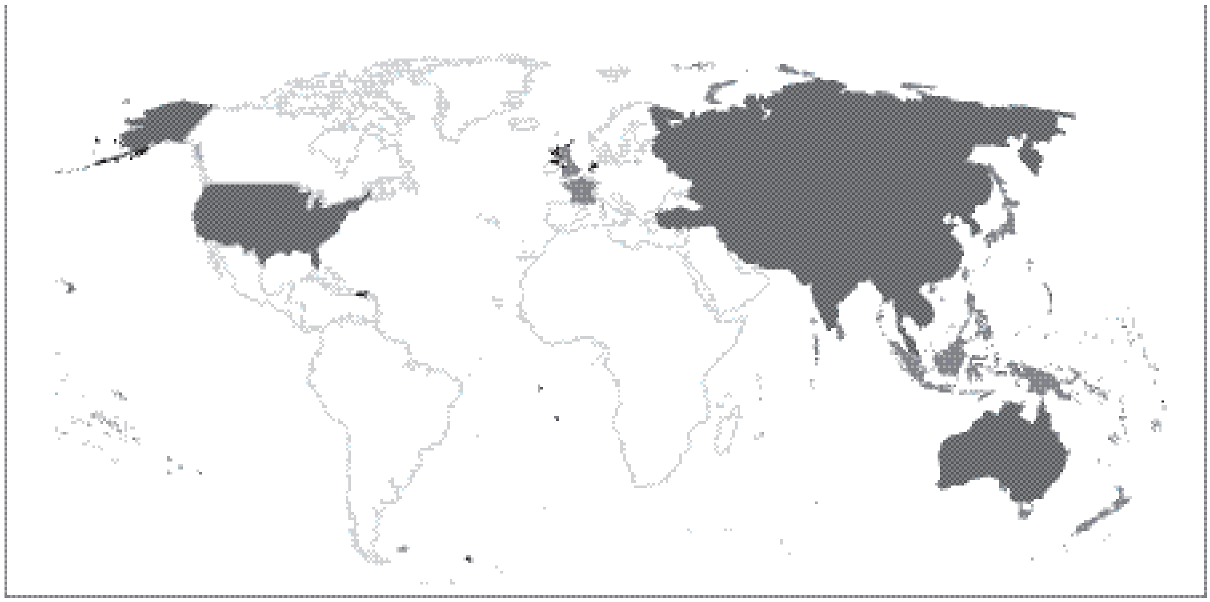
Strengthening innovation-driven inclusive and sustainable development

Asia-Pacific Tech Monitor

Vol. 39 No. 1 Jan - Mar 2022

Technology transfer for sustainable development in the Asia-Pacific

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



*The shaded areas of the map indicate ESCAP members and associate members.**

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.

**The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries*

Asia-Pacific
Tech Monitor
Vol. 39 No. 1 ❖ Jan - Mar 2022

The **Asia-Pacific Tech Monitor** is a quarterly periodical of the Asian and Pacific Centre for Transfer of Technology (APCTT) that brings you up-to-date information on trends in technology transfer and development, technology policies, and latest technology innovations.

Web: https://apctt.org/techmonitor

ASIAN AND PACIFIC CENTRE FOR TRANSFER OF TECHNOLOGY
C-2, Qutab Institutional Area
Post Box No. 4575
New Delhi 110 016, India
Tel: +91-11-3097 3700
Fax: +91-11-2685 6274
E-mail: postmaster.apctt@un.org
Website: http://www.apctt.org

ISSN: 0256-9957

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

CONTENTS

Introductory Note 2

Technology Market Scan 3

Technology Scan: Technologies for renewable energy and low carbon development 12

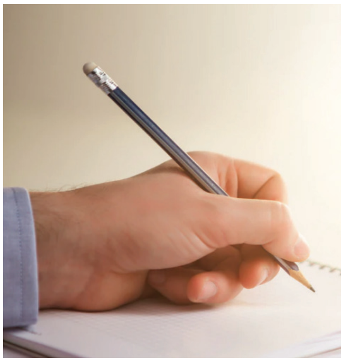
Special Theme: Technology transfer for sustainable development in the Asia-Pacific

- **Transfer of technology, MSMEs and sustainable development - The Indonesian story** 21
  Tulus T.H. Tambunan
- **Role of co-innovation in accelerating towards climate neutrality** 30
  Dr. Nandakumar Janardhanan, Dr. Eri Ikeda, Sruthi Kalyani, Temuulen Murun, Dr. Kentaro Tamura

Technology Networks, Resources and Offers 40

- **National Technology Networks and Resources** 40
- **Technology Offers and Opportunities** 40

Tech Events 45



Introductory note

Technology is considered vital for achieving the Sustainable Development Goals (SDGs). The COVID-19 pandemic has underscored the critical need of innovative technologies to address the challenges across sectors. Emerging technologies, particularly the fourth industrial revolution technologies (e.g., Artificial Intelligence, Internet of Things, Blockchain among others) offer innovative solutions in critical areas such as climate change, food and energy security, and resilient recovery of the industry.

Enabling policy environment is a prerequisite to facilitate transfer, adoption and diffusion of technologies and leapfrog especially in key emerging technology areas. The success at national (and subnational levels) depends on the capabilities to strengthen laws and regulations, R&D and innovation, institutional support systems, human resources, finance and entrepreneurship development. The national technology policy frameworks also have to be aligned with related policies on trade, industry, investment and intellectual property rights. Key strategies for accelerating technology transfer include enhanced funding for R&D, incentives for development and adoption of innovative technologies, creating technology parks and supporting incubators among others.

The micro, small and medium enterprises (MSMEs) play an important role in creating jobs and business opportunities. Through adequate government support, the MSMEs can be the key actors in facilitating technology transfer through investment promotion and subcontracting arrangements to accelerate industrial production at the local level. Co-innovation (jointly innovate, manufacture and scale-up technologies) is considered as a useful mechanism for technology transfer to meet the demand for cleaner technologies for addressing climate change. Collaborative platforms to facilitate technology cooperation among member States can be critical to enhance technology transfer and commercialization.

This issue of *Asia-Pacific Tech Monitor* discusses enabling strategies and good practices to promote technology transfer for sustainable development in the Asia-Pacific countries. We hope you will find this edition interesting and useful.

Preeti Soni
Head, APCTT-ESCAP

ASIA-PACIFIC

BANGLADESH

New patents bill passed

The parliament has enacted the Bangladesh Patents Bill 2022, aiming to make a century-old patents law more time-befitting and safeguard intellectual property rights. The law, among others, extends the validity period of patents from 16 years to 20 years. The pre-existing patent and design law was enacted in 1911. In 2016, the law was divided into two parts, a patent law and a design law.

The bill states that any technological product would be patentable if it has something new in it. However, inventions, scientific theories and mathematical methods, business methods, rules or methods of performing purely mental work or sports and any such computer programme would not be patent protected.

In addition to the need to prevent the commercial use of patents within the borders of Bangladesh to protect the public order and ethics, a number of other issues have been left out of the patent protection, including innovation. A registrar office will be there to issue or cancel patents of any single inventor or joint inventors of a technical innovation under the proposed law.

https://www.thedailystar.net

CHINA

Increase in invention patent volume

China has authorized more than 2.53 million invention patents over the past five years, with an average annual growth rate of 13.4 per cent according to the country's top intellectual property regulator. More than 27.7 million trademarks were registered in the same period, an average annual increase of 29 per cent, Shen Changyu, the head of the China National Intellectual Property Administration said at a press conference.

In 2021, the country authorized 696,000 invention patents, with an average ownership of high-value invention patents reaching 7.5 per 10,000 people, nearly twice compared with the end of 2017, Shen said. He added that China also witnessed significant improvements in the efficiency of the use of intellectual property rights (IPR). The added value of patent-intensive industries reached 12.13 trillion yuan (about 1.88 trillion US dollars), up 5.8 per cent year on year, accounting for 11.97 per cent of the country's GDP.

According to China's 15-year plan (2021-2035) for IPR development, a clear target has been set: the added value of patent-intensive industries should account for 13 per cent of the GDP by 2025.

China has been committed to promoting the orderly development of international intellectual property rights (IPR) cooperation and competition. In 2021, Chinese companies filed 8,596 patent applications in countries along the Belt and Road, a year-on-year increase of 29.4 per cent, while these countries in turn applied for 25,000 invention patents in China, Shen said.

https://www.shine.cn

Spending on research and development

China's spending on research and development (R&D) hit a new high of 2.44 per cent of its gross domestic product (GDP) in 2021, an increase of 0.03 per cent from the previous year, official data showed. The country's total expenditure on R&D amounted to about 2.79 trillion yuan (about 441.13 billion US dollars) last year, an increase of 14.2 per cent year-on-year, according to a report released by the National Bureau of Statistics (NBS). After deducting the price factors, the R&D spending of China in 2021 rose to 9.4 per cent year-on-year, said the NBS. The investment in the basic research stood at 169.6 billion yuan last year, accounting for 6.09 per cent of the total R&D spending, an increase of 0.08 per cent from the previous year, the data showed.

The growth of China's R&D spending is attributable to the steady recovery of the Chinese economy last year, the enhanced innovation drivers and also the improved incentive policies, said NBS statistician Zhang Qilong. The Global Innovation Index 2021 released by the World Intellectual Property Organization showed that China has made continuous progress rising from the 14th rank in 2020 to the 12th rank in 2021 among 132 economies. China should further accelerate the implementation of science and technology policies and improve the mechanism for diversified investment to provide strong support for achieving high-level self-reliance in science and technology, Zhang said.

http://www.china.org.cn

Basic research spending

China's basic research spending hit 169.6 billion yuan (about 26.84 billion US dollars) in 2021, accounting for 6.09 per cent of the country's entire research and development expenditure, data from the Ministry of Science and Technology showed, as the country inches closer to achieving its goal of increasing the ratio to over 8 per cent by 2025 as a part of a broader push to accelerate its technological rise.

A policy framework spanning the whole process of scientific research has been established with a two-pronged development path to basic research exploration that is both free exploration-motivated and target-oriented, He Defang, the deputy secretary-general of the ministry said at a press conference in Beijing while disclosing the reading for basic research outlays. With scientific questions refined based on the country's major demand, and strengthened reforms of the national natural science foundation, the policy framework supports basic research, application research and the conversion of research results, he stated.

The country's basic research spending rose by 15.6 per cent to 169.6 billion yuan, or 6.09 per cent of its total R&D commitments, an increase of 0.08 per cent from the year before, according to the official data. The basic research outlays as a percentage of total R&D spending exceeded 6 per cent for the first time in 2020, after hovering around 5 per cent for multiple years.

Moreover, the country's whole-of-society R&D spending grew by 14.2 per cent year-on-year to 2.79 trillion yuan in 2021 over the past year, with the R&D intensity hitting 2.44 per cent, the Minister of Science and Technology, Wang Zhigang told the same media briefing, adding that the national innovation capacity ranking rose to No.12 globally, enabling a stellar start to the 14th Five-Year Plan (2021-25).

China has set a target of having its basic research spending account for over 8 per cent of the total R&D expenses by the end of the 14th Five-Year Plan.

The national high-tech zones, where a raft of world-class industrial clusters have been nurtured are home to roughly one-third of the country's high-tech firms, according to the Vice Minister of Science and Technology, Shao Xinyu, noting that these zones have shown strong risk resistance capacity. In 2021, 169 national high-tech zones posted over 48 trillion yuan in full-year operating income, an increase of about 12 per cent from the prior year, and their profits combined jumped roughly from 17 per cent to 4.2 trillion yuan, Shao said, citing preliminary figures.

The national high-tech zones, covering 0.1 per cent of the country's land area, generate about 13 per cent of the GDP, he revealed.

In a sign of the business community's investment in research, Shao disclosed businesses expand outside their home turf at a faster pace, having set up 2,000-plus research institutions overseas. In addition, over 200 sci-tech achievements were used to support the Beijing Winter Olympics in 2022, Wang said.

https://www.globaltimes.cn

Tax support for research and development investments

China further increased its tax support for R&D investments in 2022, expanding super deduction on the R&D expenditure to technology-based small and medium-sized enterprises (TSMEs) in an effort to encourage innovation, promote industrial upgrade, and strengthen the core competitiveness of the country.

As China endeavors to shift from being a low-end mass manufacturer to a high-end producer, the government has doubled down on encouraging targeted investments in research and development (R&D) and technological innovation. The ongoing technology confrontation with the US is another factor at play, impacting a wide range of segments from access to chips and other key input technologies and products. This has resulted in China labeling its technology sector as a strategic one and for which government support has increased.

In 2022, China further increased its tax support for R&D investments. According to the 2022 Government Work Report released on March 5 during the 2022 Two Sessions, it was declared that technology-based small and medium-sized enterprises (TSMEs) will be able to enjoy the super deduction policy on R&D expenditure, according to which 100 per cent of the R&D expenses will be additionally deducted from the taxable income amount, on the basis of actual deduction.

Previously, this policy was only applicable to manufacturing enterprises (except tobacco manufacturing). For other enterprises, including technology-based small and medium-sized enterprises (TSMEs) that are not in the manufacturing sector, only 75 per cent of the R&D expenses will be additionally deducted from the taxable income amount, on the basis of the actual deduction.

On 1 April 2022, the Ministry of Finance together with the State Taxation Administration and the Ministry of Science and Technology released an announcement that provides more details on the implementation of this policy.

https://www.china-briefing.com

FIJI

Blue Bond for funding ocean-centric projects

Fiji will launch its first Blue Bond to fund ocean-centric projects later this year. Speaking at the 7th Our Ocean conference, the Attorney-General, Aiyaz Sayed-Khaiyum, said that the issuance would focus on raising capital market finance.

This will support projects in:

- blue shipping to reduce emissions, sustainable fisheries to expand aquaculture and protect natural fish stocks;
- a blue investment fund to provide affordable blue debt to non-government organizations in the ocean space; and
- sustainable waste management to build a second sanitary landfill and recycling facility in Fiji's Western Division.

"These are small steps on the journey to the blue economy we're building by 2030," he said. "Much of this work will require partnerships, including in the Pacific to decarbonize our regional shipping sector. To deliver on these commitments, and open possibilities for ocean-generated energy in the future, we need significant and urgent expansions in the blue concessionary finance."

https://www.fijitimes.com

INDIA

Registration of more Indian patents than foreign

India has taken a step closer to the ambitious goal of being in the top 25 nations of Global Innovation Index, with another milestone of the number of domestic patent filing surpassing the number of international patents filed at the Indian patent office in the January-March quarter of the financial year 2022 for the first time in the last 11 years.

Of the total 19,796 patent applications filed in this period, 10,706 were filed by Indian applicants against 9,090 by non-Indian applicants, latest data from the Ministry of Commerce and Industry shows. Driven by a slew of efforts by the government to strengthen the Intellectual Property Rights (IPR) regime, foster innovation, and reduce compliance burden, the filing of patents increased by more than 50 per cent in the last seven years.

https://swarajyamag.com

One-stop space technology destination

The Telangana government will be launching a State-specific space tech framework, with the aim of establishing the State as a globally recognized one-stop destination for space technology. This event would be India's first-ever official event hosted on the Metaverse.

Telangana is already a leader in space technology with the presence of global companies, both mid-sized and startups, in the sector. This is evident from the fact that the State produced 30 per cent of parts used in the Mars Orbiter mission. Telangana also leads with the many micro small and medium enterprises (MSME)units of defence and has been a base for several defence institutes.

Space technology in particular has seen countries racing to establish their superiority. In this regard, the Telengana government will initiate a space technology research programme in partnership with the industry, academia, and other government agencies to catalyze innovations. This framework aims to encourage private partnerships in the space industry.

The government will also facilitate grants, suitable incentives, and infrastructure support to promote research and development to boost space technology innovation. The downstream space technology applications have the potential to directly impact citizens' lives and so the government would support pilots and proof-of-concept with the various government departments. The departments shall assist with on-ground implementation, provide mentorship, closely monitor the deployment to leverage the developed solution across the state and across these projects, and will leverage the application at the State level.

According to the draft policy, the state will offer space-tech fellowships to students from India and abroad, to work on high-end use cases in partnership with the government departments, and national and international research academic institutions. The fellowships shall focus on both the technical as well as business aspects in order to ignite the spirit of entrepreneurship.

The state would set up space technology innovation cohorts in partnership with industry and in-focus areas of the state viz. agriculture and insurance, urban planning and flood modelling, disaster management, forestry and environment, and internet and communication. These cohorts will be carefully mentored by both the space technology experts and target domain experts across industry, academia, and government agencies. The state will forge partnerships with prominent academic and research institutions globally to collaborate with the Telangana based universities and work towards applied space technology research and innovation.

The government will facilitate joint projects between researchers with both virtual collaborations and active exchange programs. With a focus to deliver socio-economic impact that may arise from the use of space technology, the State will also identify high impact use-cases and shall conduct grand challenges for the same. This initiative will allow innovators to work towards building applications that can alleviate various problems for the citizens. The best solutions shall be on-boarded on the proposed space tech accelerator to build a comprehensive business model, which will quickly go to the market and deploy the solutions at scale.

https://www.newindianexpress.com

Platform to empower startups from idea to unicorn

Tech giant Microsoft has launched its "Microsoft for Startups Founders Hub" in India. The aim is to empower startups' vision and fuel innovation to drive economic and societal progress for India and beyond. Microsoft for Startups Founders Hub is a new digital inclusive platform for startup founders in India. The platform offers over $300,000 worth of benefits and credits, giving startups free access to the technology, tools, and resources they need to build and run their businesses, from the most trusted, secure, open-source friendly and compliant cloud platform, to the best-in-class developer and productivity tools including GitHub Enterprise, Visual Studio Enterprise and Microsoft 365.

Beyond access to technology, Microsoft for Startups Founders Hub will empower entrepreneurs to innovate and grow by connecting them with mentors who will provide them with the industry, business, and technical support to guide them through their next business milestones. Microsoft is also partnering with innovative companies like OpenAI, a global leader in AI research and deployment, which develops AI systems such as GPT-3 and Codex to provide startups with exclusive benefits and discounts. In addition, the founders will also have access to Microsoft Learn for tailored startup-centric training and a variety of startup and unicorn programs to help them build connections with customers or industry veterans and accelerate their growth.

Microsoft for Startups Founders Hub is designed specifically for early-stage startups to lower the barriers of business creation, be a catalyst for entrepreneurship and innovation, and contribute to easing the journey from an idea to a unicorn. It is available to all startups in India, including those without third-party validation or funding, as part of Microsoft's commitment to empower startups' ambitions to drive innovation from India to the world.

https://www.business-standard.com

Medical device industry

The Indian medical device industry has the potential to touch $47 billion by the financial year 2030 four times its current size of $12 billion, says a KPMG report. The growth will be driven by increasing healthcare needs and the government's commitment to facilitate growth, it suggests.

The suggestion comes in the backdrop of a KPMG survey with the medical device industry leaders, which revealed that 90 percent of the respondents found lack of predictability in the policies acting as a major barrier to operating in the Indian market. Similarly, 85 per cent considered the pricing policy framework as a challenge, while 75 per cent found the absence of an established supplier base and ecosystem as the problem. Broadly classified into five segments – electronics equipment, surgical instruments, implants, in vitro diagnostic devices, and consumables and disposables – the medical devices sector is 70-80 per cent import dependent in India. Import dependence is higher in high-end sophisticated device segments.

A collaborative effort of KPMG, Invest India, and Asia Pacific Medical Technology Association (APACMed), the report proposes multiple recommendations including predictable regulatory environment, harmonization of quality standards, a friendly public procurement policy, acreation of supplier ecosystem and a skilled talent pool and an establishment of "brand India" as a global hub for medical device manufacturing and innovation.

On changes on the regulatory front, the report called for a single central authority for medical device regulation and a long term roadmap for 10-15 years detailing the growth plans and implementation timelines. It wanted the Bureau of Indian Standards (BIS) to harmonize the Indian standards with the globally acceptable quality standards to enable domestic device makers attain global competitiveness.

