyond the investment capacity of most local companies and local financial institutes. It is therefore proposed that a Special Purpose Vehicle (SPV) or a joint venture initiative be set up with several local private companies, with us and the CEB as equity partners, centered around an Energy Park located in a particular geographical area, deemed suitable for wind power generation.
- Several countries in Europe, e.g. Denmark, Germany, Norway, offer low-interest or low-interest credit facilities (called Mixed Credit) for projects in developing countries, which are important to the recipient country, but are financially unviable under normal commercial terms. These are however tied-aid programs in which goods and services must be financed from the donor country.
- The Government partner of the SPV would act as the Project Team Leader, undertaking the following main activities:
  - Collection of reference data and site-specific data for the particular energy resource
  - Seek soft financing including a long-term renewable energy bond, issued to local investors
  - Land survey, acquisition, and related vesting tasks
  - Local infrastructure development including rail/road building
  - Extension/strengthening of HV transmission
  - Addition/augmentation of Grid Sub Station Capacity
  - Approvals from state agencies and environmental clearance

Advantages of energy parks

A renewable energy park, or "energy park" is an evolving concept, and the definition still varies; but for the most part, it is an area used and planned for the purpose of clean energy development, like wind and solar generation. This renewable infrastructure can

serve as smart and sustainable assets for areas with surplus industrial property. Renewable energy parks not only provide a source of reliable, locally produced clean energy, but they have also contributed to eco-tourism and served as an educational resource to local schools, universities, and business groups.

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Clean Technology Fund

The Clean Technology Fund (CTF), one of two multi-donor trust funds under the Climate Investment Funds (CIF) framework, promotes scaled-up financing for demonstration, deployment and transfer of low-carbon technologies with significant potential for long-term greenhouse gas emissions savings implementation in renewable energy, energy efficiency, and clean transport in emerging market middle-income and developing economies. The CTF is at the forefront of financing promising renewable energy technologies, such as concentrated solar power (CSP). Channelled through the African Development Bank, Asian Development Bank, European Bank for Reconstruction and Development, Inter-American Development Bank, and World Bank Group, the CTF finances 19 country programmes and one regional programme with over 90 individual projects.

For more information, access,
https://climatefundsupdate.org/the-funds/clean-technology-fund/

Green ratings in India

Small Industries Development Bank of India (SIDBI), India
http://smallb.sidbi.in

Green rating is an estimate of an industry's environment friendliness. It assesses the adverse impact on environment caused by an industry's activities and methods adopted by an industry to minimize the damage. This assessment is done by a credible third-party evaluator. The rating is arrived at after considering industry's current processes and technology and their impact on the environment, adoption of clean technology, and various processes adopted for mitigating adverse impact on environment.

Relevance of green rating around the world

Rapid industrialization and the associated global warming have placed a question mark on the sustainability of the planet's delicate ecological balance. The "United Nations Framework Convention on Climate Change (UNFCC)" and more particularly the "Kyoto Protocol" have placed stringent and legally binding Green House Gas (GHG) emission norms on developed/industrialized countries. Countries like the USA and those within the EU have also imposed carbon taxes on fossil fuel-based industries.

The increased awareness about environmental degradation is making environmental regulations more stringent the world over. The MSME sector cannot remain insulated from this trend. Exporting MSMEs may soon see themselves set against trade barriers such as the impending imposition of carbon taxes by European countries. In order to position themselves as responsible corporate citizens and as a preventive measure against probable censure from environmental organizations like Green Peace, MSMEs will feel the need for Green Ratings in near future.

Green rating in India

Green Rating initiatives in India are spread across various sectors ranging from buildings to manufacturing industries.

Green building initiative

In order to create more energy efficient and eco-friendly buildings, the Ministry of New and Renewable Energy in collaboration with The Energy and Resource Institute (TERI) initiated Green Rating for Integrated Habitat Assessment (GRIHA), the National Rating System for Green Buildings in India. GRIHA rating system consists of 34 criteria categorized under various sections such as site selection and site planning, conservation and efficient utilization of resources, building operation and maintenance, and Innovation points. For further details, visit GRIHA.