The report suggests a series of measures to promote innovation and proposes an innovation linked incentive (ILI) scheme on the lines of the existing production linked incentive (PLI) scheme. The need for seed capital to facilitate the R&D on frugal innovation and the establishment of innovation parks were other suggestions. On building a supplier ecosystem, the report wanted the government to take necessary steps to create pay-per-user common testing facilities, machine tool centres, solid waste management units and warehouses.

The report however says that the government's production linked incentive (PLI) scheme, clusters of medical devices, parks, and improved regulatory approval processes are steps in the right direction to support domestic manufacturing.

https://www.fortuneindia.com

ISLAMIC REPUBLIC OF IRAN

Technological innovations for smart agriculture

The Biotechnology Development Council of the Vice Presidency for Science and Technology supports biotechnology projects and innovative ideas in the field of smart agriculture. Smart agriculture is the sustainability of food security focused on providing the agricultural industry with the infrastructure to leverage advanced technology – including big data, the cloud, and the internet of things (IoT) – for tracking, monitoring, automating, and analyzing operations.

With the participation of knowledge-based companies, smart agriculture is to be accelerated in the country, and innovative ideas and plans of individuals and companies applying to achieve this goal will be supported. Biotechnology Development Council called on all companies and teams with innovative ideas or plans that can help promote the concept of smart agriculture and food security to cooperate. Topics such as "Agriculture Management, Water and Soil Chemistry", "Pesticide Consumption Recommendation Platform", "Agriculture and Horticulture Management Platform", "Livestock and Poultry Management Platform" and "Aquaculture, Shrimp and Fisheries Management Platform" are given priority.

Iranian knowledge-based companies have so far produced 120 technological products in the field of agriculture, according to the Vice Presidency for Science and Technology. Some 30 knowledge-based companies are working to integrate the agricultural industry with innovation and creativity by producing 120 technological products so that the new generation of agriculture will be realized in the country.

This work covers everything from the cultivation to the harvest and sale of crops and can play an effective role in the development of the new generation of agriculture and the promotion of productivity and sustainability of crops.

https://www.tehrantimes.com

MALAYSIA

New Patents (Amendment) Act 2022

The Intellectual Property Corporation of Malaysia (MyIPO) has announced a Patents (Amendment) Act 2022 that comes into force on 18 March 2022. The amendments take into account Malaysia's commitments in the Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement (on public health), the Regional Comprehensive Economic Partnership Agreement (RCEP), and the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), as well as to comply with the provisions of the Budapest Treaty on the International Recognition of the Deposit of Microorganisms for the Purposes of the Patent Procedure.

Some of the notable key changes under the amended Act are as follows:

- deferment of substantive examination is no longer available, only deferment of *modified* substantive examination is available on the basis that the prescribed corresponding patent to be used for a modified substantive examination has not been granted;
- for post-grant amendment, the Registrar may require a patentee to file a request for re-examination of the amendment, or apatentee may make such a request on his own volition;
- any person may, within the prescribed period, make observations on any matter relating to the patentability of a patent application;
- certain deadlines can no longer be extended;
- it is now made clear that a divisional application cannot be filed once an application is granted, refused, deemed to be withdrawn, withdrawn or abandoned;
- the period for reinstatement of a lapsed patent (due to non-payment of renewal fee) has been shortened to 12 months instead of 2 years from the date on which a notice of the lapsing of a patent is published; and

- any interested person may now initiate opposition proceedings within the prescribed period from the date of the publication of the grant of a patent by filing a notice of opposition.

https://www.spruson.com

Tax incentives for pharmaceutical manufacturers

Malaysia will continue to accept applications for tax incentives from pharmaceutical manufacturers until 31 December 2022, as the government looks to strengthen the country's position in the global pharmaceutical value chain and promote its healthcare industry as an attractive foreign investment destination. To be eligible, manufacturers must fulfill a variety of requirements ranging from collaborating with local higher learning institutions, incurring the first qualifying capital expenditure within a year of approval, hiring a minimum number of local employees, and undertaking research and development (R&D) activities, among others.

From January to September 2021, Malaysia's pharmaceutical industry recorded almost 400 million ringgit (about 94 million US dollars) in approved investment, surpassing the previous highest full-year figure in 2017. In addition, the exports of pharmaceutical products increased around 24 per cent in 2021, compared to 2020, totaling 2.42 billion ringgit (about 570 million US dollars).

Both new and existing qualified manufacturers will benefit from the following tax incentives:

- An income tax rate of 0 to 10 per cent income tax rate for the first 10 years; and
- A 10 per cent income tax rate for the next 10 years.

https://www.aseanbriefing.com

PHILIPPINES

Incentives for green projects, research and development

A draft of the Strategic Investment Priority Plan (SIPP) retains all the priority industries listed in the 2020 plan, while creating two other tiers for "green" industries and research and development (R&D) activities, among others.

The draft, which was released to the media by the House Ways and Means Committee Chairman and Albay Rep., Jose Ma. Clemente S. Salceda, remains unsigned but appears to be set for implementation via executive order (EO). The draft that Mr. Salceda released appears to be set to go out initially as a memorandum order to be issued by the Office of the President (OP), over the signature of Executive Secretary Salvador C. Medialdea.

The latest version of SIPP will be a companion document to the Corporate Recovery and Tax Incentives for Enterprises (CREATE) Law and seeks to identify the industries, to which the government hopes to attract investments by offering tax incentives.

According to the draft, Tier I consists of industries included in the 2020 version of the SIPP. The 2020 SIPP was carried over as a transitional list pending the release of a new SIPP that conforms to the provisions of the Corporate Recovery and Tax Incentives for Enterprises(CREATE), which took effect in April 2021.

Tier II was defined as activities "that are supportive of a competitive and resilient economy and will fill in gaps in the Philippines' industrial value chains, which are critical in promoting green ecosystems, ensuring a dependable health system, achieving robust self-reliance in defense systems, and transforming industrial and agricultural sectors to being modern, competitive, and resilient," according to the draft.

Tier III will include activities which are "supportive of the acceleration of the transformation of the economy primarily through the application of research and development (R&D) and attracting technology investments." The tie also proposes to incentivize equipment and parts manufacturing and services related to new technologies, as well as the commercialization of R&D.

A draft foreword to the SIPP that was to go out in the name of the Trade Secretary, Ramon M. Lopez, listed the Tier I projects as follows: various manufacturing activities including agro-processing projects; strategic services; healthcare and disaster risk reduction management services; mass housing; infrastructure and logistics projects including public-private partnerships entered into with local governments; innovation drivers, innovative business models, environment or climate-change-related projects and energy. Tier I also incentivizes export activities and other projects granted incentives by special laws.

According to a draft message that was to go out in the name of the President, Rodrigo R. Duterte, which was attached to the draft SIPP, the President expressed hope that the plan will allow the Philippines to "attract more investments that will help propel economic recovery beyond the pre-pandemic levels while promoting sustainable inclusive growth, which will put us back on track towards upper-middle income country status in the long term."CREATE is the second package of the Comprehensive Tax Reform Program. It reduced the corporate income tax rate from 30 to 20 per cent, and made fiscal incentives more time-bound and performance-based.

https://www.bworldonline.com

Patent application fees waived for women-led ventures

The Intellectual Property Office of the Philippines (IPOPHL) and the Department of Trade and Industry (DTI) have teamed up for the implementation of a program that would waive fees for patent applications of women-led micro, small and medium enterprises (MSMEs). A memorandum of understanding was signed by IPOPHL director general, Rowel Barba, and Trade Secretary, Ramon Lopez, for the Juana Patent and the Juana Design Protection Incentive Program.

Ann Edillon, the head of the IPOPHL Enforcement Office, said the program would waive fees for the filing of invention, utility model and industrial design. It will also waive the first publication fee and substantive examination fee for invention. She said the program would start on 15 April 2022 and run until 30 April 2023 or until 50 inventions, 150 utility models and 150 industrial design applications have been qualified and filed.

To be eligible for the program, the MSME must be a woman-led and engaged in business for at least one year. In addition, the applicants must be engaged in a business activity, which is considered as a part of the priority sectors by the DTI or by IPOPHL registered with the DTI, Securities and Exchange Commission or Cooperative Development Agency have total assets not over P100 million and have a maximum of 20 employees.

The program is open only to those yet to avail a funding under the Republic Act 7459 or the Philippine Inventors and Inventions Incentive Act. Barba said the new program is the latest initiative of the IPOPHL to help micro, small and medium enterprises (MSMEs) in intellectual property (IP) registration. In 2017, the IPOPHL launched the Juana Make a Mark Program, which enables women-led micro, small and medium enterprises (MSMEs) to register their trademarks and make them more competitive.

https://www.philstar.com

REPUBLIC OF KOREA

Research and development spending of major firms

A major of the Republic of Korea's firms' spendings on research and development (R&D) expanded more than 8 per cent in 2021 though their sales weakened amid the coronavirus pandemic, a market tracker said. The combined R&D expenditures by 224 companies out of the country's top 500 companies by sales stood at 60.4 trillion won (about 48.1 billion US dollars) last year, an increase of 8.2 per cent from a year earlier, according to the CEO Score. It represents the first time that major domestic firms' R&D spending has surpassed the 60 trillion-won mark.

In 2021, the increase was seen as part of their efforts to secure future growth engines despite slackening sales in the wake of the prolonged COVID-19 outbreak. Their total R&D spending accounted for 3.2 per cent of sales in 2021, compared to 3.5 per cent from a year earlier.

Samsung Electronics Co., the world's largest smartphone and memory chipmaker, was the top R&D spender with 22.6 trillion won in 2021, which was up from 21.2 trillion won, a year earlier. Samsung was followed by the chip behemoth SK hynix Inc. with 4.04 trillion won, and the home appliances giant LG Electronics Inc. with 3.6 trillion won. Samsung and nine other firms spent more than 1 trillion won in 2021 and 13 corporations posted R&D-to-sales ratios of 10 per cent or more.

Naver Corp., the country's largest internet portal operator, ranked at the top among the businesses in terms of the R&D-to-sales ratio with 24.3 per cent, trailed by the major pharmaceutical firm Celltrion Inc. with 22.5 per cent, and the mobile game developer Netmarble Corp. with 22.4 per cent.

http://koreabizwire.com

R&D spending as portion of GDP

The Republic of Korea placed second in research and development (R&D) spending as a portion of its gross domestic product (GDP) among major developed countries in 2020, but its rapid growth in recent years call for more policy support, a report said.

The Republic of Korea's R&D expenditures reached 93.1 trillion won (75.4 billion US dollars) in 2020, accounting for 4.81 per cent of the GDP, according to a recent report by the Federation of Korean Industries (FKI), the country's largest business lobby. This made the Republic of Korea the biggest R&D spender among 36 out of 38 member countries of the Organization for Economic Cooperation and Development (OECD) trailing only Israel, whose R&D portion came to 5.44 per cent, the report said.

Chile was excluded from the finding due to limited available data. Costa Rica was also excluded from the report because it joined the OECD last year.

The report also found that the Republic ofKorea's R&D portion jumped 2.54 percentage points last year from 2001, a nearly fivefold increase compared with the OECD average of 0.53 percentage point. Large companies spent 71.3 trillion won, representing the bulk of the expenditures, while 21.6 trillion won was spent by the government or other public entities. The R&D spending, however, has remained stalled at the average of around 7.5-8.0 per cent in the past decade, retreating from the average 11.4 per cent for 2001-2010.

In 2018, the Republic of Korea ranked far below the OECD average in earnings from intellectual property royalties versus R&D spending, with the percentage coming to 9.9 per cent, compared with the OECD's 27.7 per cent.

http://www.koreaherald.com

Trade deficit in Intellectual Property rights in 2021

The Republic of Korea's deficit in the trade of intellectual property rights touched a record low in 2021 on increased exports of cultural content, central bank data showed. The nation's deficit in the intellectual property account stood at $30 million last year, compared to a $2.02 billion shortfall in 2020, according to a preliminary data from the Bank of Korea (BOK).

The exports of products and services subject to intellectual property right payments came to $20.86 billion, an increase from $15.42 billion from a year earlier, with imports rising to $20.89 billion from $17.44 billion. It marks the lowest red ink in the trade of intellectual property rights since data tracking began in 2010.

The central bank said that the tumble in the deficit came as the country posted a big surplus in copyright trade, thanks to the overseas popularity of the boy group BTS, Korean dramas and movies, and webtoons.

The Republic of Korea registered the largest surplus of $750 million in the trade of cultural and art copyrights, an increase from $70 million, compared with a year earlier. The surplus in the trade of the copyrights related to software and research and development also surged to $1.7 billion from $1.57 billion over the cited period.

By country, the Republic ofKorea chalked up a shortfall of $3.03 billion in the trade of intellectual property rights with the United States last year. It also posted a shortfall of $990 million with Britain and a deficit of $580 million with Japan. The Republic of Korea posted a trade surplus of $2.58 billion in intellectual property rights with China in 2021, down slightly from a $2.59 billion surplus a year earlier.

http://www.koreaherald.com

SINGAPORE

Plant-based food innovation

The Singapore Institute of Technology (SIT) and a leading agricultural supply chain company recently jointly launched a research programme to accelerate Singapore's capabilities in enabling a sustainable and efficient supply of plant-based food alternatives.

This partnership will see a first-of-its-kind research programme that is aimed at leveraging science and technology to improve the extraction of proteins from plants to maximize protein quality, yield and functionality, and to render the extraction process greener. To enable this, the four-year collaboration will see the establishment of Singapore's first Research & Development (R&D) platform focused on extraction and processing capabilities, with the Agrocorp being the university's anchor partner.

Specifically, the research programme seeks to improve plant protein quality by tweaking the protein recovery process to minimize their denaturation, and validating the proteins' functionality in the food products developed. Traditional methods of extraction are often marked by the challenge of "high cost, low functionality," – where drawbacks include low protein quality, intensive use of water, and high cost of scaling. Understanding how ingredient extraction processes can be achieved using greener methods can decrease cost curves, facilitate clean labelling of food products, and enhance quality.

The joint R&D effort will feature advanced food technology and methods to achieve the extraction of plant-based proteins under greener conditions and upcycling of agri-waste. Amongst the technology used is the *Pulsed Electric Field*, a method of using short electrical impulses of high voltage to permeabilize the plant cell membranes under non-thermal conditions; and enzymatic-based release of proteins from plants. The findings from the research programme will be used to optimize Agrocorp's ongoing product development process and enhance the quality of their plant-based products for consumers.

https://opengovasia.com

National consortium for clinical research, innovation

Singapore has brought together five Ministry of Health-led research and development, clinical translation, and service initiatives under one umbrella group called the Consortium for Clinical Research and Innovation (CRIS). This comprises the Singapore Clinical Research Institute (SCRI), the National Health Innovation Centre Singapore (NHIC), Advanced Cell Therapy and Research Institute Singapore (ACTRIS), Precision Health Research Singapore (PRECISE), and Singapore Translational Cancer Consortium (STCC).

Based on a press statement, CRIS aims to "build networks and collaborations for regional clinical trials, perform cost-effectiveness assessments for healthcare interventions, and foster industry engagement" to fulfill its vision of nurturing and building capabilities and innovation in clinical research and translation for Singapore.

Dr Danny Soon, the consortium's CEO, said it was just about time to bring together the said government initiatives under one roof as Singapore's basic science capabilities and talent base have begun to mature with research initiatives gaining ground. CRIS, he said, seeks to ensure a "unity of mission" across their respective programmes and synergize their capabilities, scientific resources, and industry engagement."This way, we stay relevant and aligned to the needs of Singapore patients, healthcare system, and researchers, and build long-term sustainability for these efforts," he added.

https://www.healthcareitnews.com

THAILAND

Fast-track patent approval

The Intellectual Property Department is set to create a fast-track system for patent registration to facilitate Thai inventors, starting with a pilot project on inventions related to health care, including medicines, treatments, care and food. VuttikraiLeewiraphan, the department's director-general, said the new system will increase competitiveness in innovation and intellectual property as well as create more employment and income for Thais and entrepreneurs.

Currently, the patent applications and registrations take about 55 months from the filing date until the patent is granted. Under the fast-track system, the consideration period will be cut by half to 24-36 months.

From the start of the Covid-19 pandemic, there have been 225 Thai patents and petty patent applications related to the prevention and treatment of the coronavirus, comprising 61 invention patent applications and 164 petty patent applications.

There are three patent types available in Thailand: patent for invention, petty patent, and design patent (also known as industrial design).

The invention patent has the strictest requirements to qualify for protection, followed by the petty patent, then the design patent. The invention patent protection period is 20 years, while the protection period for the design and petty patents is 10 years.

https://www.bangkokpost.com

UZBEKISTAN

Law on Geographical Indications

Uzbekistan's first law on Geographical Indications was adopted on 21 December 2021 and entered into force on 3 March

2022, introducing the rules and grounds for registration and use of the geographical indications (GIs). The law defines a geographical indication (GI) as a designation that identifies the goods as originating from a certain geographical area, if their quality, reputation, and other characteristics can be essentially attributed to their geographical origin. Unlike appellations of origin (AOs), for which all products' stages should take place in the specified geographical location, for GIs, it is acceptable that at least one stage of production, which substantially influences the quality, reputation or the characteristics of a product, takes place in the territory in question.

While the Law on Trademarks, Service Marks, and Appellations of Origin provides for the registration and use of AOs, the new GI law provides for the registration of new GIs and the registration of the right to use the existing GIs. The GI law also provides for the registration of foreign GIs – the procedure is the same as for national GIs.

The applicant may be a group of natural and/or legal persons (the applicant may also be one person, if there are no other applicants or if the other applicants do not express a desire to apply) located in a certain geographical area, whose name is used to designate the product they produce. The applicant may also be a non-governmental organization or a local executive body located in that area.

The application for the registration of a GI or the right to use an existing GI should be filed with the Uzbek Intellectual Property Office (IPO) and must contain the following:

1. Representation/image of the claimed designation;
2. Product description;
3. The production location within the geographical area;
4. The description of the specific product's characteristics and its link with the production area, climate, craft, etc.;
5. The names and the locations of the competent inspection bodies or laboratories certifying a product's compliance with the declared, specific characteristics, if provided for in the administrative instructions of the state service for GI registration;
6. A proof of payment of the official fee; approximately EUR 510 (570 US dollars);
7. Documents confirming that an applicant is located in a certain geographical area and that the applicant produces the goods with characteristics essentially linked to that geographical area, if the applicant's production is based in Uzbekistan;
8. Documents confirming an applicant's right to use the GI in the country of origin, if the applicant's production is based outside of Uzbekistan;
9. In case of collective filing, a document confirming the applicable characteristics of a product being produced;
10. For applicants claiming the right to use a registered GI, documents confirming that the applicant is a manufacturer of goods with the characteristics declared in the IPO's registry.

While new GI registrations are valid for an unlimited period of time, certificates granting the right to use the already registered GIs are valid for 10 years from the application filing date, and can be extended for an unlimited number of an additional 10-year periods.

The GI registration process takes less than two months. The formal examination is carried out within 15 days from the application filing date and substantive examination within one month from the formal examination decision date.

During substantive examination, the IPO does not only check if the claimed designation is in conflict with registered AOs and GIs, but also if it is in conflict with registered trademarks, service marks, plant varieties, animal breeds, or any mark which could cause public confusion regarding the product and its origin. Interested parties can, therefore, invalidate a GI registration based on both absolute and relative grounds.

The registration of a GI or of a right to use a GI does not grant exclusive rights. It is worth mentioning that the GI law has no provisions regarding penalties for the breach of the law. In contrast, the Law on Trademarks, Service Marks and Appellations of Origin includes monetary fines ranging from EUR 2,130 (2,370 US dollars) to EUR 4,255 (4,737 US dollars).