Green rating project

It is a nongovernment initiative launched by Centre for Science & Environment (CSE) in 1995 to guide Indian industries to improve their environmental performance. The project mainly relied on voluntary participation of companies and depended up on the company's eagerness to avoid bad publicity as these ratings are released for public. Along with the assignment of Green Rating, the initiative charted out steps need to be taken by each industry to improve their performance. In majority of the cases, the companies have implemented the road map provided by CSE. The industries covered in this project are paper and pulp, cement, automobile, and the chlor alkali sector. For further details, visit Green Rating Programme. A larger proportion of companies rated for green credentials under this programme are large enterprises.

SMERA green ratings

In India Green Rating of enterprises is offered by SME Rating Agency of India Limited (SMERA). Green Rating is a joint initiative of SMERA and SIDBI. The Energy and Resource Institute (TERI) acts as a Knowledge Partner. SIDBI promotes and facilitates the process by offering credit at concessional rate to Green Rated companies. The Government of India (GoI) has urged lending institutions to encourage borrowing MSMEs to go for "Green Rating." SMERA is only agency that exclusively caters to Indian MSMEs' "Green Rating" needs. Read extract on Green Ratings from OPTIMiSM (SIDBI bimonthly magazine).

Benefits of green rating

- **An independent third-party evaluation about environment friendliness:** It indicates that the MSME is conscious about its duty toward environment and society at large
- **Credit at concessional rate:** It will help a MSME to obtain credit at a concessional rate from lenders like SIDBI
- **Mitigation of environmental risk:** It reduces the risk associated with the stringent environmental norms that is becoming stricter
- **Confidence among value chain partners:** The rating assures lenders, buyers, collaborators, JV partners that the MSME is a responsible corporate citizen and does not adversely impact ecology
- **Self-assessment tool:** Green Rating is a self-assessment tool that can be used to identify areas of improvement
- **Creating awareness:** Green Rating awarded by an independent agency improves the visibility of MSME in the eyes of various stakeholders like buyers, suppliers, collaborators/JV partners, etc

L(−) Malic acid production technology

The new technology of the Hungarian leading biotechnology center produces only the biologically active L(−) form. This new biosynthesis process of L(−) malic acid has proved to be more efficient and cost-effective than the presently used ones. Genetically altered micro-organisms and a continuous flow-through conversion assure the efficiency of this method. The method uses genetically enhanced, immobilized, and killed micro-organisms that have highly elevated (one thousand-fold) catalytic potential over the unaltered cells. This modification pushes the chemical equilibrium towards the required 98% conversion; consequently this new method enables an 80% conversion in industrial scale while the existing technologies have maximum 70% conversion capacity. Not only do the cell immobilization techniques increase the original activity potential, but also allow a continuous flow-through conversion. Moreover, the reactor column possesses extremely long half life time (600 days). The bioreactor does not produce any bypass products, e.g., amino acids, or other organic acids from the substrate. The scientific team scaled up the reactor technique to a working volume of 25 liters and optimized the various parameters affecting the production. A reactor with 25 liters/hour capacity can produce approximately 30 tons of L(−) malate per year. The second basic thing in the offered technology is the downstream process. We have tested a pilot, modified electro dialysis equipment (EDU) technique based on bipolar membrane operation. We have combined the bioreactor with EDU process. During the downstream process, we have recovered residual fumarate, and the alkali, and the most part of the solvent (water) too, putting them back to the first step of the technology.

Area of Application

Potential areas of use • Food industry • Chemical industry • Pharmaceutical industry

Advantages

This technology has some significant advantages in comparison with the traditional fermentation and chemical production. Firstly, downstream operations become cheaper by the high conversion rate and lack of bypass products. Secondly, the very intensive technology decreases the investment expenditures. Thirdly, it is an environment-friendly production, which does not have any effect on human health. There are no environmental risks or contraindications to use this technology, because the genetically modified cells are killed before use. No huge amount of wastewater, no bypass salts (NaCl, $CaSO_4$). The bioreactors are working as enzyme reactors during the process.

Environmental Aspects

Cleaner production

Development Status

Laboratory Model

Transfer Terms

Technology licensing, Research partnerships

Target Countries

Worldwide

Wastewater treatment in electroplating

A Hungarian SME offers wastewater treating equipment family for treating and decontaminating wastewater deriving from surface-treating workshops. The wastewater treating equipment removes and eliminates the contaminants from various types of wastewater produced in the surface-treating workshop, in order to keep their concentration under the limits. The wastewater treating equipment is designed according to the quantity and the type of wastewater (e.g., acidic, alkaline, etc.) and with the concentration of contaminant (thin solution or concentrated solution).