As of today, the Uzbek IPO online registry includes four active AO registrations. Following the adoption of the new GI law, it is expected that more geographically related signs and names will be registered, as the GI registration procedure is less time consuming and less rigid regarding the place of production requirement.

https://www.lexology.com

VIET NAM

Plan to develop digital government, economy

In Viet Nam, the two important goals in the National Committee on Digital Transformation's digitization plan for 2022 are to have 85 per cent of the population own a smartphone and 75 per cent of all households to be connected to a broadband internet. The plan, which was promulgated by the Prime Minister and the committee's chairman, Pham Minh Chinh, outlines goals for digital infrastructure, e-government, and the digital economy and society.

According to a press release, to build a digital government, the goal for 2022 is to increase the rate of online public services to 80 per cent, the rate of the administrative procedures dossiers processed online to 50 per cent, and the rate of the digitization of dossiers and results of the administrative procedures to 100 per cent. Also, the rate of reports made online by the state administrative agencies to 50 per cent as well as the rate of state agencies providing full open data by category to 50 per cent.

Regarding the development of a digital economy and society, the targets include the percentage of small and medium-sized enterprises using digital platforms to reach 30 per cent, the rate of enterprises using e-invoices to reach 100 per cent, and the rate of enterprises using e-contracts to be 50 per cent. The government wants the proportion of e-commerce revenue in the total retail sales to reach 7 per cent, and the percentage of people over15 years of age with transaction accounts at banks or other authorized organizations to reach 65-70 per cent.

Under the plan, there are 18 tasks assigned to the committee's members, which include universalizing smartphones, electronic identities, and broadband fiber optic cables. It also aims to enhance network information safety and security, develop electronic health records, support online teaching, and digitally transform small and medium-sized enterprises.

Other goals involve comprehensively promoting digital payment methods, boosting e-commerce and digital commerce, focusing on smart urban planning, and increasing spending on scientific research for digital transformation. It aims to operationalize an agricultural database and create a national database on cadres, civil servants, and public employees. The government aims for the total amount of non-cash payments of tuition and hospital fees to reach at least 50 per cent by the end of 2022.

The country is also looking to improve telecommunications infrastructure and digital content services. Earlier, OpenGov Asia reported that at the recent World Mobile Broadband and ICT Summit, an official from the Ministry of Information and Communications (MIC) said that the government wants to master broadband infrastructure, 5G equipment infrastructure, and made-in-Viet-Nam technology platforms.

According to statistics of the MIC's Authority of Telecommunications, in 2021, VietNam had 70.9 million mobile broadband subscribers, accounting for 57.23 per cent of the total mobile subscribers and representing an increase of more than 4 per cent compared to 2020. In 2022, the authority aims to have 85 per cent mobile broadband subscribers per 100 people. As of October 2021, the country had more than 18.8 million fixed broadband internet subscribers. Around the same time, Vietnam had 71 million mobile broadband subscribers, with 89.81 per cent prepaid and 10.19 per cent postpaid.

https://opengovasia.com

Progress on COP26 commitments

Following Vietnam's commitment to net-zero carbon emissions at the Conference of the Parties (COP26), the government released *Notice No 30/TB-VPCP* on guidance on implementation. Vietnam's Prime Minister, Pham Minh Chinh, held a meeting with the National Streeting Committee and urged ministries to develop programs and plans to implement Vietnam's commitments at COP 26.

Particularly, the Notice highlights eight areas that the government agencies will be required to focus on:

- Transitioning from fossil fuels to green/clean renewable energy sources;
- Reduction of greenhouse gas emissions;
- Reduction of methane, particularly in agriculture and waste management;
- Use of electric vehicles (EVs);
- Sustainable management including using forests and increasing trees to offset carbon emissions;
- R&D for construction material usage and urban development for sustainable development;
- PR campaigns for public and businesses to increased awareness and support for the government's COP26 commitments; and
- Step up the adoption of a digital economy to address climate change.

With this, the Ministry of Industry and Trade (MoIT), the Ministry of National Resources and Environment (MONRE), and relevant government agencies are expected to release further guidance on the implementation.

While the revised Law on the environment will go to some degree to mitigate greenhouse gas emissions and is consistent with the COP26, the implementation will be the key. Low or minimal emissions will play a major role if Viet Nam wants to change from fossil fuels to low emissions. To this effect, the government is likely to issue a new decree on mitigating greenhouse gases, while protecting the ozone layer, as well as setting up committees to promote laws and policies, admin reforms, and so on for a climate-proof infrastructure and renewable energy. The government also plans to complete and upgrade the National Strategy on Climate Change including net-zero carbon emissions and reducing emissions of methane gas.

Viet Nam has asked for international assistance in meeting its climate change commitment. To this effect, the US is funding US $36 million in Viet Nam's Low Emission Energy Program. Under this project, USAID will help Vietnam transform towards clean energy using advanced technologies while improving energy performance and increasing competition in the energy sector.

To achieve net-zero carbon emissions, Viet Nam will need to reduce carbon emissions, reduce pollution, and implement higher energy optimization in practical terms. For example, a factory in Ho Chi Minh City's District 9, has already started implementing these measures even before Viet Nam signed a commitment. It installed a solar power system on the roofs of factories, rearranged factory corridors to allow for light, as well as used lights with higher luminescence efficiency.

Vietnam's Power Development Plan 8 (PDP8) for 2021 with a vision till 2045 was supposed to be released in 2020. The initial drafts included a plan to incorporate renewable energy. However, another draft raised the country's coal capacity to 40GW by 2030.

After PM Chinh's commitment at the COP26, sources indicate that the current Power Development Plan 8 (PDP8) draft is further being revised to reflect Viet Nam's commitment. In addition, to deal with overcapacity, the Deputy Prime Minister, Le Van Thanh, has asked relevant government agencies to reduce solar energy capacity and increase off-shore wind capacity to increase efficiency.

https://www.vietnam-briefing.com

Technology Scan

Focus: Technologies for renewable energy and low carbon development

ASIA-PACIFIC

CHINA

Perovskite solar cells

Chinese researchers have developed a type of perovskite solar cell (PSC) with high power conversion efficiency. Perovskite solar cells have been considered one of the most promising photovoltaic technologies for low-cost power generation and high efficiency. Since the world is experiencing climate change, the United Nations has set carbon reduction goals to offset its long-term effects.

PSCs can be generally classified into two categories: n-i-p devices and inverted p-i-n devices. The p-i-n PSCs can be produced at low temperature with good stability. They are compatible with crystal silicon cellsand so are considered indispensable for achieving the development of laminated cells, according to Fang Junfeng, a Professor at the East China Normal University (ECNU).

At present, the efficiency of n-i-p perovskite cells has reached 25 per cent, while the maximum efficiency of inverted p-i-n devices remains at 22 to 23 per cent. The new inverted p-i-n PSCs achieve a power conversion efficiency higher than 24 percent. During illuminated operation for 1,000 hours at 55 degrees Celsius and after dark aging at 85 degrees Celsius for 2,200 hours, the p-i-n devices maintain more than 90 percent of this efficiency, according to a research article recently published in the journal *Science*. The new PSCs are developed by researchers from the ECNU and the Ningbo Institute of Materials Technology and Engineering under the Chinese Academy of Sciences.

https://news.cgtn.com

INDIA

Clean hydrogen

A group of scientists from the CSIR-Indian Institute of Chemical Technology (CSIR-IICT), Hyderabad, have designed a hybrid material to simulate capturing carbon dioxidefrom non-fuel grade bioethanol in-situ (onsite) and converting it into clean hydrogen. The research details were published in the scientific journal *Chemical Engineering and Processing*.

In a first for India, the scientists developed a fluidized bed reactor (FBR) facility in Hyderabad to perform sorption enhanced steam methane reforming (SESMR) to achieve clean hydrogen in its purest form. The facility was commissioned at CSIR-IICT in January this year. The facility was commissioned under a Mission Innovation Project supported by the Department of Science and Technology, Government of India.

The FBR system measures the performance of dual-functional materials for SESMR. This method results in certain advantages for onsite carbon dioxide removal through sorbents. Itthere by over comes the equilibrium restrictions of steam reforming, leading to clean hydrogen production. The researchers conducted a thermodynamic investigation using Aspen plus models (imperative programming language to study scientific computation), which led to the discovery of two methods by which high purity hydrogen could be produced from non-fuel grade bioethanol.

The two schemes are based on the sorption process where a gas or vapor (sorbate) is captured or fixated by a substance in a condensed state (solid or liquid) called sorbent. The methods studied by the team are the chemical looping combustion (CLC) integrated process, sorption enhanced steam reforming (CLC-SESR) and sorption enhanced chemical looping reforming (CLC-SECLR).

The two schemes are energy-wise self-sustainable. The heat and power demands in the two processes are met by integrating them with heat recovery, steam generation, and power generation mechanisms. The efficiency of carbon capture achieved by the IICT scientists were 99.13% and 99.58% respectively. The purity level of hydrogen obtained in the process were 99.15% and 99.71% respectively, with an energy efficiency of 39.47% and 37.30% respectively. The optimal hydrogen yield achieved by the team were97.38%, and 82.45%, demonstrating the efficacy of the above two schemes in facilitating low temperature reforming of partially distilled bioethanol of 14 mole % (34.5% by volume), with the concentration maintained at 550 degrees and 500 degrees Celsius respectively.

Earlier this year, scientists at the Indian Institute of Science Education and Research (IISER), Kolkata demonstrated a strategy to synthesize novel solid absorbents to capture and utilize carbon specifically. The group discovered particular types of nanoparticles which capture carbon dioxide in their micro and mesoporous voids.

Many research institutes across the globe are focused on studies to capture carbon and control or reduce carbon emissions. Earlier this month, a U.S.-based electric public utility company, Cleco Power, announced an allocation of $12 million to develop a carbon capture facility in Lousiana's Brame Energy Center.

https://mercomindia.com

Smart solar stove

Researchers at the Department of Electrical Engineering at the National Institute of Technology-Calicut (NITC) have designed and developed an eco-friendly smart solar stove with zero operating cost for domestic and roadside eateries. An excellent alternative cooking system, especially when prices of domestic cooking gas are rising, the smart solar stove with multiple versions has been tested for practical feasibility and is ready to be launched in the market at an affordable price, a press release stated here on Tuesday. The Department of Biotechnology of the Union Ministry of Science and Technology had funded the project. NITC Director Prasad Krishna launched the product on the campus. One of the product versions that can be used directly under the sun has a single and double stove suitable for domestic cooking. Another model, which can be employed for all types of cooking purposes, has a provision to connect an LED lamp.

The sufficient illumination will help vendors to extend their business operating hours during night hours. Besides, this model, having a foldable solar panel, can be used by travelers and tourists. Another model has a battery with a control unit for extending the cooking time during overcast weather. V. Karthikeyan, Assistant Professor, Department of Electrical Engineering, NITC, said that the smart stove was similar to a user-friendly induction cooker. It had no thermal or electromagnetic wave radiation. Multiple safety features were added to the product, he said. S. Ashok, Chairman, Centre for Innovation and Entrepreneurship, NITC, said that a number of industries had expressed interest in securing the technology for commercial manufacture of the smart solar stove.

https://www.thehindu.com

Technology to convert diesel to alternative fuel

The Indian Institute of Technology (IIT) Delhi researchers have developed a technology which enables a diesel-powered automotive vehicle to run in flex fuel mode — the other fuel being the environment-friendly Dimethyl Ether (DME). The technology enables the transition of diesel trucks from conventional diesel to DME as an alternative fuel. The project was funded by the Department of Science and Technology (DST), Government of India.

Dimethyl Ether (DME) is one of the alternative fuels for compression ignition engines and vehicles. It can be produced from biomass, coal, industrial wastes, municipal solid wastes, black liquor (a by-product of pulp) through gasification and the Fisher-Tropsch synthesis process. It can also be produced via catalytic dehydration of methanol. DME is generally stored in liquid form, and phase change from liquid to vapor or gas could easily occur at the ambient temperature and pressure.

The technology has been developed by the researchers of the institute's Department of Energy Science and Engineering (DESE), Indian Oil Corporation (IOC)'s R&D Department, and the auto major Ashok Leyland Ltd. They have converted a diesel-powered automotive vehicle into a flex fuel vehicle on a pilot basis.

The technology produces less/negligible smoke, soot and PM emission. It has lower noise with smoother engine and overall vehicle operation. Further, it helps in the improvement in transient engine performance and enhancement of energy security, and creates a sustainable environment as there is substantial reduction in greenhouse gas emissions.

The flex fuel technology-based vehicle named DOST was jointly flagged off on April 8 at IIT Delhi by Dr Srivari Chandrasekhar, Secretary, DST; Prof Rangan Banerjee, Director, IIT Delhi; Dr SSV Ramakumar, Director (R&D), Indian Oil; Krishnan Sadagopan, Senior Vice President, Ashok Leyland; Prof. Sunil Kumar Khare, Dean R&D, IIT Delhi; and Prof KA Subramanian, Head, DESE, IIT Delhi, in the presence of other senior officials from IIT Delhi, IOC R&D Department, and Ashok Leyland.

https://www.news18.com

JAPAN

Glass-integrated BIPV module

Japan's AGC Group has developed a BIPV module consisting of laminated safety glass with embedded solar cells. The press release by the Groupstated that the "SunJoule" panel can be adapted to different building requirements. SunJoule is available with either monofacial or bifacial cells and the cell arrangement can be customized according to a client's need, the manufacturer said. The spaces between the cells can be customized from 6 mm to 30 mm.

Customers can choose between simple laminated glass and laminated insulating glass. The glass composition is determined by the manufacturer after calculations considering wind load, glass size, and the chosen support method. An interlayer film is placed between the solar cells and the glass. Each module can have a maximum size of 2,400 mm x 1,800 mm.

The product was recently used for the 3D-shaped entrance canopy of the Global Zero Emission Research Center of the National Institute of Advanced Industrial Science and Technology in Tokyo. The PV system has a power output of 6.7 kW. AGC said the solar cells embedded in the glass can effectively reduce heat transmission, as they block sunlight while harvesting solar energy. The PV devices are also said to create a comfortable space with natural light through the spaces between the cells "like sunbeams through the leaves of trees." The company said the BIPV glass has already been deployed at 215 sites since its launch in 2000.

https://www.pv-magazine-india.com

NEPAL

Eco-friendly electric scooter

Nepal Academy of Science and Technology has developed an electric scooter in collaboration with the government of Lumbini province of Nepal. The preliminary version of the eco-friendly two-wheeler was launched by Pampha Bhusal, Minister of Energy, Water Resources and Irrigation, during an official event.

The innovation is viewed as significant at a time when the entire world is searching for alternatives to fossil fuels, bearing in mind their negative implications on the environment, depleting reserves and skyrocketing prices. The innovation is claimed to be appropriate in terms of the roadways in Nepal and its topography.

On the occasion, Ms. Bhusal urged NAST to seek response from the government whether the country needs to introduce internationally available technology or develop a homegrown technology for the automotive industry.

https://thehimalayantimes.com

REPUBLIC OF KOREA

Photovoltaics on railroad noise barriers

Land-scarce South Korea is currently hosting a series of initiatives aimed at deploying solar on unused surfaces. The latest development comes from the city of

Suncheon, which will test several photovoltaic railroad noise barriers based on bifacial PV modules. The project will be developed with the support of the Korea Railroad Corporation (Korail) and other government entities.

Suncheon City has been selected by the Korean Ministry of Trade, Industry and Energy (MOTIE) to host the Railway-suitable Solar Power Demonstrator for Noise Reduction project. It is a KRW 6 billion (US$4.8 million) initiative aimed at testing the deployment photovoltaic panels on railroad noise barriers.

The project will be developed with the support of the Korea Railroad Corporation (Korail) and other government entities. The installations will rely on bifacial solar modules and will be applied to noise barriers in high-speed and conventional railroads as well as on bridges. The solar modules will be adapted to the aesthetics of each side and should be resistant to pollution, the city government said in a press release.

"The foundation has been laid for the development of solar power generation on railroad sound barriers, and if the technology will become viable it will contribute to the creation of an energy-independent and carbon-neutral city," the statement read.

Scientists from the Korea Institute of Energy Research (KIER) developed last year a photovoltaic-thermal noise barrier that could be used to replace conventional soundproof walls to reduce traffic noise. Korea Hydro and Nuclear Power Co. (KHNP*)*, a unit of Korea Electric Power Corp. (Kepco), also recently signed a memorandum of understanding with Hanmaeum Energy, a Singapore-based private equity firm owned by Affirma Capital and Duham Partners to deploy 100 MW of solar capacity on idle areas close to highways in South Korea.

In the future, the country may host one of the world's largest floating PV projects – a 2.1 GW floating solar complex - that the South Korean government is developing near the Saemangeum tidal flats, on the coast of the Yellow Sea.

https://www.pv-magazine.com

Zinc-air batteries get solar energy makeover

Researchers at the Korea Institute of Science and Technology (KIST) developed a technology to improve the electrochemical performance of zinc-air batteries by utilizing solar energy. Zinc-air batteries, which produce electricity through a chemical reaction between oxygen in the atmosphere and zinc, are considered to be the next-generation candidatesrather than lithium-ion batteries to meet the explosive demand for electric vehicles. The devices theoretically meet all required characteristics for next-generation secondary batteries, such as high energy density, low risk of explosion, eco-friendliness and low cost of materials.

The battery developed at KITS utilizes a photoactive bifunctional air-electrocatalyst with a semiconductor structure with alternating energy levels, which significantly improves the rates of oxygen reduction reaction (ORR) and oxygen evolution reaction (OER) that generate electricity. The photoactive bifunctional catalyst is a compound that accelerates chemical reactions by absorbing light energy and has an improved light absorption ability compared to conventional zinc-air battery catalysts.

In a zinc-air battery, which uses metal and air as the anode and cathode of the battery, OER and ORR must be alternately performed for electrical energy conversion of oxygen as the cathode active material. Therefore, the catalytic activity of the positive electrode current collector, made of carbon material, is an important factor in determining the energy density and overall cell efficiency of zinc-air batteries.

Accordingly, the research team focused on the p-n heterojunction, the basic structural unit of solar cells and semiconductors, as a measure to improve the slow catalytic activity of zinc-air batteries. The goal was to accelerate the oxygen production-reduction process by using the interface characteristics of semiconductors in which electron movement occurs. To this end, a cathode material with a heterojunction bandgap structure was synthesized, with an n-type semiconductor.

In addition, an experiment was conducted under real-world conditions without light in order to confirm the commercial potential of the photoactive bifunctional catalyst with a p-n heterojunction structure with alternating energy levels. The prototype battery showed an energy density of 731.9 mAh gZn-1, similar to the best energy efficiency performance of existing zinc-air batteries.

In the presence of sunlight, the energy density increased by about 7% up to 781.7 mAh gZn-1 and it showed an excellent cycle performance of 334 hours at1,000 cycles, the best among known catalysts.

https://www.mining.com

Green hydrogen production

Researchers have developed a new photoelectrode structure that is used for the production of green hydrogen which does not involve any fossil fuel during its creation process. The new structure allows the electrode to have 400 percent more efficiency than current photoelectrodes.

A photoelectrode is a semiconductor that absorbs solar energy to initialize electrochemical transformations. The electrode dissociates water molecules into hydrogen and oxygen. Because the photoelectrode uses sunlight as its main energy source, the semiconductor is perfect for the production of green hydrogen which relies on renewable energy for its production. Normally, a photoelectrode is created by embedding self-assembled nanopillars in a semiconductor film, without regarding the detailed structure of the stacked material. Such production methods lead to a lowered efficiency of electrical charge collection.

The National Research Foundation of Korea (NRF) stated that a joint team involving researchers from NRF, Ajou University, and Stanford University developed a photoelectrode with a dual-textured heterostructure. Researchers said that the new semiconductor has a largersurface area for the production of hydrogen compared to conventional electrodes. The larger the surface area, the more effective the electrode becomes.

"This research has a meaning as it suggested a new idea to the field of dual-textured heterostructures," Ajou University researcher Cho In-sun said in a statement on April 5. The research paper was published in *Chemical Engineering Journal*, an international scientific journal.

https://www.ajudaily.com

SINGAPORE

Efficiency record for solar cell technology

A team of researchers from the National University of Singapore (NUS) has set a new record in terms of the power conversion efficiency of solar cells made using perovskite and organic materials. This technological breakthrough paves the way for flexible, light-weight, low cost and ultra-thin photovoltaic cells which are ideal for powering vehicles, boats, blinds and other applications.

"Technologies for clean and renewable energy are extremely important for carbon reduction. Solar cells that directly convert solar energy into electricity are among the most promising clean energy technologies. High power conversion efficiency of solar cells is critical for generating more electrical power using a limited area and this, in turn, reduces the total cost of generating solar energy," explained lead researcher Presidential Young Professor Hou Yi, who is from the NUS Department of Chemical and Biomolecular Engineering and also leads the "Perovskite-based Multi-junction Solar Cells Group" at the Solar Energy Research Institute of Singapore at NUS.

"The main motivation of this study is to improve the power conversion efficiency of perovskite/organic tandem solar cells. In our latest work, we have demonstrated a power conversion efficiency of 23.6% - this is the best performance for this type of solar cells to date," added Dr Chen Wei, Research Fellow at the NUS Department of Chemical and Biomolecular Engineering and the first author of this work.

This achievement is asignificant leap from the current power conversion rate of about 20% reported by other studies on perovskite/organic tandem solar cells, and is approaching the power conversion rate of 26.7% of silicon solar cells, which is the dominating solar technology in the current solar photovoltaic (PV) market. This innovation was published in *Nature Energy* on 20 January 2022. The research was conducted in collaboration with scientists from the University of Hong Kong, China and Southern University of Science and Technology, also in China.

In their latest project, Assistant Professor Hou and his team break new ground in the field of perovskite/organic tandem solar cells. Their discovery opens the doors to thin-film tandem solar cells that are light and bendable, which could have wide-ranging applications such as solar-powered blinds, vehicles, boats and other mobile devices.

A tandem solar cell comprises two or more subcells electrically connected using interconnecting layers (ICLs). The ICL plays a critical role in determining the performance and reproducibility of a device. An effective ICL should be chemically inert, electrically conductive and optically transparent.

Although perovskite/organic tandem solar cells are attractive for next-generation thin-film photovoltaics, their efficiency lags behind other types of tandem solar cells. To address this technological challenge, Asst Prof Hou and his team developed a novel and effective ICL that reduces voltage, optical and electrical losses within the tandem solar cell. This innovation significantly improves the efficiency of the perovskite/organic tandem solar cells, achieving a power conversion rate of 23.6%.

https://www.newswise.com

Biodegradable batteries

A team of scientists at the Nanyang Technological University (NTU) in Singapore have developed paper-thin biodegradable zinc batteries in an attempt to find a sustainable option for powering flexible and wearable electronic systems.

The paper-thin zinc batteries are made of electrodes that are screen printed onto both sides of a piece of cellulose paper which is then reinforced with hydrogel. The thickness of the battery is around 0.4mm, which is roughly the thickness of two strands of human hair. As the printed paper items are extremely thin and non-toxic, they do not require aluminium or plastic casings or packaging to encapsulate the battery components. Also, avoiding the packaging layers enables the battery to store a higher amount of energy, and thus power, within a smaller system. Once the battery reaches the end of its usable life, it can be buried in the soil, where it breaks down completely within a month.

According to the *Journal of Advanced Science*, the NTU research team used a 1.5 in x 1.5 inches (4 cm x 4 cm) square printed paper battery to successfully power a small electric fan for up to 45 minutes. The researchers also pointed out that even bending or twisting the battery did not affect the power supply.

Also, in another experiment they used a 4cm x 4cm battery to power an LED where it remained lit even after cutting away parts of the paper battery. The research team opined that their biodegradable paper-thin batteries could be used for flexible electronics such as wearables and foldable smartphones. They could also be used in biomedical sensors for health monitoring. It could also solve the issue of finding batteries of the right size.

https://www.thebetterindia.com

THAILAND

Floating solar farm

Renewables firm BayWar.e has worked with one of Thailand's leading manufacturers and distributors of processed cassava products – Ubon Bio Ethanol PCL (UBE) - to set up its first floating solar platform in Ubon Ratchathani, The Floating Photovoltaic farm, often termed "floatovoltaic", is expected to generate 2.83 MW or about 4,440 MWh of energy in the first year of operation alone. The project started supplying electricity as Commercial Operation Date (COD) in early 2022 and it is the first floating solar cell platform project operate as Corporate PPA in Thailand.

Two floating platform technologies have been deployed over two ponds, with one using a pure pontoon technology and the other deployed with a pontoon and metal support structure floating technology. In addition, the project is made up of 6,900 units of bifacial PV modules and a bespoke Medium Voltage SKID being engineered for the floating farms.

"This project with UBE in UbonRatchathani sets the stage for more floating solar opportunities not only in Thailand but beyond for BayWar.e. Many countries and urban cities in Asia face issues with land scarcity and as such, we are constantly looking at innovative and new ways to adapt, providing solutions that work locally driven not only at the government level, but also complemented by private sector led initiatives." said Daniel Gaefke, APAC Director, BayWar.e. In developing its floatovoltaic farm, BayWar.e. was selected as UBE's partner because of the firm's successful track record globally and in the region.

"Sustainability is important to UBE for both social and environmental dimensions, and it is our mission to be responsible corporate citizens. The solar floating farm in UbonRatchathani is one of many renewable energy projects we have done as we place more emphasis on sustainable operations and the use of clean energy. Furthermore, waste from the production process is used to create renewable energy. In total, we are now generating more than 10 MWh in electricity alone from renewable energy. UBE is passionate and ambitious about our sustainability initiatives and is targeting to operate on 100% green energy."

The project in Ubon Ratchathani, with UBE, represents BayWar.e.'s desire to partner with corporations and government agencies in Thailand and around the region to work on clean energy projects. Working with UBE on the floatovoltaic farm in Ubon marks BayWar.e.'s first floating solar project outside of Europe and the first in Asia Pacific, with more upcoming projects in the pipeline, including a few in Asia Pacific.

https://www.pv-magazine.com

EUROPE

GERMANY

New record for solar cell efficiency

A German research team has developed a tandem solar cell that reaches 24 percent efficiency – measured according to the fraction of photons converted into electricity (i.e. electrons). This sets a new world record in terms of the highest efficiency achieved so far with this combination of organic and perovskite-based absorbers. The solar cell was developed by Professor Dr. Thomas Riedl's group at the University of Wuppertal together with researchers from the Institute of Physical Chemistry at the University of Cologne and other project partners from the Universities of Potsdam and Tübingen as well as the Helmholtz-Zentrum Berlin and the Max-Planck-Institut für Eisenforschng in Düsseldorf. The results have been published today (April 13, 2022) in *Nature* under the title "Perovskite/organic tandem solar cells with indium oxide interconnect."

Conventional solar cell technologies are predominantly based on the semiconductor silicon and are now considered to be "as good as it gets." Significant improvements in their efficiency – i.e., more watts of electrical power per watt of solar radiation collected – can hardly be expected. That makes it all the more necessary to develop new solar technologies that can make a decisive contribution to the energy transition. Two such alternative absorber materials have been combined in this work. Here, organic semiconductors, which are carbon-based compounds that can conduct electricity under certain conditions, were used. These were paired with a perovskite, based on a lead-halogen compound, with excellent semiconducting properties. Both of these technologies require significantly less material and energy for their production compared to conventional silicon cells, making it possible to make solar cells even more sustainable.

As sunlight consists of different spectral components, i.e. colors, efficient solar cells have to convert as much of this sunlight as possible into electricity. This can be achieved with so-called tandem cells, in which different semiconductor materials are combined in the solar cell, each of which absorbs different ranges of the solar spectrum. In the current study the organic semiconductors were used for the ultraviolet and visible parts of the light, while the perovskite can efficiently absorb in the near-infrared. Similar combinations of materials have already been explored in the past, but now the research team succeeded in significantly increasing their performance.

At the start of the project, the world's best perovskite/organic tandem cells had an efficiency of around 20 percent. Under the leadership of the University of Wuppertal, the Cologne researchers, together with the other project partners, were able to increase this value to an unprecedented 24 percent. "To achieve such high efficiency, the losses at the interfaces between the materials within the solar cells had to be minimized," said Dr. Selina Olthof of the University of Cologne's Institute of Physical Chemistry. "To solve this problem, the group in Wuppertal developed a so-called interconnect that couples the organic subcell and the perovskite sub-cell electronically and optically."

As interconnect, a thin layer of indium oxide was integrated into the solar cell with a thickness of merely 1.5 nanometres to keep losses as low as possible. The researchers in Cologne played a key role in assessing the energetic and electrical properties of the interfaces and the interconnect in order to identify loss processes and further optimize the components. Simulations by the group in Wuppertal showed that tandem cells with an efficiency of more than 30 percent could be achieved in the future with this approach.

https://scitechdaily.com

SWEDEN

New energy storage system

Researchers from Sweden's Chalmers University of Technology designed an energy system that stores solar energy in liquid form for up to 18 years, a press statement reveals. With the help of scientists from China›s Shanghai Jiao Tong University, the Chalmers team has tested its device, called the Molecular Solar Thermal system (MOST), by connecting it to a thermoelectric generator, proving that it can produce electricity on-demand. The Chalmers team has been working on its technology for more than a decade, and it believes it may soon be a viable option for charging low-power electronics devices.

The system was designed using specially-developed molecules of carbon, hydrogen, and nitrogen. When these are hit by sunlight, the atoms within the molecules are rearranged, turning them into an energy-rich isomer that's stored in liquid form. Impressively, the researchers say their system stores energy in this liquid form for up to 18 years. It is then released using a special catalyst that returns the molecules to their original shape, releasing the stored energy as heat.

The Chalmers researchers collaborated with scientists from China's Shanghai Jiao Tong University, who brought a thermoelectric generator to the table. This allowed them to produce a small amount of electricity, though the collaborators believe this could be improved by future models.

"The generator is an ultra-thin chip that could be integrated into electronics such as headphones, smart watches, and telephones," said researcher Zhihang Wang from the Chalmers University of Technology. "So far, we have only generated small amounts of electricity, but the new results show that the concept really works. It looks very promising."

According to research leader Kasper Moth-Poulsen, Professor at the Department of Chemistry and Chemical Engineering at Chalmers, the MOST system "means that we can use solar energy to produce electricity regardless of weather, time of day, season, or geographical location. It is a closed system that can operate without causing carbon dioxide emissions."

The proof of concept's current output stands at a relatively small 0.1 nW, though the researchers say their system could be used to address the issue of solar energy being intermittent by storing energy for months on end and deploying it just when it's needed. A finished model could be used to power small electronic devices. Next, the Chalmers team aims to improve their system's performance and also are also working on building an affordable commercial version of their system that could potentially be used in homes.

https://interestingengineering.com

UK

Hydrogen fuel cell

Scientists at Imperial College London have engineered a hydrogen fuel cell that utilizes iron rather than rare and expensive platinum, allowing better application of the technology. Hydrogen fuel cells transform hydrogen into electricity with water vapor being the sole by-product, rendering them an appealing green substitute for portable power sources, especially for vehicles. Nevertheless, their extensive use has been hindered partly by the cost of one of the main parts. To enable the reaction that generates the electricity, the fuel cells depend on a catalyst composed of platinum, which is costly and rare.

Currently, a European team directed by scientists at Imperial College London has developed a catalyst using just iron, nitrogen and carbon — materials that are inexpensive and easily available — and shown that it can be used to operate a fuel cell at high power. Their outcomes are reported in the journal *Nature Catalysis*.

The team's innovative goal was to create a catalyst where all the iron was spread as single atoms inside an electrically conducting carbon matrix. Single-atom iron possesses more diverse chemical properties than bulk iron, where all the atoms are crowded together, making it additionally reactive. These properties will enable the iron to boost the reactions desirable in the fuel cell, serving as a good alternative for platinum. In laboratory trials, the researchers demonstrated that a single-atom iron catalyst has a performance close to that of platinum-centered catalysts in an actual fuel cell system.

Besides creating an inexpensive catalyst for fuel cells, the technique the researchers formulated could be adjusted for other catalysts in other processes, for example, chemical reactions utilizing atmospheric oxygen as a reactant rather than costly chemical oxidants, and in wastewater treatment using air to eliminate harmful pollutants.

The researchers worked together with UK fuel cell catalyst producer Johnson Matthey to test the catalyst in suitable systems. They hope to expand their new catalyst's scope, so that it can be employed in commercial fuel cells. For the time being, they are aiming to enhance the stability of the catalyst, so that it equals platinum in both durability and performance.

https://www.azocleantech.com

Ultra-thin solar panels

A team of researchers from the University of Surrey and Imperial College London collaborated with Amsterdam's research institute AMOLF to develop a method to help achieve a 25% increase in energy levels absorbed by wafer-thin solar photovoltaic (PV) panels. The researchers claim that their solar panels, just one micrometer thick (1µm), convert light into electricity more efficiently than others due to their thinness and pave the way towards making it easier to generate more clean, green energy.

In the paper published in the American Chemical Society's (ACS) journal *Photonics*, the team demonstrates the power of hyperuniform disordered (HUD) patterns for lightweight, flexible, and efficient PVs by focusing on the absorption properties in ultrathin (~1 µm) silicon.

The HUD pattern consists of a two-dimensional network of silicon walls resembling the underlying honeycomb structure in black butterfly wings. The current 3D nanophotonic wafer designs can only prevent light reflection via impedance matching of the solar cell, but it fails to extend the light paths in silicon cells required for photon absorption.

Dr. Marian Florescu from the University of Surrey's Advanced Technology Institute (ATI) said, "One of the challenges of working with silicon is that nearly a third of light bounces straight off it without being absorbed and the energy harnessed. A textured layer across the silicon helps tackle this, and our disordered yet hyperuniform honeycomb design is particularly successful."

Hyperuniform disordered media are isotropic (having the same properties in all directions) and possess constraint randomness — such that the density fluctuations on large scales behave more like those of ordered solids. HUDs are highly flexible mediums to control light transport, emission, and absorption in unique ways. In the study, the research team achieved light absorption in a 1 micrometer (~1 µm) thick silicon slab, over twofold in the wavelength range from 400 to 1000 nm when textured with optimized HUD patterns compared to slabs that are without patterns.

The level of absorption obtained is the highest demonstrated until now in a silicon slab as thin as one micrometer. To achieve this, researchers pursued the approach of k-space engineering (an array of numbers representing spatial frequencies in the MR image) of HUD patterns with a tailored scattering spectrum and diffractive coupling of solar irradiation into guided modes of the silicon slab.

The team focused on the trade-off between light trapping and increased carrier recombination shown by the nanostructures. On investigation, they discovered that efficiencies above 20% could be obtained for several optimized HUD designs and state-of-the-art silicon PV technologies. The team used the diffraction approach in the absorber to enhance light trapping into the ultrathin photovoltaic. Guided modes of thin silicon slab tend to become leaky (quasi-guided) in the presence of textures, which can in and out couple to the electromagnetic modes supported by the surrounding medium. Total absorption is achieved by summing the coupling contributions of each mode.

To maximize the sunlight absorption in the slab, the team efficiently coupled the loose modes for wavelengths ranging from 350 nm to 1100 nm. Due to several modes in a one µm silicon slab, a pattern structure that diffracts incident light to the range from ~15µm to ~20µm raise to minus one ensures all sunlight has a mode to couple to. The team decorated the two-dimensional HUD point pattern with 200 nm tall silicon walls following a Delaunay tessellation protocol (fundamental computational geometric structure) that forms a continuous silicon network.

However, the light absorption with the two-phase design was no longer expected to be optimal as the 3D texture strongly disrupted the wavelengths of the silicon slab. Researchers then considered the power spectral density (PSD), which is the Fourier transform of the 2D design, to represent scattering strength better. The tessellation protocol causes the resulting 3D network to become nearly hyperuniform.

The team successfully demonstrated light trapping in the thinnest silicon slab by decorating the point pattern with two materials in a wall network fashion. In the laboratory, absorption rates of 26.3 mA/cm2 were achieved, a 25% increase from the previous record of 19.72 mA/cm2 in 2017. They secured an efficiency of 21% but anticipate that further improvements will push the figure higher, resulting in significantly better efficiencies than many commercially available photovoltaics.

Besides improving solar power generation, the findings could also benefit other industries where light management and surface engineering are crucial, such as photo-electrochemistry, solid-state light emission, and photodetectors.

https://mercomindia.com

Rigid and flexible solar modules

A group of researchers at Dartmouth College in New Hampshire, USA, have developed a new flexographic printing method that can help manufacture Perovskite solar cells quickly and reliably. This new technique brings inexpensive mass printing of solar cells closer to reality. Perovskites are materials that have the same crystal structure as the mineral calcium titanium oxide, which was the first-discovered perovskite crystal.

These materials have shown potential for high performance and low production costs when used to create solar cells. The researchers documented their findings in a study titled, "Eliminating the Perovskite Solar Cell Manufacturing Bottleneck via High-Speed Flexography," published in *Advanced Materials Technologies*. The authors of the paper are Julia Huddy, a third-year PhD student at Dartmouth; Youxiong Ye, a former postdoctoral researcher at the university and is now working as a metallurgist at an American steel corporation, and William Scheideler, Assistant Professor of Engineering at the university.

Currently, all the commercially produced solar panels use solar cells made from silicon which must be processed to very high purity. This energy-intensive process uses large amounts of hazardous solvents and is also very expensive. In comparison, these perovskite cells are made of layers of minuscule crystals made of low-cost light-sensitive materials. The raw materials can be mixed into a liquid to form a kind of ink that can be printed onto many different kinds of materials.

The new printing method developed by the engineers at the Dartmouth Engineer combines high-speed flexography, where ink is applied to various surfaces using flexible printing plates, and sol-gel inks composed of perovskite crystals. This accelerates the processing time of the material by 60 times, according to the study.

https://indianexpress.com

NORTH AMERICA

USA

Solar panels that work at night

Researchers at Stanford modified commercially available solar panels to generate a small amount of electricity at night by exploiting a process known as radiative cooling, which relies on, no lie, the frigid vacuum of space. The research was published in early April 2022 in *Applied Letters in Physics*.

"We tend to think of the sun as the important renewable energy resource," said Shanhui Fan, the lead researcher on the project. "The coldness of outer space is also an extremely important renewable energy resource. "While the modified panels generate a tiny amount of energy compared with what a modern solar panel does during the day, that energy could still be useful, especially at night when energy demand is much lower, "the researchers said. Technically speaking, the modified solar panels don't generate solar electricity at night. Instead of exploiting sunlight (or starlight or moonlight, which still doesn't work), the researchers added technology that exploits radiative cooling."

When an object is facing the sky at night, it radiates heat out to outer space, which means that an object can become cooler than the air temperature around it. This effect could have obvious applications in cooling buildings, but the difference in temperature can also be used to generate electricity.

Fan, a professor of electrical engineering, and his fellow researchers added technology to a commercial solar panel that could do just that and were able to generate a small amount of electricity at night. The modified panel generated 50 milliwatts per square meter at night. While that's much more than previous iterations of this technology, it's well below what a commercial solar panel can produce during the day. One back-of-the-envelope calculation returns close to 200 watts per square meter for one commercial solar panel.

"So, this is significantly lower," Fan said. "But it may potentially be useful for some of the low power density applications." That might include nighttime lighting, charging devices, and keeping sensors and monitoring equipment online, Fan said. Fan says that the modifications were made to commercial solar panels, which means the technology could be widely deployed. He also said that by improving the design, more electricity could be generated.

There are still a lot of questions to be answered before any commercial application can be rolled out, Geoff Smith, emeritus professor in applied physics at The University of Technology Sydney, wrote in an email response to questions. Smith, who was aware of the research but not involved, has doubts that it ever will be an economically viable source of energy." Adding complexity and avenues for degradation to renewable energy systems despite being scientifically interesting rarely makes it in practice," he wrote.