Area of Application

Electroplating, Metal Processing: companies providing electroplating services and companies active in metal processing and/or machinery industry having an in-house electroplating workshop.

Advantages

All regulation relating to contaminants can be kept - water demand of the surface-treating workshops can be decreased radically - the quantity of sludge deriving from surface treatment and costs of deposition can be significantly dropped - due to the individual manufacturing, special problems can be solved - the equipment operates automatically and does not need expensive manpower

Environmental Aspects

Wastewater treatment

Development Status

Commercial prototype

Legal Protection

Secret know-how

Transfer Terms

Technology licensing, Others

Procedure for sewage sludge composting

A Hungarian SME has developed a new procedure for sewage sludge composting. The offered technology is based on the application of controlled composting for rapid degradation of organic pollutants and immobilization of inorganic micro-pollutants for safe land disposal by using industrial slurry-phase by-products (e.g., by-products from sunflower seed oil processing industry). The process of controlled composting contributes to preserve the fertilizer value. Before the composting the untreated sewage sludge is mixed with waste sludge (e.g., sludge produced by sunflower seed oil processing industry) and other specific additives to accelerate mineralization and to moderate ammonia and GHG (greenhouse gas) emission. In some cases composting simulation is used for optimalization of raw material composition and gas emission controlling within 3 weeks in an adiabatic drum system. Composting

occurs under controlled condition means that additives, digesters, and labile carbon sources are added continuously to the compost pile. Specific additives are responsible for the suitable and rapid mineralization and thermophilic stage to preserve fertilizer value. Depending on the properties of raw materials encapsulated windrow composting is applied for controlled composting which means a covering of compost pile by using specific polymers. The end-product is a potential source for soil improvement and conditioning after 4-pre- and 6-week-term post-maturation stages. The whole composting process is not longer than 70–90 days.

Area of Application

Waste management, sewage works

Advantages

During the pre-storage of raw sewage sludge, the GHG (greenhouse effect) emission and f. coliform and streptococcus number is reduced significantly within 24–48 hours. - Application and utilization of non-hazardous specific additives and digesters result safe land disposal. - Application of non-hazardous additives, digesters, water treatment residual by-products is suitable for reduction of total N loss, P loss, and suppressing pathogens before and during the composting. - The offered technology is able to utilize solid phase biogas residuals, post-maturation of pre-maturated municipal sewage sludge from closed composting reactor or root-zone treatment.

Environmental Aspects

Bio-degradable and environmentally friendly

Development status

Pilot plant

Legal protection

Patent

Transfer Terms

Technology licensing

For the above three offers, contact

Laser Consult Ltd (Hungary)
H-6701 PO Box 1191
Szeged
Hungary

INDIA

Microfine ginger powder with high drug and spice values

Microfine ginger powder has wide applications in pharmaceutical, brewery, soft drink, meat canning, pickle processing, curry, and confectionery industries. The microfine ginger powder can be directly added in soda water for removal of certain throat irritation and similar affections. The product has high domestic and export potential. From 5 kilogram of peeled ginger, around 700 grams of microfine powder can be produced. The process of production is free from pollution.

Area of Application

Domestic and industrial kitchen, Food processing industries, Brewery and confectionery industries

Advantages

Microfine Free from presence of ash. Produced without generating temperature at the pulverizing point. The product maintains high drug and spice values. The process of production prevents evaporation of oil during pulverization.

Environmental Aspects

Cleaner production

Development Status

Commercial prototype

Transfer Terms

Turnkey

Target Countries

India

Contact

Innova Reserach Centre Pvt Ltd
Ochanthuruth, Kochi, 682508, India

Nanoparticle for drug delivery

The technology suggests a sustained-release nanoparticle composition composed of a copolymer of an N-alkylacrylamide, a vinyl monomer, and a polyethylene glycol conjugate for preventing or treating a disease or a condition. The said nanoparticle composition further contains a therapeutic agent such as an antibiotic, anti-restenotic agent, anti-proliferative agent, anti-neoplastic, chemotherapeutic agent, cardiovascular agent, anti-inflammatory agent, immunosuppressive agent, or anti-tissue damage agent. Such nanoparticle compositions generally have a diameter in the range of 20–100 nm and are used locally for the prevention or treatment of diseases or conditions. The said technology also suggests a method for using a sustained-release nanoparticle composition for preventing or treating a disease or condition. The preclinical studies of this technology have been performed on animal model (rat).

Area of Application

Medical industry

Advantages

The technology can be used for delivery of various pharmaceuticals agents. Provides efficacious treatment. It is an adjunct to the existing approaches. Nanoparticle prolonged the release of drugs and thus make it bio-available for longer duration.

Development Status

Laboratory model

Legal Protection

Patent

Transfer Terms

Technology licensing

Target Countries

India

Composite anti-retroviral drug and its process

The present technology provides a pharmaceutical composition of anti-retroviral drugs having improved dissolution, content uniformity, and bulk properties for use in pharmaceutical field and also a method of preparation of the product. It relates to a process of preparing pharmaceutical composition with improved process and product performance. Tablets and capsules are the most preferred dosage forms by the pharmaceutical scientists and clinicians because of accurate dosing, good patient compliance, manufacturing ease, and low cost of production. Subsequently, in this technology spray drying is used for preparing the pharmaceutical composition.

Area of Application

Medical diagnostics

Advantages

Process description and method of preparation of a pharmaceutical composition with improved process and product performance. A pharmaceutical composition comprising a coprocessed product of nevirapine and stavudine. Single processing step Enhanced dissolution rate of nevirapine. Cost-effective production Improved content uniformity of stavudine. Enhanced oral bioavailability.

Development Status

Laboratory model

Legal Protection

Patent in progress

Transfer Terms

Technology licensing

Target Countries

India

For the above two offers, contact

SkyQuest Technology Consulting Pvt. Ltd.
501, Krishna Complex, Opp. Devashish School, Bodakdev
Ahmedabad
India

Novel transducer matrix and its application in biosensors

The principal objective of the present invention is to provide a process for the synthesis of nanostructured conducting polymer (NSCPs) by using structure directing agents. • In addition, this invention also provides a process to develop a nanostructured conducting polymer with high electrical conductivity. • Another objective of the present invention is to use the synthesized nanostructured conducting polymers as a transduction matrice for the development of biosensor. • Yet another objective of the present invention is to provide a method for the development of optical biosensor by using synthesized nanostructured conducting polymers as a transduction matrice • Last, but not the least, this invention also intends to provide an optical biosensor having possible application in the testing of biological samples. • High Surface Area of nanostructured conducting polymer-enhancing enzyme loading • Bio-compatibility • Dimensional compatibility with biomolecules. • Film forming ability

Area of Application

An optical glucose biosensor has a potential application in the testing of biological samples.

Environmental Aspects

Bio-degradable and environmentally friendly

Development Status

Laboratory model

Legal Protection

Patent

Transfer Terms

Consultancy, Technical services, Technology licensing

Tea catechins as anti-aging compounds

The present invention relates to the preparation of consumable composition for oral administration that contains tea catechins. The composition prepared by the process of this invention is useful in providing controlled release of catechins contained therein. In a preferred embodiment of the present invention, consumable composition containing tea catechins dispersed therein is provided.

Area of Application

Application includes anti-aging agents

Environmental Aspects

Bio-degradable and environmentally friendly

Development Status

Laboratory model

Legal Protection

Patent

Transfer Terms

Consultancy, Technical services, Technology licensing

Bacterial lipase and its application in food industry

We could offer a technology to synthesize bacterial lipase that has potential applications in the food industry. The present invention provides an extra cellular bacterial lipase from *Pseudomonas mendocina* M-37 (MTCC 7054) with high stability and substrate specificity. The bacteria were iso-

lated from oil industry effluent showing high activity on olive oil. The substrate specificity of *Pseudomonas mendocina* M-37 lipase shows that the lipase was especially more active towards the synthetic triglycerides and fatty acids esters that possesses butyryl group like benzyl butyrate (1,120% relative activity), tributyrin (744%), and amyl butyrate (550%), respectively. The stability of lipase in organic solvents offers advantages for ester synthesis. Exposure of M-37 lipaoctanol (215%).

Area of Application

The bacterial lipase showing high activity in organic solvents and substrate specificity for butyrated esters has possible significant applications in food industry for ester synthesis. The esterification reactions in food industry are carried out in organic solvents and uses butyrated substrates. *Pseudomonas mendocina* lipase has possible applications in synthesis of flavor and fragrance esters; for organic synthesis and modification of fats and oils

Advantages

Pseudomonas mendocina lipase possessing high stability in organic solvents, high substrate specificity mainly for butyrated esters has possible significant applications in food industry for ester synthesis.