In response, Fan says that the research proves that you can generate electricity in this way, and it wasn't meant to prove anything about future practical applications. Still, Smith agrees that greater attention should be paid to outer space as a renewable energy source. In his view, cooling and other modes of electricity generation are more promising, but the night sky is indeed a valuable avenue for shifting energy use. Even if it's not yet producing a lot of electricity, radiative cooling is pretty much ubiquitous.

https://www.cnet.com

AI to help scale up solar cell manufacturing

Perovskites are a family of materials that are currently the leading contenders to potentially replace today's silicon-based solar photovoltaics. They hold the promise of panels that are far thinner and lighter, that could be made with ultra-high throughput at room temperature instead of at hundreds of degrees, and that are cheaper and easier to transport and install. But bringing these materials from controlled laboratory experiments into a product that can be manufactured competitively has been a long struggle.

Manufacturing perovskite-based solar cells involves optimizing at least a dozen or so variables at once, even within one particular manufacturing approach among many possibilities. But a new system based on a novel approach to machine learning could speed up the development of optimized production methods and help make the next generation of solar power a reality.

The system, developed by researchers at MIT and Stanford University over the last few years, makes it possible to integrate data from prior experiments, and information based on personal observations by experienced workers, into the machine learning process. This makes the outcomes more accurate and has already led to the manufacturing of perovskite cells with an energy conversion efficiency of 18.5 per cent, a competitive level for today's market.

The research is reported today in the journal *Joule*, in a paper by MIT professor of mechanical engineering TonioBuonassisi, Stanford professor of materials science and engineering Reinhold Dauskardt, recent MIT research assistant Zhe Liu, Stanford doctoral graduate Nicholas Rolston, and three others.

Perovskites are a group of layered crystalline compounds defined by the configuration of the atoms in their crystal lattice. There are thousands of such possible compounds and many different ways of making them. While most lab-scale development of perovskite materials uses a spin-coating technique, that's not practical for larger-scale manufacturing, so companies and labs around the world have been searching for ways of translating these lab materials into a practical, manufacturable product.

"There's always a big challenge when you're trying to take a lab-scale process and then transfer it to something like a startup or a manufacturing line," says Rolston, who is now an assistant professor at Arizona State University. The team looked at a process that they felt had the greatest potential, a method called rapid spray plasma processing, or RSPP.

The manufacturing process would involve a moving roll-to-roll surface, or series of sheets, on which the precursor solutions for the perovskite compound would be sprayed or ink-jetted as the sheet rolled by. The material would then move on to a curing stage, providing a rapid and continuous output "with throughputs that are higher than for any other photovoltaic technology," as per Rolston.

https://news.mit.edu

Plant-based jet fuel

Researchers at Washington State University announced the development of a plant-based jet fuel that could displace petroleum-derived fuels. Based on lignin, an organic polymer in plants, the WSU jet fuel was tested for its energy density, fuel efficiency and emissions. The results, the WSU team says, suggest their fuel, when combined with other bio-fuels, could serve as a 100% drop-in replacement.

According to Bin Yang, professor with WSU's Department of Biological Systems Engineering and co-author of a study recently published in the journal *Fuel*, the lignin-based fuel displayed increased energy density and could totally replace aromatics.

"Aromatics are associated with increased soot emissions, as well as contrails, which are estimated to contribute more to the climate impact of aviation than carbon dioxide," said Joshua Heyne, co-author, University of Dayton scientist and current co-director of the joint WSU-Pacific Northwest National Laboratory Bioproducts Institute.

"Aromatics are still used in fuel today because we do not have solutions to some of the problems they solve: they provide jet fuel with a density that other sustainable technologies do not," he added. "Most unique is their ability to swell the O-rings used to seal metal-to-metal joints, and they do this well."

Yang developed a patented process that turns lignin from agricultural waste into bio-based lignin jet fuel. Such sustainable fuel, the researchers say, could help the aviation industry reduce dependance on increasingly expensive fossil fuels while meeting higher environmental standards. Additional contributors to the study include Zhibin Yang, University of Dayton; Zhangyang Xu and Maoqi Feng, WSU; John Cort, Pacific Northwest National Laboratory; and RafalGieleciak, Natural Resources Canada.

Yang and his team's research has been supported by the DARPA through the U.S. Department of Defense, the U.S. Department of Energy, the National Science Foundation, the U.S. Department of Transportation, the National Renewable Laboratory, the Joint Center for Aerospace Technology Innovation and WSU's Bioproducts, Science and Engineering Laboratory.

https://www.design-engineering.com

Device to convert heat into electricity

Most of the world's electricity today is produced by burning coal or natural gas to boil water and create steam for spinning turbines. In a paper published in *Nature*, researchers have now reported a solid-state device with no moving parts that can convert heat into electricity with an efficiency higher than that of steam turbines. The breakthrough could lead to an affordable and low-maintenance thermal battery system for storing renewable energy on the grid.

The new device, which its developers at MIT and the National Renewable Energy Laboratory call a heat engine, is a thermophotovoltaic (TPV) cell. Just like solar cells convert sunlight into electricity, TPV cells are made of materials that can convert infrared radiation from heat sources into electricity. The efficiency of these cells so far has hovered around 32 percent because they operate at lower temperatures.

By combining two different metal alloy layers, the researchers have made a device that harnesses heat from white-hot sources at temperatures of 1,900 to 2,400°C. The top layer absorbs the highest-energy infrared waves, while the lower layer captures lower-energy radiation. A mirror at the bottom of the device reflects any unabsorbed heat back to the heat source, so that it can be reused.

A 1cm x 1cm prototype device made by the researchers was able to produce electricity with 40 percent efficiency. By contrast, the average steam turbine has an efficiency of around 35 percent. With better reflectors the TPV efficiency could go up to 50 percent, the team says. Plus, what gives TPVs added advantage over steam engines is also "the potential for lower cost, faster response times, lower maintenance, ease of integration with external heat sources and fuel flexibility."

For a grid-scale thermal battery, the team envisions a system in which surplus electricity from wind or solar farms could be stored in insulated banks of materials such as graphite. When the grid needs power, TPVs could convert the stored heat into electricity and send it to the grid. Such a large-scale system would need TPV cells that are 10,000 square feet in size, or about a quarter of a football field. But Henry points out that the existing infrastructure for making large-scale photovoltaic cells could be adapted to manufacture TPVs.

https://www.anthropocenemagazine.org

Transfer of Technology, MSMEs and Sustainable Development

The Indonesian Story

Tulus T.H. Tambunan
Center for Industry, SME and Business Competition Studies
Universitas Trisakti Kampus A, Grogo, Jakarta Barat, 11440, Indonesia
Tel: 62-21-5663232
Emails: tulustambunan@trisakti.ac.id
ttambunan66@yahoo.com

Abstract

Indonesia is committed to working toward achieving 17 sustainable development goals (SDGs) by 2030. One group of business actors who play an important role in this endeavor is micro, small, and medium enterprises (MSMEs) because they are the largest source of job and business opportunities in the country. But to be able to fulfil this role, they need technological assistance and the Indonesian government hopes that foreign direct investment (FDI) can transfer technologies to local MSMEs through measures like subcontracting arrangements. This article discusses the importance of MSMEs in achieving sustainable economic development and the transfer of technology (ToT) through FDI to these enterprises in Indonesia. Although without strong evidence due to the lack of data and empirical research, it assumes that the government's efforts to promote ToT have not been very successful due to various problems in its ToT policy. It also discusses the ecosystem of technology transfer and diffusion in Indonesia.

Introduction

It has been recognized worldwide that micro, small and medium enterprises (MSMEs) play a vital role in economic development. Majority of business firms in developing and least developed countries, including small island developing states (SIDS) in the Asia-Pacific region, are MSMEs. Thus, MSMEs are critically important in this region for job creation, poverty alleviation, the improvement of income distribution, the development of the manufacturing industry, rural economic development, the growth of export especially manufactured goods, and gross domestic product (GDP) growth. Since MSMEs are labour intensive, they provide business opportunities to women and unemployed and less educated youths. In many countries, including Indonesia, MSMEs as a group are the biggest labour absorber (Tambunan, 2021). An International Finance Corporation report (IFC, 2017) extrapolating data from the World Bank Enterprise Surveys shows that there are close to 162 million formal MSMEs in developing and least developed countries, of which 41 million are microenterprises (MIEs) and 21 million are small and medium enterprises (SMEs). Countries like Brazil, China, and Nigeria contribute 67 per cent to the total number of MSMEs, which is equivalent to 109 million enterprises. There are close to 12 million MSMEs in China alone, which represent 56 per cent of all MSMEs in developing countries. China also has 44 million MIEs, which represent 31 per cent of all MIEs in developing countries. There is a large concentration of MSMEs in the East Asia region (64 million), followed by Sub-Saharan Africa, which has 44 million enterprises, the majority of which (97 per cent) are MIEs.

In developing economies in the Asia-Pacific region, more than 98 per cent of companies were considered MSMEs with more than half of the economies, including Indonesia, holding a share of more than 99 per cent (Table 1). This share has remained constant over the past decade for all economies. Based on how each economy defined its MSMEs and the availability of most recent data, nearly 150 million businesses in the region were considered as MSMEs, representing around 99.8 per cent of all businesses in the region. It is important to note that what is considered as MSMEs in one economy may not be considered as MSMEs in other economies given the fact that economies in the region define MSME differently.

Given their vital role discussed above, especially in poverty eradication, mostly amongst women, the United Nations (UN) has assigned a great role to MSMEs to take a lead in achieving most of the economic-related sustainable development goals (SDGs). They include promoting inclusive and sustainable economic growth, increasing productive employment opportunities and decent work especially for the poor and vulnerable, particularly women and youth, advancing sustainable industrialization and innovation, and creating a positive push for a higher quality of life, better education and good health for all (OCED, 2017, cited in Dasaraju et al., 2020). At least theoretically, as they are the greatest generator of employment and business opportunities in developing and least developed countries, MSMEs are the backbone of these countries in achieving the SDGs. But, for MSMEs to be able to play this role, they must be highly competitive and able to grow rapidly in a sustainable manner.

Table 1. Number of MSMEs in selected developing economies in the Asia-Pacific Region*

Economy	Total number (million)	% of total enterprises	Year
Brunei Darussalam	5.90	97.20	2017
China	21,921.10	99.60	2017
Indonesia	64,194.10	99.99	2018
Malaysia	907.10	98.50	2015
Papua New Guinea	49.50	13.00	2016
Philippines	920.70	99.60	2017
Singapore	262.60	99.50	2018
China Taipei	1,466.20	97.60	2018
Thailand	3,077.80	99.80	2018
Viet Nam	507.90	98.10	2017

Note: * The number of MSMEs was rounded up. Source: APEC (2020).

This is where the problem lies. MSMEs, especially micro and small enterprises (MSEs) in Indonesia as probably also in all other developing and least developed countries in Asia and Pacific, have many limitations in becoming a driving force for sustainable economic development. The limitations include a lack of advanced (appropriate) technologies. Unfortunately, for these advanced technologies, Indonesian MSMEs are still much dependent on the transfer of technology (ToT) from outside including foreign direct investments (FDIs).

Although there are many ways for Indonesian MSMEs to obtain advanced technologies from outside, this paper focuses on the potential role of FDI as the main and more efficient source of technology. The Indonesian government hopes that all foreign companies can partner with local MSMEs through production linkages in the form of subcontracting and the ToT can take place through this form of business partnership.

Development of MSMEs

Data from the State Ministry of Cooperatives and SMEs (Menegkop & UKM) as well as the Central Statistics Agency (BPS) show that in 1997 there were approximately 39.765 million MSMEs representing 99.8 percent of the total business establishments in Indonesia. The number grew every year except in 1998 when the Asian financial crisis in 1997-98 hit Indonesia. However, when the national economy began to recover in 1999, the number of MSMEs started to grow again to 37.9 million enterprises or an increase of 2.98 per cent and the growth continued afterward. As Table 2 shows, the number of MSMEs was nearly 61.7 million units representing approximately 99 per cent of the total companies in Indonesia in 2016 and it increased to more than 64 million in 2018.

Sustainable Development Goals

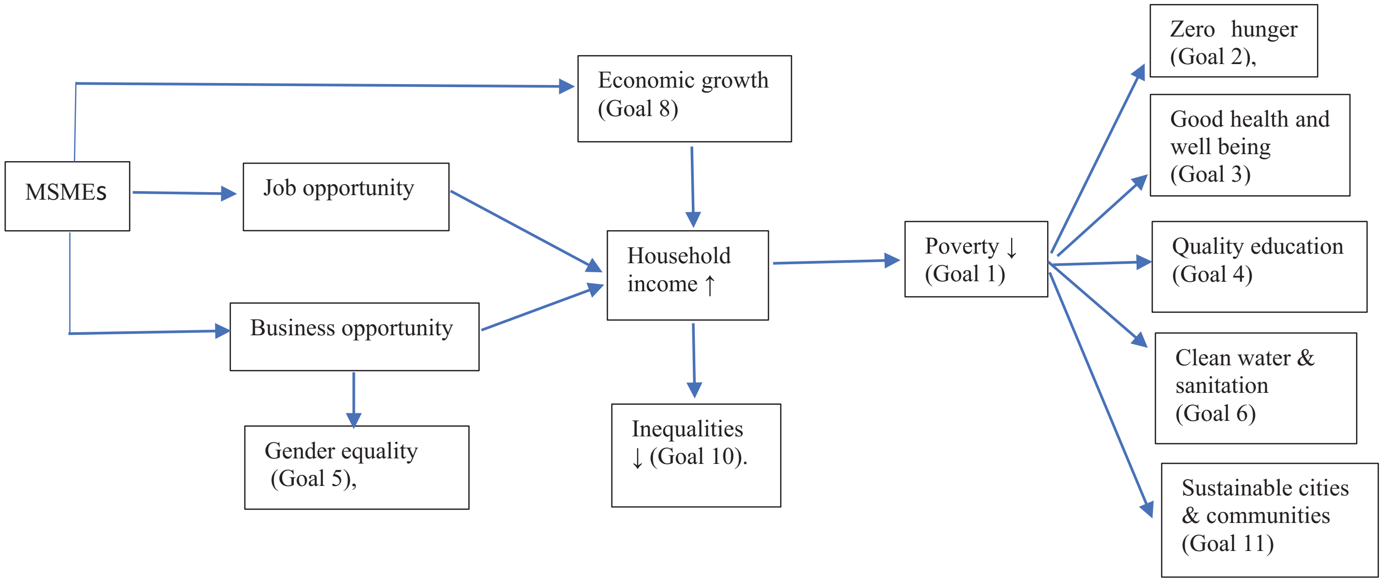
Indonesia is committed to working toward the successful implementation of the SDGs. In this regard, the Indonesia's Presidential Regulation no. 59/2017 concerning the implementation of SDGs mandated the Ministry of National Development Planning of the Republic of Indonesia to provide the Roadmap of SDGs Indonesia. The roadmap defines issues and projections of main SDGs indicators in each goal, including its forward-looking policies to achieve such targets. From the projection exercises and intervention scenarios of the indicators, it is clear that the achievement of such targets needs strong collaboration among stakeholders and commitments in both activities and financing, as the gaps still remain for achieving the ambitious 2030 agenda (Bappenas, 2019).

Table 2. Number of firms and their workers by sub-category in Indonesia, 2016-2018

Description	unit of measure	2016		2018	
		Total	Share (%)	Total	Share (%)
MSMEs	Unit	61,651,177	99.99	64,194,057	99.99
LEs		5,370	0.01	5,550	0.01
Total companies		61,656,547	100.00	64,199,607	100,00
MSMEs	People	112,828,610	97.04	116,978,631	97.00
LEs		3,444,746	2.96	3.619,507	3.00
Total workers		116,273,356	100.00	120,598.138	100.00

Source: Menegkop & UKM (http://www.depkop.go.id/)

Notes: MSMEs = micro, small and medium enterprises; Les = large enterprises

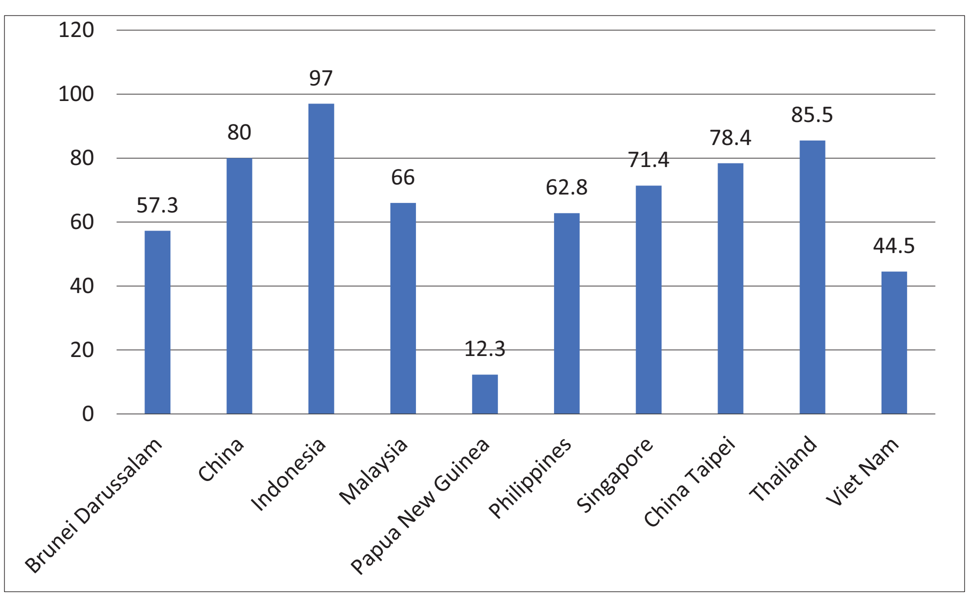


Source: Created by the author

Figure 1. The role of MSMEs in achieving various SDGs

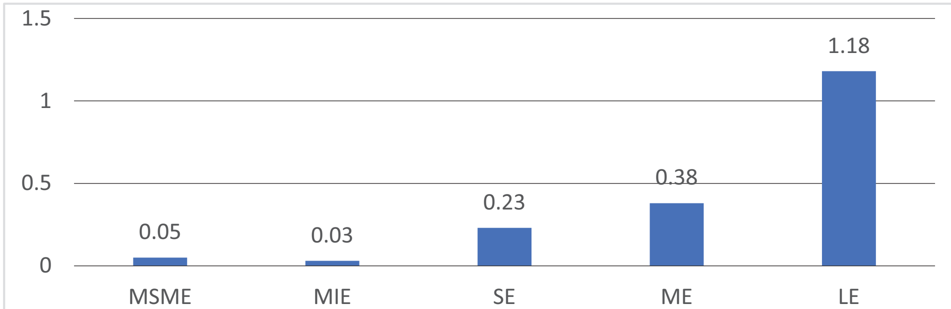
Among the stakeholders are MSMEs, and perhaps their most important role in sustainable development is as the largest source of job and business opportunities. Through the creation of job and business opportunities, MSMEs support the achievement of a number of sustainable development goals (SDGs) as Figure 1 illustrates.

In Asia Pacific, Indonesia is the economy with the largest ratio of workers in MSMEs to the total workforce. However, as shown in Figure 2, there are also many other developing economies in the region in which MSMEs absorb more than 60 per cent of the total workforce, and even a few having more than 80 per cent. It was also discovered that there were more than 950 million people employed by MSMEs across the region, depending on how each economy defines MSMEs and availability of data, and this number accounted for nearly two-thirds of the total employment in the region and remained constant for the past 5-10 years across the economies in the region with only Malaysia and Thailand observed to have experienced a substantial change over the reference period as indicated by an increase of 13.3 and 7.3 percentage points, respectively.



Source: APEC (2020)

Figure 2. Share of employment in MSMEs in selected developing economies in the Asia-Pacific region



Source: Menegkop & UKM/BPS

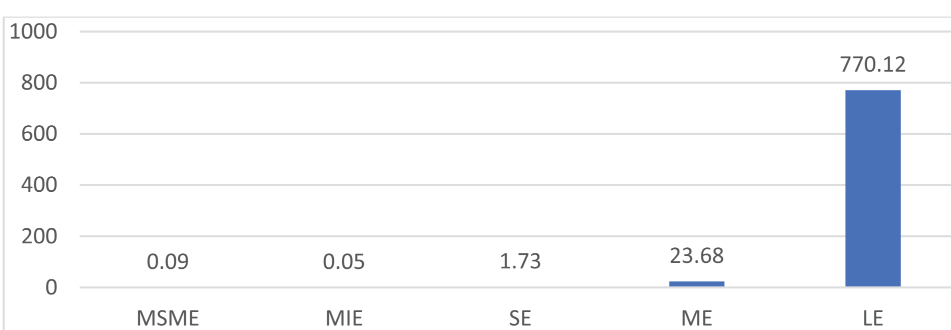
Figure 3. Labor productivity by business size in Indonesia, 2018 (IDR billion)

However, Indonesian MSMEs, particularly MIEs, have a serious problem, namely low productivity and competitiveness, and this threatens their sustainable development, which may also limit their contribution to the achievement of the country's sustainable economic growth and hence the various SDGs shown in Figure 1. Figure 3 shows that the value-added ratio (based on constant market prices) to the number of labors in the LE group (including FDI-based companies) is greater than that in the MSME group. Within the MSME group itself there are also striking differences. As can be seen in the figure, MIEs that mostly use family members as unpaid workers found to have the lowest ratio while the highest was recorded in MEs.

Figure 4 shows that there is a much greater difference in terms of productivity of firms (i.e., the ratio of output to the number of firms) between MSMEs and LEs when compared to the productivity of labor. Here MIEs have the lowest level of productivity within the MSME group.

Takii and Ramstetter (2005) attempted to measure the current technological capacity of Indonesian firms by comparing their levels of labour productivity with that of foreign firms. They compared the average levels of labour productivity, as determined by value-added labour ratio, of foreign-owned and domestic medium and large enterprises within the manufacturing sector in Indonesia. Their study shows that compared to fully locally owned enterprises, the average level of labour productivity was 388-745 per cent higher in minority foreign-owned firms, 436-594 per cent higher in majority foreign-owned firms, and 164-542 per cent higher in firms with foreign shares of 90 per cent or more. According to their finding, higher levels of labour productivity in local firms than in foreign firms were extremely rare. Since the productivity level is determined, among others, by technology, the difference in productivity can be considered as indirect evidence of Indonesian companies in general lacking technology compared to FDI-based companies.

Their finding supports the general assumption that in a developing country like Indonesia, foreign firms are more productive than local firms because they have relatively large endowments of firm-specific, generally intangible assets. One of the greatest of these intangible assets is assumed to be technological capacity. That minority foreign-owned enterprises appear to be less productive than majorly or heavily foreign firms supports the assumption that these enterprises restrict the access of minority-foreign affiliates to these firm-specific assets to avoid losing control of them.



Source: Menegkop & UKM/BPS

Figure 4. Productivity of firm by business size in Indonesia, 2018 (IDR billion)

With respect to competitiveness of MSMEs, one way to measure it is by estimating their share in total export. Based on the finding from the World Bank Enterprises Surveys, in the Asia-Pacific region, Indonesian MSMEs have a recorded share of around 13.2 per cent (Table 3). Only in Papua New Guinea, the share of MSMEs that exported directly was higher than that of LEs. In terms of the share of total sales that were exported directly by the company, this ranged from an average of 2.8 per cent for MSMEs in Thailand to 9.8 per cent for MSMEs in Malaysia. Again, apart from Papua New Guinea, LEs exported a higher share of their total sales than MSMEs did. This evidence strongly confirms that doing direct export is much more difficult than indirect export for MSMEs, especially MSEs.

Based on the above evidence, it can be argued that MSMEs in Indonesia, like in other developing and least developed countries, need to be empowered in, among others, technology. Since MSMEs, especially MSEs, have not generally been able to develop the technology they need by themselves, the ToT from outside, especially from FDIs, is very much needed.

Table 3. Exporters as a share of firms and exports as a share of total sales by size in several developing economies in the Asia-Pacific region (%)

Economy	Share of Firms Exported Directly			Share of Total Sales Exported Directly			Year
	MSEs	MEs	LEs	MSEs	MEs	LEs	
China	4.6	12.5	29.4	3.3	5.7	13.9	2012
Indonesia	5.3	7.9	25.2	2.9	5.0	11.7	2015
Malaysia	4.3	19.2	69.0	2.2	7.6	30.3	2015
Papua New Guinea	11.5	4.9	0.0	1.2	2.1	0.2	2015
Philippines	3.9	9.0	23.6	1.8	6.1	16.6	2015
Thailand	2.2	3.4	28.1	0.8	2.0	18.9	2016
Viet Nam	4.0	11.5	36.1	2.2	6.6	21.6	2015

Source: The World Bank Enterprise Surveys (www.enterprisesurveys.org.).

Note: The share of firms that exported directly included only companies with direct exports of at least 10 per cent of total annual sales.

FDI and transfer of technology

A company can obtain technology through internal and external sources—internal by doing own research and development (R&D), and external by getting technology from outside the company, either from other domestic companies, universities, R&D institutions or other agencies or through ToT from abroad.

By definition, ToT is the transfer of capabilities from technology producers to technology users or from technology owners to technology recipients. The most important thing in the ToT is know how a technology can be mastered by the users themselves. There are many channels through which the ToT can take place directly or indirectly. Among these, the most frequently mentioned in the literature are the following (e.g., Sarah Y. T., 2001; Thee Kian Wie, 2005; Egbu and Lee, 2007; Mahmoud et al., 2012; Tambunan, 2016):

i) Imported intermediate, capital or consumption goods that embody the technological know-how involved in their production. The reverse engineering of these imported goods promotes the ToT from the exporting companies to the importing companies. It can be assumed that this is also a very important channel for the ToT to Indonesia, as the country is heavily dependent on imports of many intermediate, capital and consumption goods.

ii) Attending trainings, workshops, seminars, or study abroad. This way is also effective for developing countries to get advanced technologies from developed countries. This was proven by Japan during the Meiji era when many engineers were sent abroad by the government mainly to the United Kingdom, Germany, and the United States to learn their advanced technologies. The Ministry of Education and the military selected the best graduates from educational or training institutes for continued study abroad (Oqubay and Ohno, 2019).

iii) Learning from the internet. The presence of the internet and Google makes it easy for people in developing countries to get knowledge or know-how in all areas from developed countries. This is probably the cheapest or most efficient mode of the ToT. The coverage of the ToT through this channel can be assumed to be much wider than the ToT through FDI, depending on internet conditions (ICT infrastructure and facilities) and the number of people who have access to the internet in a particular.

iv) Franchising. The ToT may also take place in connection with the system of franchising as it relates to the selling of goods and services. This form of marketing and distribution in which the owner of a business (the franchisor) grants to an individual or group of individuals (the franchisee) the right to run a business selling a product or providing a service directly to consumers using the franchisor's business system also provides knowledge or know-how to the franchisee. It is a business arrangement in which the reputation, technical information, and expertise of one party are combined with the investment of another party for the purpose of selling goods or rendering services.

v) Licensing agreement. It is an arrangement by which a company, as the holder of the technology right, authorizes or permits another company to execute the rights of the relevant technology based on a licensing contract. When that permission is given, a "licence" has been granted. This enables the latter company to have access to the technology for commercial usage.

vi) Technical assistance. For instance, the Republic of Korea and Taiwan were able to build up production capabilities through the simple assembly of mature products for exports, often developed through technical assistance provided by foreign buyers. This process of coupling exports with technology development is called "export-led technology development" (Hobday 1994; cited in Tambunan, 2006).

vii) Turnkey project. A company entrusts the planning, construction, and operation of a factory to a single technology supplier or to a very limited number of technology suppliers. Thus, the turnkey project may involve a comprehensive arrangement in which a company undertakes to hand over to another company as the technology recipient an entire industrial plant that is capable of operating in accordance with agreed performance standards.

viii) Management contract. It is an arrangement under which the operational control of a company is vested by contract in another company that performs the necessary managerial functions in return for a fee. A management contract involves not just selling a method of doing things but also actually doing it.

ix) Foreign direct investment (FDI). A company from a country that owns advanced technology makes investment in another country and at same time its local affiliates or local suppliers can gain access to its new technology and know-how directly and effectively.

Although other channels, especially the import of equipment and other capital goods (e.g., machinery and tools needed for the manufacture of products or the application of a process) and the internet, are important ToT channels, the Indonesian government relies on FDI more than any other channel for ToT. However, so far there is no strong evidence that foreign firms in Indonesia have indeed transferred their technologies to their local partners.

Because of the resources it brings and the attributes embedded in it, FDI is expected to bolster technology capabilities of local industries through the ToT and spillover effects. Foreign companies that own advanced technologies and have production linkages through subcontracting arrangements with local domestic suppliers of components and parts, for instance, may bring new opportunities and challenges to them to improve their technology capability or to innovate. The foreign companies as the buyers provide direct training to their domestic suppliers to meet technical standards for their components and parts. They may also provide direct training to the domestic retailers of their products. Thee and Pangestu (1994, cited by Tambunan, 2006), for instance, found that in an effort to increase their technological capability, Indonesian textile and garment manufacturers established strategic alliances with their Japanese counterparts to open up a vital channel of technology transfer. Similarly, business linkages with foreign firms have been a very important technology transfer channel for electronics firms, especially for consumer electronics and electronic components.

However, the evidence from their study suggests that the nature and extent of the transferred technology was limited to improvements in production capability, while more sophisticated activities that might help local firms upgrade their technological capabilities, including activities related to pre-investment, project implementation and technical changes in production or the product, were conducted by Japanese counterparts.

On the other hand, the ToT to developing and least developed countries tends primarily to impact only certain domestic, mainly larger and predominantly urban-based firms. Therefore, for the ToT to improve performance, especially productivity and competitiveness of all other companies, including MSMEs throughout the recipient countries, an effective mechanism is needed for the domestic diffusion of technical knowledge from the first recipient firm to other domestic firms, or from a local university as the first recipient to local firms. The diffusion of technology ("spillover" effects) can occur in various ways. It can occur when the domestic suppliers as the first recipient firms also have business linkages with other domestic firms or by means of magazines and newspapers, education programs and documentaries on television, seminars, workshops, training, plant visiting, and exhibitions. It can also occur if, for instance, an Indonesian manager or senior technician in a foreign firm leaves this firm to work in an Indonesian firm. The knowledge and experience this employee gained while working for the foreign firm is then deployed in the new job in the national firm (Tambunan, 2006).

Unfortunately, empirical studies on FDI as a channel for the ToT in Indonesia fail to provide strong evidence to support the general view that there is a significant degree of the ToT and spillover effect from foreign firms located in Indonesia to Indonesian firms. Moreover, whether the ToT will have a positive effect on the recipient Indonesian firms and hence the country's economic development depends on the absorptive capacity of Indonesian firms; that is, their ability to understand, assimilate, and make effective use of the transferred technology (Tambunan, 2006).

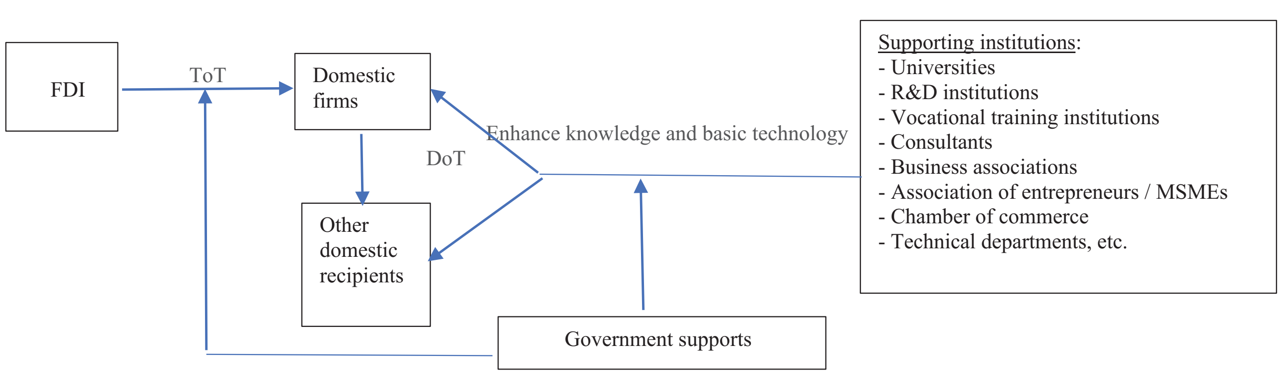
Referring to the importance of the ability of domestic companies to absorb technologies from abroad, the Law Number 18 of 2002 on the National System of Research, Development and Application of Science states that the ToT through FDI from developed countries has the potential to generate significant economic impacts on Indonesia if the business activities of the foreign companies in the country can be linked to a network of domestic firms in the production value-added chain. However, the ToT through this channel cannot run effectively if domestic firms are not ready yet or unable to meet international standards of quality, performance, and technology costs so that they do not have the eligibility to act as suppliers of these foreign companies (Sulastri, 2014).

To find out the extent to which Indonesian MSMEs are able to absorb advanced technologies brought by FDI, Tambunan has investigated production activities in a metalworking industry cluster in Tegal District located near the north coast of Central Java in Indonesia. There were several large-sized private companies that subcontracted work to Tegal metal workshops including *PT Komatsu Indonesia Tbk*, *PT Daihatsu*, and some divisions of the Astra Group such as *PT Sanwa* and *PT Katshusiro*. These companies often source metal components from several parts of the country, mostly in West Java. Among these companies, the most prominent was *PT Komatsu Indonesia Tbk*, which was a subsidiary of a Japanese company that established subcontracting production linkages with Tegal metal workshops in 1998. This company produced various types of equipment for construction and mining activities under the global trademark of Komatsu, such as hydraulic excavators, bulldozers, motor graders, frames and related components, cast steel products as well as dump tracks. The finding suggests that within the MSME group, MEs derived more benefits from the presence of FDI than their smaller counterparts, as they are better able to meet requirements to become subcontractors to various affiliates of Japanese companies technologically and managerially. In other words, MEs are more ready than MSEs to absorb advanced technologies, whereas most MSEs, especially MIEs in the cluster, lack the technical ability to produce complicated components with the precision required by *PT Komatsu*, making it unlikely that they will receive subcontracting orders. MSEs often use second-hand or homemade equipment. They hire low-skilled, low-wage workers with little or no experience and rely on the shop-owner's technical knowledge. Since many plasma owners built their expertise through working in small shops and rarely have a formal academic training, they have difficulty reading technical drawings and instead rely on copying samples, leading to less accurate output (Tambunan, 2016). And if the diffusion of technology (DoT) from MEs to MSEs across the country does not run smoothly, the spillover effect will not materialize or the ToT will be limited to MEs; hence the presence of FDI will widen the technology gap between MEs and MSEs. As a further consequence, inequality will widen and poverty will aggravate, which will, in the end, make sustainable development efforts in Indonesia fail.

Therefore, for the ToT and DoT process to run smoothly with optimal results, it requires a well-designed ToT and DoT ecosystem that involves all key stakeholders, not only FDI as a technology provider and domestic companies as the first or direct recipient (ToT) and the second or indirect recipient (DoT) (Figure 6). Other key stakeholders are institutions that provide supports or assistance to recipient companies at the first layer (ToT) and the second layer (DoT) in enhancing their knowledge and basic technology to make them able to absorb new technologies. The government also has a crucial role to play to ensure that the ToT and the DoT actually occur and the process runs smoothly without any problems by, for instance, enforcing a law that requires foreign companies licensed to operate in the country to transfer their technology or knowledge to their local workers and/or partner (e.g., domestic suppliers of components) in any form; giving a fiscal incentive for foreign companies that transfer their technology; providing a special credit scheme for domestic companies that are candidates for technology recipients; and facilitating the implementation of the ToT such as (i) creating a special website that contains ToT-related information, for instance, on foreign companies seeking local partners (e.g., component suppliers), the preconditions for partnering, the forms of incentive available for foreign companies doing the ToT, and forms of assistance available for local companies that will partner with foreign companies; and (ii) organizing business matching between foreign companies and potential local partners.

ToT policies and barriers

In the mid-1960s, foreign capital inflows into Indonesia were practically non-existent. Foreign involvement was limited to



Source: Created by the author

Figure 6. Ecosystem of ToT from FDI and DoT

oil and gas and a small number of other sectors and joint production sharing with countries from the socialist bloc. However, since the issuance of the investment law in 1967, FDI inflows into Indonesia began to enter mainly from Japan and The United States of America (USA). At that time, the Indonesian government began to realize that Indonesia could not carry out its economic development by its own strength because of constraints related to factors such as technology, skilled labour force, and capital. Indonesia desperately needs the presence of FDI especially from the West (i.e., including the USA) and Japan with the hope that it will bring advanced technologies and management know-how into the country.

Although the Indonesian government is aware of the importance of the ToT from FDI and has made some regulations to promote it, there have been a number of weaknesses so far. First, as a member country of the World Trade Organization (WTO) Indonesia has ratified the WTO convention through Law Number 7 of 1994. One of the attachments to the WTO is the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs Agreement). Consequently, Indonesia has adapted various intellectual property rights (IPR) laws to the provisions of the TRIPs Agreement. Article 7 of the agreement aims that the protection and enforcement of intellectual property rights should contribute to the promotion of technological innovation and to the transfer and dissemination of technology, to the mutual advantage of producers and users of technological knowledge and in a manner conducive to social and economic welfare, and to a balance of rights and obligations. Although one of the objectives of the TRIPs Agreement is to facilitate the spread of technology and ToT in the world, the Indonesian Intellectual Property Rights Act and other relevant laws do not regulate this matter clearly in their articles (Irawan, 2019).

Second, Indonesia already has the Government Regulation (PP) Number 20 of 2005 concerning the transfer of intellectual property technology of the and the of research and development results. But this PP does not cover technology transfer through foreign capital (FDI) or domestic investment by national companies while more than 80 per cent of technologies used in Indonesia originated from foreign countries, through either FDI or other sources.

In addition to this PP, Indonesia has several laws and regulations related to ToT issues, including laws on investment (no. 25, 2007), trade secret (no. 30, 2000), industrial design (no.31, 2000), patents (no.14, 2001), trademarks (no.15, 2001), copyrights (no.19, 2002), and the national system of research, development and application of science and technology (no. 18, 2002) (Tampubolon, 2013). In the law on patents, there are two channels for the ToT to occur, namely licensing contracts and the implementation of patents by the government (government use principle) related to the interests of defence and security as well as urgent needs for the benefit of the community. ToT is regulated in Article 10 Paragraph (4) of Law no. 25 (2007), which states that investment companies that employ foreign workers are required to organize training and carry out technology transfer to Indonesian workers in accordance with the provisions of the legislation applicable (Irawan, 2019).

Researchers usually refer to the definition of technology transfer provided in the *Transnational Corporations and Technology Transfer: Effects and Policy Issues*:

The word "technology" itself is used in at least two senses. In the first, it means technical knowledge related or know-how, i.e., knowledge related to the methods and techniques of production of goods and services. In this sense it may include the human skills required for the application of these techniques, since it is difficult to separate such application from a knowledge of the techniques themselves. In the second, broader sense, "technology" also encompasses capital goods – tools, machinery, equipment, and entire production systems – that are themselves the embodiment of technical knowledge. In some instances, the term "embodied technology" is used to distinguish capital goods from technical knowledge proper (UNCTC, 1987, page 1).

By referring to this definition, some researchers in Indonesia have tried to estimate the extent of the ToT process in the country, and although data practically does not exist, they doubt it. Of course, this is not saying that the ToT does not happen at all, but perhaps only a handful of foreign companies in Indonesia transfer their technology. In his research on the role of FDI in the ToT from a legal perspective, Irawan (2019) concludes that due to the aforementioned weaknesses, the presence of foreign companies in Indonesia are not followed by a fairly significant ToT to the country while in foreign companies in the country got a lot of investment facilities such as tax breaks, duty exemptions, land, repatriation of profits. Therefore, according to him, Indonesia needs to make a clearer rule for the ToT, and it can be done in two ways, namely through amendments or revisions of various existing laws and regulations and by making special laws on technology transfer. Some of the important things to be regulated include (i) the rules for investment contracts or technology licenses that do not limit the occurrence of ToT, (ii) the obligation to transfer technology from foreign investment companies to national companies, and (iii) the obligation of foreign investment companies that have strategic technology or which are of great importance to Indonesia to cooperate with national companies (state-owned or private companies) and transfer technology.