Environmental Aspects

Bio-degradable and environmentally friendly

Development Status

Laboratory model

Legal Protection

Patent

Transfer Terms

Consultancy, Technical services, Technology licensing

For the above three offers, contact

Amity University Uttar Pradesh, Sector-125, Noida
Distt Gautam Buddha Nagar 201303
India

Chitin and chitosan

Chitin and chitosan are important by-products from the shell of shellfishes. Chitin is the most important organic constituent of the exoskeletal material of invertebrates and the important economical source of this material is the shrimp processing industry. Chitin and its derivatives, chitosan, find various industrial applications like biotechnology, food processing, pharmacy, and medicine.

Area of Application

Various industrial applications like biotechnology, food processing, pharmacy, and medicine.

Advantages

Chitin and its derivatives, particularly chitosan, find industrial application in various fields namely flocculation, paper making, textile printing and sizing, ion exchange chromatography, removal of metal ions from industrial effluents, manufacture of pharmaceuticals and cosmetics, and as an additive in food industry.

Environmental Aspects

Waste utilization

Development Status

Pilot plant, Fully commercialized

Transfer Terms

Consultancy, Technology licensing

Contact

Central Institute of Fisheries Technology, CIFT Junction,
Matsyapuri, Willingdon Island,
Cochin 682029
India

Prevention of gasoline evaporation & fire risk at gas station

The gas leaking in manhole tank while it is loaded could be solved with good quality instruments. The leaking occurred when the gas is loaded and unloaded from the manhole tank. This would cause loss for the company. The instruments which have been setting at gas station are able to prevent gasoline evaporation, water, and fire inside the tank. Besides that, it is also prevent dropped gas around the tank. The technology used has copyright and also proved in some laboratory test, so that the quality of the product is better than any other products. Therefore, with refining in product, facility, management, and also marketing, it would develop the company. Another benefit which can be got is healthier environment, time and power saving because of the strainer in pomp is not cleaned too often. Besides that, the gas loaded pump will work lighter. That could prevent loss caused by gas evaporation.

Area of Application

Industry

Environmental Aspects

Cleaner production, Energy efficiency

Development Status

Laboratory model

Legal Protection

Patent

Transfer Terms

Joint venture

Contact

Indonesian Network for Technology-Industry Matching (INTIM),
Gedung BPPT 1, Lt. 21 Jl. MH. Thamrin no. 8
Jakarta 10340
Indonesia

SRI LANKA

Sawdust operated baking oven

The National Engineering Research and Development Centre (NERDC) of Sri Lanka has developed the baking oven which can be fueled on sawdust as the energy source. Presently the operational cost of the baking oven operated by the L.P. Gas as energy source is very expensive as the L.P. Gas in the world market is very expensive. Presently the sawdust is the waste of agricultural sector as well as the industrial sector. By using the sawdust as energy the environmental pollution can be minimized. Technology transfer can be the offering of full package and the technical consultant services.

Area of Application

Food industry, energy, baking industry

Advantages

1. Reduce the usage of firewood as well as L.P. Gas
2. Reducing the area required for baking process
3. low cost
4. hygienically good food can be obtained as there is no flue gas contamination

Environmental Aspects

Waste utilization, Energy efficiency

Development Status

Fully Commercialized

Legal Protection

Patent

Technical Specifications

SIZE- 4′ × 4′ × 4′ for 64 loaves of bread per batch - 2′ × 2′ × 2′ for 16 loaves of bread per batch TEMP- 300 c chimney-4′ energy as sawdust

Transfer Terms

Consultancy, Technology licensing, Equipment supply, Turnkey

Contact

National Engineering Research and Development Centre of Sri Lanka
2P/17B, IDB Industrial Estate, Ekala,
Ja-Ela, Sri Lanka

Solar chimney for electricity generation

Thai university offers solar chimney technology for electricity generation. By this technology, solar energy is converted into wind energy that is used by a turbine generating electric power.