Sulastri (2014) also shares the same opinion that although Indonesia has a law on investment, which also requires foreign firms operating in the country to transfer their technology or know-how to their domestic partners, the foreign investment destination related to the ToT has not been seen in real terms, especially in the area of human resource development. She identifies one obstacle at the root of Indonesia's ToT problem, namely the law that regulates ToT. The ToT through FDI in Indonesia does not yet have a clear set of regulations, so here, as she explained, the term "ToT" is only seen as an option for foreign investors, not as an obligation for all foreign companies in the country.

Other main constraints that hinder the ToT from FDI to Indonesian MSMEs, especially MSEs, include (*a*) low skilled workers, (*b*) minimal amount of capital, (*c*) low mastery of basic technology, (*d*) poor management practices and no clear organizational structure, and (*e*) no innovation culture inside the company.

Conclusion

The success of developing and least developed countries in Asia-Pacific and beyond in achieving the SDGs depends not only on appropriate government policies but also on the ability of business actors including MSMEs to achieve certain SDG-related targets such as high and sustainable economic growth, increased employment with higher average income per worker, more women involved as owners or managers of MSMEs, and higher competitiveness. However, to achieve all these, MSMEs and in particular MSEs should be empowered especially in the field of technology.

For technology, the Indonesian government has long hoped for the role of FDI. Even though data is not available, it is assumed that the ToT from foreign companies in Indonesia to local MSMEs has not occurred as expected, especially because the subcontracting arrangements between FDI and local MSMEs in Indonesia are relatively weak. Apart from subcontracting production linkages, the ToT or transfer of knowledge can also occur if local employees after working for many years in foreign companies come back to work in a national company or open their own businesses. But this is even more difficult to trace.

The conclusion of this paper is that the obstacles that hinder the smooth process of the ToT come from two sources, the first being government policies or regulations that have not been very supportive so far. There is no regulation that requires every foreign company in Indonesia to do the ToT to local MSMEs and imposes a penalty if they fail to do so. The second source of obstacles is the fact that that MSMEs, especially MSEs in the manufacturing industry, agriculture and mining, are not yet technologically and managerially ready to partner with foreign companies in the country. Therefore, the government, in collaboration with the private sector, including universities, business associations, and chambers of commerce, must fully support the preparation of MSMEs as potential suppliers to FDI, especially in technology and management. Prospective suppliers must have already mastered basic technology and good management.

References

- ✓ APEC (2020), "Overview of the SME Sector in the APEC Region: Key Issues on Market Access and Internationalization", April, APEC Policy Support Unit, Singapore: Asia-Pacific Economic Cooperation Secretariat, 2020.
- ✓ Bappenas (2019), "Roadmap of SDGs Indonesia: a Highlight", Jakarta: Ministry of National Development Planning/National Development Planning Agency.
- ✓ Dasaraju, Himachalam, Kishore Somalaraju and Sreenivasa Murthy Kota (2020), "MSMEs in Developing Economies and Their Role in Achieving Sustainable Development Goals in the Context of Covid19: A Theoretical Exposition", *International Journal of Small and Medium Enterprises and Business Sustainability*, 5(2), 93-120.
- ✓ Egbu, C., and C. Cynthia Lee (2007), "Information technology Tools for Capturing and Communicating Learning and Experiences in Construction SMEs in Developed and Developing Countries", *Journal of Information Technology*, 12: 167-189.
- ✓ IFC (2017), *MSME Finance Gap*, Washington, D.C.: International Finance Corporation
- ✓ Irawan, Candra (2019), "Pengaturan Alih Teknologi pada Kegiatan Penanaman Modal Untuk Percepatan Penguasaan Teknologi di Indonesia", *Supremesi Hukum: Jurnal Penelitian Hukum*, 28(1): 71-84.
- ✓ Mahmoud, Omer' Othman khalifa; Aisha-Hassan A. Hashim; and Rashid S.A, Shihab Ahmed (2012), "Technology Transfer in Developing Countries", *Advances in Natural and Applied Sciences*, 6(5): 620-624.
- ✓ Oqubay, Arkebe and Kenichi Ohno (2019), *How Nations Learn: Technological Learning, Industrial Policy, and Catch-up*, Oxford Scholarship Online, August.
- ✓ Sarah, Y.T. (2001), "Foreign Direct Investment, Technology Transfer and Firm Performance", Hong Kong: Hong Kong Institute of Economics and Business Strategies.
- ✓ Sulastri, Endah (2014), "Analisis Kewajiban Alih Teknologi dalam Investasi Asing", *Jurnal Filsafat dan Budaya Hukum*, November: 267-280 (https://www.academia.edu/9998032).
- ✓ UNCTC (1987), Transnational Corporations and Technology Transfer: Effects and Policy Issues, United Nation.
- ✓ Takii, Sadayuki and Eric D. Ramstetter (2005), "Multinational Presence and Labour Productivity Differentials in Indonesian Manufacturing, 1975-2001", *Bulletin of Indonesian Economic Studies*, 41(2): 221-42.
- ✓ Tambunan, Tulus T.H. (2006), "Transfer of Technology to and Technology Diffusion among Non-farm Small and Medium Enterprises in Indonesia", *Copenhagen Journal of Asian Studies*, 24: 105-136.
- ✓ Tambunan, Tulus T.H. (2016), "Transfer of technology by FDI to local SMEs: A Story from Indonesia", *Asia-Pacific Tech Monitor*, 33(2):32-39.
- ✓ Tambunan, Tulus T.H. (2021), *The Role of MSMEs in Achieving SDGs in Developing Economies. The case of Indonesia*, Eliva Press, Chisinau, Moldova, 2021.
- ✓ Tampubolon, Sabartua (2013), Politik Hukum IPTEK Di Indonesia, Yogaykarta: Janabadra University Press dan KEPEL Press.
- ✓ Thee Kian Wie (2005), "The Major Channels of International Technology Transfer to Indonesia: An Assessment", *Journal of the Asia-Pacific Economy*, 10(2): 214-36.

Role of Co-Innovation in Accelerating Towards Climate Neutrality

Dr. Nandakumar Janardhanan

Research Manager, Institute for Global Environmental Strategies (IGES), 2108-11 Kamiyamaguchi, Hayama, Kanagawa, Japan- 240-0115
Tel: +81-(0)46-855-3828, Email: janardhanan@iges.or.jp, URL: http://www.iges.or.jp

Dr. Eri Ikeda

Assistant Professor, Department of Management Studies, Indian Institute of Technology, Delhi (IIT-D), IV Floor, Vishwakarma Bhavan, Saheed Jeet Singh Marg, Hauz Khas, New Delhi, India– 110016
Tel: +91-11-26597371, Email: Eri.Ikeda@dms.iitd.ac.in, URL: https://dms.iitd.ac.in/

Ms. Sruthi Kalyani

Doctoral Scholar, Centre for East Asian Studies, Jawaharlal Nehru University, New Mehrauli Road, New Delhi - 110067, India
Tel +91-11-26704346, Email: sruthikalyani.a@gmail.com

Ms. Temuulen Murun

Policy Researcher, Institute for Global Environmental Strategies (IGES), 2108-11 Kamiyamaguchi, Hayama, Kanagawa, Japan- 240-0115
Tel: +81-(0)46-826-9597, Email: murun@iges.or.jp, URL: http://www.iges.or.jp

Dr. Kentaro Tamura

Research Director, Institute for Global Environmental Strategies (IGES), 2108-11 Kamiyamaguchi, Hayama, Kanagawa, JAPAN- 240-0115
Tel: +81-(0)46-855-3812, Email: tamura@iges.or.jp, URL: http://www.iges.or.jp

Note: The authors thank Ms. Emma Fushimi for the support in finalising the manuscript.

Abstract

Today the global demand for cleaner technologies has been growing significantly to help countries meet the Paris climate goals and carbon-neutrality targets. However, developing economies, many of which are vulnerable to adverse climate impacts, continue to face critical challenges in terms of the availability, accessibility, affordability and adaptability of low-carbon technologies. This is due primarily to the fact that the existing technology transfer mechanisms have not been able to widely promote cleaner technologies in developing countries. On the other hand, though technologically advanced countries have been keen to market cleaner technologies beyond their borders, the lack of conducive economic and policy enablers continues to remain major hurdles. This paper examines the role of "co-innovation" to strengthen collaboration among technology suppliers and recipient countries, thereby helping these stakeholders accelerate towards carbon neutrality. It discusses conducive policy and legal and financial mechanisms in the backdrop of Asia and also presents the example of Japan's role in promoting clean technologies across the region.

Introduction

Technology has been playing a pivotal role in steering the development of the economy worldwide (IPCC, 2007). Economic development and increasing production and consumption patterns have resulted in increased greenhouse gas (GHG) emissions. On the other hand, it is widely understood that the use of clean technology can significantly help reduce greenhouse gas emissions and help mitigate climate change impacts.

Today, as the world is witnessing an alarming trend in terms of growing GHG emissions, it is important to make use of advanced clean technologies to leapfrog towards carbon neutrality. The Sustainable Development Scenario (SDS) of the International Energy Agency (IEA, 2021) highlighted that radical technology transformation is required in all key sectors, especially the energy sector to enable countries to achieve their net-zero emissions targets. These changes should go well beyond nominal or incremental changes of existing technology options. In fact, these should be disruptive technologies and urgently needed integration into the key sectors. For the energy sector, the SDS focuses on four types of technology options: electrifying end-use sectors (such as advanced batteries); integrating carbon capture, utilisation and storage (CCUS); developing hydrogen and hydrogen-related fuels; and developing bioenergy (IEA, 2021). Similarly, technology changes are also critical for other industrial sectors as well as the transportation sector, which together are responsible for a significant share of energy consumption and the corresponding GHG emissions.

Technological innovation and efficient technology sharing mechanisms are important for the global community to make better use of clean technologies in meeting carbon-neutrality goals (Wang, et al., 2021). There are various technology collaboration approaches to facilitate the transfer of technology or know-how among countries. The Clean Development Mechanism (CDM), which is defined in Article 12 of the Kyoto Protocol under the United Nations Framework Convention on Climate Change (UNFCCC), has played a major role in clean technology collaboration. The CDM is viewed as the first global environmental investment and credit scheme of its kind, providing a standardised emissions offset instrument (UNFCCC, 1997). Other notable efforts such as the formation of Technology Executive Committee (TEC) and the Climate Technology Centre and Network (CTCN) under the guidance of UNFCCC have also made substantial progress in the greater use of advanced technologies across the world. However, availability, affordability, accessibility, and adaptability remain key challenges that continue to hinder technology integration.

The remainder of this paper is divided into four sections. Section 2 discusses technology cooperation in the backdrop of net-zero emissions targets, and Section 3 highlights the clean technology collaboration in the Asian region. In section 4, the paper elaborates on the concept of co-innovation and its sustainability and the scalability and replicability objectives of advanced clean technologies. It also discusses policy and legal and financial mechanisms necessary to enable co-innovation. Section 5 provides a conclusion and identifies some key policy recommendations.

Need for technology collaboration against the backdrop of net-zero targets

Low-carbon technology transfer has been one of the central agendas for developing countries to enhance their economic development and reduce their GHG emissions. The expectation for developing countries has been to receive technologies from developed countries, especially from the global North and China. Conventional technology transfer typically relies on capital imports, foreign direct investment (FDI), international aid programmes, technology licensing, and joint ventures with multinational corporations (Lema & Lema, 2012) or countries. These channels rely heavily on the transfer of "hardware" and foreign counterpart's technology and investment, focusing on more diffusion in the recipient countries (Ockwell & Mallett, 2012). This type of conventional transfer also involves major financial outlays for capital imports and licensing, often draining the recipient country of financial resources. The lack of soft skills and know-how in adopting these technologies, the failure to develop locally matched and adaptable technologies, the lack of transfer of intellectual property rights, the lack of markets, and other relevant issues have hindered these traditional technology transfer mechanisms (see also, for example, (Kirchherr & Urban, 2018; Lema, et al., 2015). For conventional transfer, FDI and joint ventures tend to showcase more successful and sustainable cases (Lee & Tan, 2007; Pigato, et al., 2020). However, most of these successful technology transfer mechanisms have gone beyond the conventional transfer approaches and have built their ecosystems. Such ecosystems involves the development of a base technology originally transferred from the source country, fine-tuning the same according to local needs, and continuously incorporating elements of local knowledge and market conditions as well as taking into account the economic, social, and environmental conditions of the recipient. The development of Maruti-Suzuki in India's passenger car manufacturing sector is an example, which has even become a household name in the Indian market.

Some key emerging technologies are considered crucial for achieving net-zero targets. Examples hydrogen, efficient batteries, and Carbon Capture and Utilisation and Storage (CCUS). Though full viability of emerging technologies remains questioned, innovation is making such technologies more and more available. The renewables such as solar energy and wind energy have already become the mainstream alternative energy sources. This is primarily because the increase in the scale of deployment and such economy of scale has led to a rapid decline in cost. It now costs less to generate these forms of renewable energy, especially solar and onshore wind energy, than it does to generate energy from fossil fuels in many countries (IEA, 2020). However, upfront costs remain high for many developing countries, which hinders wider access to low-carbon technologies in developing economies (Pigato, et al., 2020). Developing economies lack not only technology but also finance and capacity. There are also limitations to accessing technology, investing in fundamental research and development (R & D), and sustainably disseminating the technology. Some economies promote locally developed and popular approaches for reducing costs and lowering the complexity needed in production, which is often termed frugal innovation (Bhatti, et al., 2013) or "*jugaad*" innovation in the Indian context (Leliveld & Knorringa, 2017). However, this is a just short-term solution, and what is needed is an ecosystem to leapfrog in technology and innovation that could eventually help a country accelerate towards carbon neutrality.

Clean technology collaboration in Asia

Countries continue to face significant challenges due to the change in climate. In the Asian region, one of the most pressing issues is, as several studies have indicated, that many Asian coastal cities would potentially be submerged if ocean levels continue to rise (Cao, et al., 2021). This demonstrates the urgency of accelerating efforts on climate mitigation and adaptation targets and also meeting net-zero targets in the coming decades. Although many countries have been making significant efforts towards these goals, assessments have been indicating that the goals set by many economies are still insufficiently ambitious (Climate Action Tracker, 2022). The continuous and rapid growth in Asian region, however, faces a challenge in balancing the increasing demand for energy and altering existing patterns of consumption and production to make a noticeable reduction in GHG emissions. Technology innovation and clean energy development play a key role in this regard by reducing GHG emissions without compromising the growth objective. This suggests that greater policy attention needs to be paid to the integration of clean technologies also to offer the co-benefit of helping to achieve sustainable development targets.

Technology collaboration initiatives in the Asian region are mostly fragmented. The common type of collaboration is the sale of advanced technology-based equipment by donor countries to recipient countries. Among the Asian countries, China has a market advantage over other countries and has played a remarkable role in disseminating efficient equipment based on clean energy technology, under competitive cost conditions (Janardhanan, 2021). The economy of scale and cheap labour help China supply equipment and machinery at lower cost in the international market. Due to this, many countries in Asia are heavily dependent on the supply chains from China. For example, India's renewable energy sector with its ambitious target of having 500 GW of installed capacity by 2030 depends on China for equipment and machinery supplies.

There have also been several bilateral collaboration initiatives on the technology front among other countries in the region. Japan has been actively contributing to the transfer of technology for energy, environment, agriculture, and health-related activities in East, Southeast, and South Asian countries since the mid-twentieth century. Probably one of Japan's most efficient technology transfer platforms is the Joint Crediting Mechanism (JCM) (see Box 1).

The JCM has the potential to evolve into a more efficient technology collaboration approach by involving newer partners from across the globe. The replicability of the projects to introduce various new technologies would also contribute to achieving a broader range of goals and targets under the SDGs.

It is important to note that several recipient countries are keen to strengthen their domestic manufacturing industry, which in turn can contribute to the employment scenario and the local economy. The prevailing technology transfer mechanisms only make the recipient countries customers of advanced technology supplier countries and do not facilitate a conducive environment for learning, scaling up, and replicating technology applications. This demands a significant change in the way technology collaboration has been done to date. The next section focuses on co-innovation and explains how it can contribute to strengthening technology collaboration between source and recipient countries.

Co-innovation: addressing barriers to technology collaboration

The existing mechanisms of traditional technology transfer broadly hinder the actualisation of the four As of technology collaboration—availability, accessibility, affordability, and adaptability—in the following ways.[1]

The primary challenge of any shift towards newer low-carbon alternatives is to make sure that these technologies are available in the first place. The availability of alternatives through technology transfer is a collective challenge incurred by all the stakeholders involved. The governments of recipient countries act as key players in guaranteeing this 'availability' via legal and policy frameworks such as patent laws and science and technology (S & T) development plans. The challenges in addressing the availability issue are manifold and include ensuring that relevant technologies are adopted and absorbed according to local situations, eliminating non-measurable barriers to the entry of technology (such as stringent local content requirements in recipient countries that may pose practical infeasibilities for the host to set up industries), and providing space for building indigenous R & D and production bases in recipient countries. By establishing technology collaborative laboratories (CoLabs) (or facilities for collaboration among active knowledge-sharing stakeholders), the collaboration stage of the co-innovation model seeks to address these availability issues.

The next significant challenge is accessibility. Once the technologies are made available, such technologies must reach end users. Equitable access, patent mechanisms, lab-to-market penetrations, and supply chain continuity, thus, become the next set of concerns. One of the major impediments to the market applicability of new technologies is the lack of a harmonised set of national standards. International standards, unless they are mandated by national regulation, act as mere voluntary guidelines. This may create market differences that may eventually impact the accessibility of alternative technologies. Hence, through expert consultation processes within the governing bodies, governments must develop synchronisation of their technical and safety regulations into a consensual international set of standards. Furthermore, market accessibility can also be augmented with green public procurement policies that may incentivise the local production of imbibed technologies. These issues can also be resolved at the collaborative stage (see Figure 1 below).

A technology that is newly accessible in the market may not be affordable to the end user. The upfront production cost of the alternatives, without any subsidies or market incentives, directly passes on to the end-user. For instance, it is observed that the production costs of the low-GWP (low global-warming potential) cooling blends are more expensive than the refrigerant components themselves, rendering the transition to sustainable cooling costly (UNEP, 2020). The additional cost of highly energy-efficient and

1 The four As are typically a generic analytical framework for analysis of the twin goals of energy security and climate mitigation.