Area of Application

Large-scale electricity generation

Advantages

Cheap and clean renewable energy generation technique

Environmental Aspects

Energy efficiency

Development Status

Pilot plant

Transfer Terms

Consultancy, Others

Contact

Mr. Tawit Chitsomboon, Suranaree University of Technology
Muang District, Nakornratchasim 30000
Thailand
Tel: (6244) 22 4264, Fax: (6244) 22 4224

THAILAND

Wind turbine

Innovative designed small wind turbine combined with aerodynamic design able to operate from low wind speed and able to withstand stormy wind with self-regulated design as functions of the main blade. The rots and moving parts are constructed with light-weight aluminum. The unique vertical-axis design ensures a robust performance in the urban environment, where wind speed is lower and wind directions change frequently. Natural Energy wind turbines operate in low wind speed (3 m/s), quiet operation, unlimited high wind performance. It is the development for area with low and medium wind speed. We deliver three main models: 500 W, 1,000 W, and 2,000 W. Moreover, we also offer VT2000 which is used for water mechanical pumping.

Area of Application

Natural Energy Industry

Advantages

Aero dynamic design -Light aluminum material; Low wind performance; self-start; Unlimited high wind performance (storm); self-regulated; Quiet operation; Simple structure-minimized moving parts

Environmental Aspects

Cleaner production, Waste utilization, Energy efficiency, Systems integration

Development Status

Fully commercialized

Legal Protection

Trade Mark, Patent, Copyright

Transfer Terms

Equipment Supply, Others

Target Countries

Thailand

Contact

Ntural Energy Co., Ltd
17th Floor, S.P. Building 388 Phaholyothin Road Phayathai
Bangkok 10400, Thailand

Selected Analytical Reports and Technology Platforms & Databases of APCTT

Analytical Reports (available online)

1. National Assessment Framework on Enabling Environment, Technology Innovation Ecosystem for Making Sustainable Energy Options Affordable and Accessible (For Indonesia and Lao People's Democratic Republic), January 2014

   http://apctt.org/nis/sites/all/themes/nis/pdf/National-assessment-framework_-final_ESCAP.pdf

2. Report on the National Assessment Framework of Enabling Environment and Technology Innovation Eco-system for Making Sustainable Energy Options Affordable and Accessible – Indonesia, May 2014

   http://apctt.org/nis/sites/all/themes/nis/pdf/Indonesia_Report-on-National-Assessment-of-Sustainable-Energy_optimized.pdf

3. Indonesia National Sustainable Energy Strategy Report on Enabling Environment and Technology Innovation Ecosystem for Affordable Sustainable Energy Options, May 2014

   http://apctt.org/nis/sites/all/themes/nis/pdf/Indonesia-National-Strategy-Report_final.pdf

4. Report on the National Assessment Framework of Enabling Environment and Technology Innovation Ecosystem for Making Sustainable Energy Options Affordable and Accessible - LAO PDR, May 2014

   http://apctt.org/nis/sites/all/themes/nis/pdf/Lao_Report-on-National-Assessment-of-Sustainable-Energy.pdf

5. Lao People's Democratic Republic National Sustainable Energy Strategy Report on Enabling Environment and Technology Innovation Ecosystem for Affordable Sustainable Energy Options, May 2014

   http://apctt.org/nis/sites/all/themes/nis/pdf/Lao-National-Strategy-Report_final.pdf

6. National Innovation System (NIS) training manual - "NIS Diagnosis and STI Strategy Development to Achieve National Sustainable Development Goals", 2016

   http://apctt.org/nis/sites/all/themes/nis/pdf/NIS%20Training%20Manual.pdf

Technology Platforms and Databases

1. APCTT's Technology4SME Database

   The Technology4SME Database serves as an online platform for information exchange on the availability and sourcing of technologies for small and medium enterprises in countries in the Asia Pacific region.

   http://apctt.org/technology-transfer

2. Renewable Energy Technology Bank

   The primary objective of the Renewable Energy Cooperation-Network for the Asia Pacific (RECAP) established by APCTT is to facilitate technology transfer cooperation among countries in the Asia-Pacific region in the area of renewable energy. RET-Bank provides tested and proven renewable energy technologies (RETs) initially in the areas of solar, biomass, wind, mini-hydro power and geo-thermal energy.

   http://apctt.org/recap/renewable-energy-technology-bank

3. Global Technology Databases

   APCTT has compiled a list of global as well as country-wise technology databases that deal with the technology transfer related services for SMEs and entrepreneurs.

   http://apctt.org/aptitude/