Box 1: Joint Crediting Mechanism

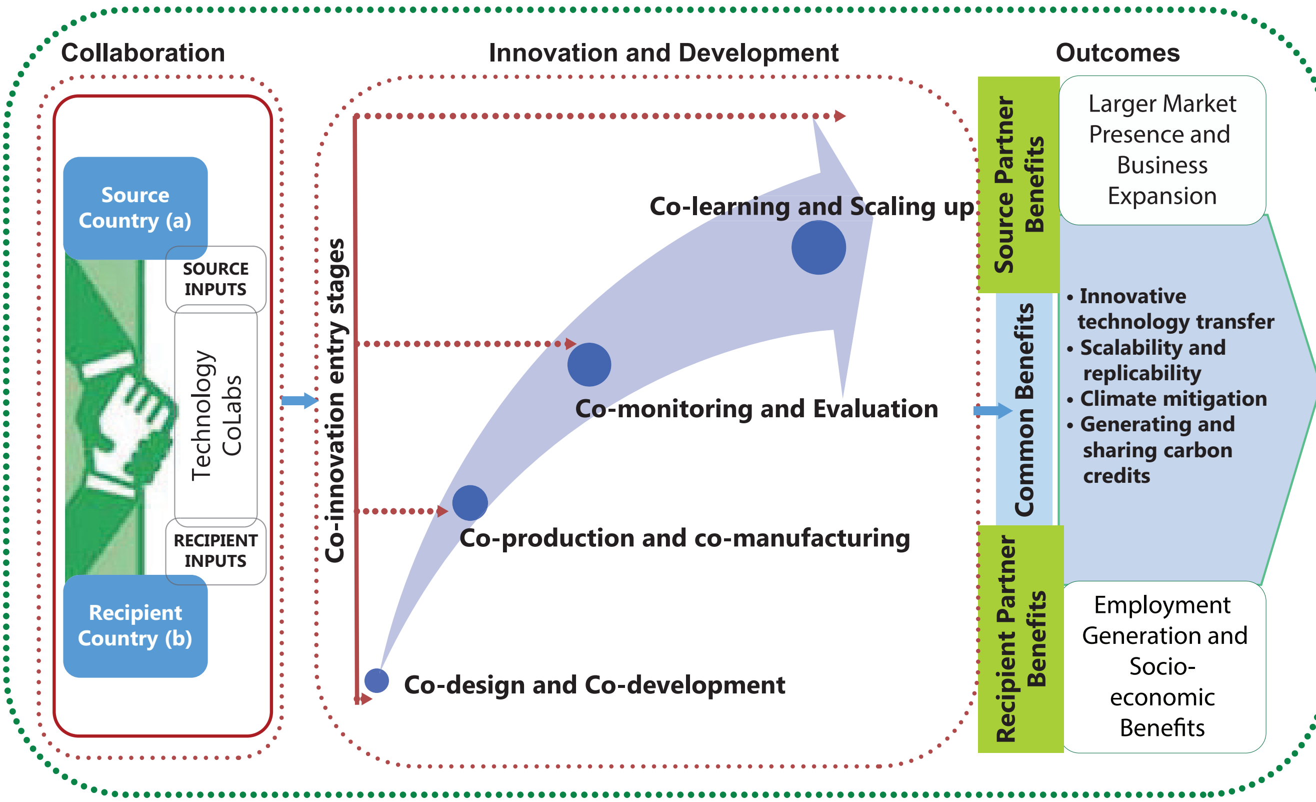
The JCM facilitates the diffusion of advanced low-carbon and zero-emission technologies, products, systems, services, and infrastructure, which contributes to sustainable development in developing countries (Government of Japan, 2013). Japan initiated this mechanism to accelerate a low-carbon society through bilateral cooperation by transferring advanced and high-efficiency technologies with financial support from the government of Japan.

To implement projects to transfer low-carbon and zero-emission technologies through the JCM, private entities from Japan and a partner country have to establish an international consortium to apply for JCM financial support. Various advanced technologies have high upfront costs, making it difficult for developing countries to implement and invest. Through the JCM, the Japanese government covers a part of the initial investment to install low-carbon and zero-emission technologies. Under the JCM, GHG emission reductions or removals from implemented projects are quantitatively evaluated by applying a measurement, reporting and verification (MRV) approach (Government of Japan, 2013).

The first bilateral agreement of the JCM was established between Japan and Mongolia in 2013 and currently, there are 17 partner countries from the Asia Pacific, Africa, and Latin American regions (Government of Japan, 2013). As of December 2021, a total of 205 projects received JCM financing support from Japan's Ministry of the Environment. The expected GHG emission reductions from all these projects are more than 19 MtCO2 by 2030 (Ministry of the Environment, Government of Japan, 2021a).

Through the JCM, capacity building and technical training are conducted to transfer advanced technologies smoothly in partner countries. With a view to implementing low-carbon and zero-emission technologies such as solar PV, the project participants from the Japanese side have regularly organised vocational training (e.g., workshops and webinars) to improve local partners' capacity building (Murun & Tsukui, 2020a). This aims to enhance the technical skills of local employees and technicians to operationalise and maintain technologies by themselves and ensure the sustainability of project implementation.

However, Japan and partner countries may need to improve and enhance the JCM for scaling up projects to reach their maximum potential. This requires active involvement from the private sector. Additionally, smoother processes may need to be developed to pursue the JCM financial support process, for which ease of documentation would be critical. As collaboration is built on mutual trust, stronger partnership between private entities from both Japan and partner countries is a necessary element in the efficient implementation and monitoring of JCM (JCM Mongolia, 2017). Since the JCM monitoring period is more than 10 years depending on the project type, it is important to develop and implement projects that are easy to monitor and maintain in the long term. One of the most important elements of the governance of the JCM is a joint committee (JC) constituting representatives from both Japan and partner countries. The JC can make all necessary decisions related to adopting rules, guidelines, and project registration under the JCM (JCM Joint Committee, 2013). Due to this equal partnership and collaboration, partner countries can transfer and introduce the technologies and projects that would contribute to their sustainable development (SD) and the achievement of sustainable development goals (SDGs).



Source: Janardhanan, et al., (2021a)

Figure 1: Co-innovation Conceptual Framework

low-carbon equipment is often passed on to the customers. Furthermore, state regulations should also ensure demand-side efficiency and place policies to reap economies of scale. The co-innovation entry-stage should conduct impact assessments of the differential tax regimes on the final product and evaluate the cost-benefits of incentivizing speedy firms for early adoption, moving fast, and greener consumer preferences. Adaptability principally focuses on end-users' ability to make full use of an imported technology or a technology's adaptability to the local requirements of end users. A common direction of technology transfer is from the Global North to the South. Often the local conditions and needs in the Global North are far different from those in the Global South. Thus, the consideration of socio-economic and environmental factors are particularly important. The adaptability to technology can be accomplished through integrated learning of local demand conditions and local knowledge in designing equipment or machinery. Mechanisms and efficiency checks, regular awareness programmes for consumers, skilling and reskilling programmes to enhance the employability of locals, training sessions for technicians, and independent assessments of climate co-benefits, etc. are important elements that can enhance the adaptability of a technology. The recipient stakeholder should have a better role in designing and improving the adaptability of new technology. Additionally, a market surveillance mechanism across sectors, products, and collaborative governments has to be set up to safeguard consumers from market shocks and non-compliant equipment.

The idea of co-innovation emerged in response to the mismatch in technology transfer practices. Co-innovation substantially improves the four As of technology collaboration. Co-innovation is defined as "*a collaborative and iterative approach to jointly innovate, manufacture, and scale up technologies*" [Janardhanan, 2019; Janardhanan, et al., 2020]. It also reflects the continuous exchange of knowledge among all stakeholders including scientists, manufacturers, and the end-users of technology to improve the product (Janardhanan, 2021). Unlike conventional technology transfer, which is a linear engagement of source and recipient players, co-innovation presents an organic engagement between the partners given greater adaptability of technology in the recipient country. Co-innovation brings profound changes to the industrial world's operating rules (Maniak & Midler, 2008) by facilitating technology fine-tuning to ensure greater adaptability to various regions.

Figure 1 demonstrates three major phases of co-innovation: (a) collaboration, (b) innovation and development, and (c) outcomes.

The first phase aims to establish a collaboration among partners involved in the co-innovation—the source and recipient partners. While the source partner is the one from which the base technology originates, the recipient partner is the host that collaborates in fine-tuning the technology application. The second phase demonstrates the entry stages of the collaboration. For a technology to be available in the market, it has to go through numerous stages from conceptualisation to design to development and marketing. The collaboration can happen at any stage between the partners, with the ultimate goal being fine-tuning and customising the technology so that it can be implemented in multiple geographic contexts. The third stage demonstrates specific advantages of co-innovation. While the source partner gets the benefit of a large market presence and business expansion opportunities, the recipient partner benefits from economic, environmental, and employment opportunities. At the same time, there are also common benefits for both, which include scalability and replicability, environmental benefits of reducing emissions, and the sharing of generated carbon credits.

The case study below (Box 2) demonstrates the opportunities for technology collaboration under co-innovation between India and Japan.

Box 2: Opportunities for Co-innovation between Japan and India

Based on work experience by the author through working on the identification of new and efficient technological options for Small and Medium-sized Enterprises (SMEs), the following three Low Carbon Technologies (LCTs) offer good opportunities for co-innovation between India and Japan:

i. Automatic looms (textile sector): Globally, India is the second-largest producer of textiles. About 95% of the 2.8 million looms installed in India are semi-automatic, conventional shuttle looms. The adoption of automatic looms in place of the conventional shuttle looms will increase productivity and improve the efficiency and quality of the fabric produced. At present, there are no manufacturers of automatic looms in India. Japan has some of the leading manufacturers of automatic looms like Tsudakoma and Toyota. However, the penetration of Japanese looms in the Indian market remains low mainly due to high costs. Considering the market potential in India, this technology is an ideal candidate for co-innovation.

ii. Efficient smelting furnaces (secondary aluminium sector): Aluminium is the second most used metal after steel. Secondary aluminium processing, which involves the conversion of ingots and scrap to cast and extruded products, is concentrated in the SME sector. The energy consumption of and consequently the GHG emissions from the secondary aluminium sector are quite high. Most units use conventional, inefficient oil-fired smelting furnaces. Some of the leading manufacturers of smelting furnaces in Japan are Nihon Kohnetsu and Sanken Sangyo. At present, only a few SME aluminium units can afford to buy smelting furnaces available in industrialised countries like Japan. The joint development of an energy-efficient smelting furnace for the aluminium industry with Japanese experts will significantly reduce energy consumption and GHG emissions.

iii. Energy-efficient agricultural pump-sets (pump-manufacturing sector): Agricultural pumps are a major consumer of electricity. More than 20 million agricultural pumps are in operation in India and about 2 million pumps are added annually. Most agricultural pumps manufactured in India have low efficiency and poor reliability. It would be a good opportunity to improve the efficiency of the locally made agricultural pumps by up to 40 per cent through co-innovation between Indian and Japanese agricultural pump manufacturers like Xylem and Tsurumi. Large-scale adoption of energy-efficient pumps would lead to huge electricity savings with consequent reduction in GHG emissions.

Source: Excerpts from the joint research conducted by the Institute for Global Environmental Strategies (IGES, Japan) and the Energy and Resources Institute (TERI, India), titled '*Co-innovation of low-carbon technologies for Small and Medium Enterprises: a framework for strengthening technology cooperation between Japan and India*' (Janardhanan, et al., 2021b)

Sustainability, scalability, and replicability of technologies through co-innovation

Unlike conventional technology transfers, co-innovation focuses on collaboration to fine-tune and customise technologies that are beneficial to climate change mitigation and carbon neutrality and that align with the key objectives of (a) sustainability, (b) scalability, and (c) replicability of low carbon technologies.

- Sustainability: The core objective of co-innovation is to promote sustainability through collaboration in the development and implementation of technologies that accelerate climate co-benefits. While the main goal of using new technology is often economic, projecting its social or environmental benefits accelerates decision-making processes to recognise its additional value. The recognition of co-benefits opens up a "window of opportunity" for additional policy goals to be achieved (Mayrhofer & Gupta, 2016). This can also help allay concerns over GHG mitigation costs (Janardhanan, et al., 2021a).
- Scalability: Enhancing the scalability of technology collaboration can broaden the reach of its outcomes to cover a wider set of beneficiaries. Collaboration on innovative technology remains critical for climate mitigation and SDGs. It is often reiterated by experts that a business-as-usual scenario may not be sufficient to address climate mitigation needs. There is a greater need to scale up clean technologies (WEF, 2015) and promote their usage across the various sectors and key industries that are responsible for GHG emissions. While a particular technology may be relevant in its initial stages for medium or small industries, it may well have the potential to be scaled up, applied, and implemented in larger industries to reduce emissions there as well. The scaling up of technology application in this way is extremely important in reaping the emission reduction benefits of clean technologies.
- Replicability: Accelerating replicability is a core element of co-innovation. The flexibility for adapting a newly developed technology to multiple geographical contexts has beneficial effects in addressing climate change (Azimoh, et al., 2017). Unlike traditional technology transfer that works in a linear direction from the source to the recipient, co-innovation is aimed at utilising the jointly developed technology or equipment in a wider geographic context. As replicability boosts economic benefits and offers wider usage of clean technologies, it also incentivizes decision-making to promote more co-innovation initiatives.

Policy, legal, and financial mechanisms to enable co-innovation

When technology is merely diffused, the transfer of tacit knowledge to a recipient country may not be guaranteed (Lema & Lema, 2016). It is now evident that the years of conventional technology transfer mechanisms (such as FDI, technology licensing, and joint ventures) have not improved the absorptive capacities of technology in recipient countries at the local level.

Firstly, for the diffusion of technologies and technological expertise to suit local production, local governments require considerable capacity. While an increasing number of countries have dedicated separate ministries for the environment and climate change, coordinated functioning of institutions and departmental task forces may improve the implementation of the co-innovation model. Most economies follow a top-down approach to climate action, particularly in the transfer of low-carbon and other climate-sound technologies. There must be synergy among local, state and national-level agencies so that technology can cater to different local conditions. Even for cases where fiscal autonomy is conferred to local governments, it has been observed that local governments prioritise economic growth over climate action, and hence refrain from investing in risk-prone newer technologies and industries to generate revenues (Zhou, 2019). The crucial role of subnational agencies in co-innovation can be understood through the following two cases. The first case can be seen in China, where, despite the establishment of an inter-ministerial National Coordinating Committee on Climate Change Policy (NCCCC), we see that excessive centralisation and the lack of coordination between administrative agencies severely affect the motivation of local governments in investing in newer, risk-prone climate technologies. This indicates that local governments cannot merely be given supervisory roles to monitor national standards; they rather should be made active players in contributing to recipient inputs at the collaboration stage. The second case involves subnational agencies in India, which have made commendable use of the quasi-federal structure of the government and moved towards institutional innovation by providing entrepreneurial support for clean energy innovation (Singh, 2021). State-level economic advisory councils have enabled support and alignment of national and sub-national net-zero targets. Thus, inter-departmental coordination within the domestic landscape can attract foreign governments and agencies to collaborate effectively.

Secondly, a major legal hurdle in the innovation and development stage of co-innovation is that the local intellectual property (IP) laws are not on a par with global standards. For instance, in the case of China, policies aspire to acquire technology "by various means" (Hannas & Tatlow, 2021) . As a member of the World Trade Organization (WTO), the Chinese state is bound for certain amendments in its national patent law. However, the enforcement mechanisms, the national review process, and the litigation systems in China are fractured, hindering effective technology transfer. While national policies aim for self-reliance through indigenous innovation, the promise of open innovation and knowledge-sharing is put under scrutiny due to various 'extra-legal' modes of technology transfers in China. Such a presence of vague IP laws and extra-legal personnel and organisations may lead to a lack of confidence and trust for host countries to collaborate with China and envision mutually benefitting co-innovation outcomes. In line with China, most developing countries have contradicting IP regulations. While unconventional transfer mechanisms such as joint R & D ventures and strategic alliances (Lema & Lema, 2016) are emerging in low-carbon technologies, there exists a simultaneous practice of traditional modes of technology use licensing, IP selling, etc. that hinder co-innovation even at the entry stages. This situation can be addressed by experimenting with alternatives to collaborative IP mechanisms such as patent pools (WIPO, 2014). Patent pools not only reap shared benefits but also reduce transaction costs. By setting up technology patent pools that incorporate a greater number of actors into the agreement, not only is access to technological know-how ensured but innovation rates are also bound to increase (Hovenkamp & Hovenkamp, 2017).

Thirdly, the co-innovation model will work only with a robust financial mechanism. Article 4.5 of the UNFCCC calls for developed (Annex I) countries not only to transfer technologies and know-how to other parties but also to "facilitate and finance" such transfers. While many corporates and regional organisations such as the European Union (EU) have established innovation funds, at present, there is no overhauling international fund specifically for technology transfer or co-innovation. Through the traditional modes of technology transfer, certain developed countries have been providing financial assistance to the least developed countries (LDCs) via one-time non-reimbursable grants (as a part of their implementation of Article 66.2 of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS)). However, the transition towards co-innovation models requires alternative financing mechanisms at all stages of development. Ideally, public funding would initiate such new high-risk projects, with governments also providing the R & D base and tax incentives to the collaborative parties. With evolving modes of financing mechanisms, governments can also support alternative private financings such as venture capital funds, incubators, and accelerators, rather than engaging only with major corporations and multinational companies.

Finally, with the CDM offering carbon offsets, there have been various concerns over the implementation of offsetting and the quality of the offsets. The benefits of shared carbon credits that the co-innovation model promises will be materialised only when the concerns of market-based balancing approaches are resolved using accurate quantification of GHG reductions with rigorous social accountability mechanisms in place.

Conclusion and policy recommendations

This paper discussed the need for clean technology against the backdrop of net-zero targets and the role of co-innovation. As climate change mitigation remains an urgent task for the world, it is imperative for the global community to enable developing countries to address this challenge collectively. Technology remains an integral part of mitigation efforts, and closing the gap in the availability, accessibility, affordability and adaptability of low-carbon solutions deserves paramount policy attention in both developing and developed countries. The paper discussed co-innovation, which is a collaborative and iterative approach to jointly innovating, manufacturing, and scaling up low-carbon technology. As radical changes are required in the way technology is developed, used, and disseminated, co-innovation will be a useful approach. The paper also highlighted that sustainability, scalability, and replicability will need to form the central elements of technology collaboration. Further, conducive policy and legal and financial enablers would play a critical role in building co-innovation.

Four specific policy recommendations can be suggested to promote co-innovation for achieving climate neutrality.

- Going beyond business-as-usual pathways: To accelerate along climate neutrality pathways, countries need to promote clean technology using approaches beyond conventional, business-as-usual pathways. In promoting the co-innovation of technology, joint conceptualization, innovation, and production, and scaling up would be some of the critical approaches that offer economic and social benefits in addition to environmental advantages.
- Prioritizing sustainability, scalability, and replicability: Technology collaboration must hold these three elements as the core objectives of co-innovation. While sustainability benefits of technologies may be the primary consideration, scalability to large-scale applications as well as replicability in other relevant sectors and regions also deserves equal attention.
- Addressing disparities in the four As of clean technology: As climate concerns deserve greater policy attention, the global community needs to address the disparities in the availability, accessibility, affordability, and adaptability of clean technology in the developing world. Greater collaboration through co-innovation needs to be built among developing and developed economies to help countries benefit from advanced technology.
- Improving enabling conditions: Among the key enablers, one of the most critical elements that shape technology collaboration is the legal framework that governs intellectual property rights. By jointly innovating, producing, and marketing machinery and equipment based on low-carbon technology, entities would share legal rights, which could potentially facilitate the technology's reach to a wider set of users.

References

✓ Azimoh, C. L., Klintenberg, P., Mbohwa, C., & Wallin, F. (2017). Replicability and scalability of mini-grid solution to rural electrification programs in sub-Saharan Africa. *Renewable Energy, 106*(June), 222-231.

- ✓ Bhatti, Y. A., Khilji, S., & Basu, R. (2013). Frugal Innovation. In C. R. Shaista Khilji, S. E. Khilji, & C. Rowley (Eds.), *Globalization, Change and Learning in South Asia* (pp. 123-145). London: Elsevier.
- ✓ Cao, A., Esteban, M., Valenzuela, V. P., Onuki, M., Takagi, H., Thao, N. D., & Tsuchiya, N. (2021). Future of Asian Deltaic Megacities under sea level rise and land subsidence: current adaptation pathways for Tokyo, Jakarta, Manila, and Ho Chi Minh City. *Current Opinion in Environmental Sustainability, 50*(June), 87-97.
- ✓ Climate Action Tracker. (2022). *Compatibility of National Action to 1.5 Degree celcius Goal*. Retrieved February 12, 2022, from https://climateactiontracker.org/countries/
- ✓ Government of Japan. (2013). *Joint Crediting Mechanism*. Retrieved from https://www.jcm.go.jp/about
- ✓ Hannas, W., & Tatlow, D. K. (2021). *China's Quest for Foreign Technology* (1 ed.). London: Routledge.
- ✓ Hovenkamp, E., & Hovenkamp, H. J. (2017). Patent Pools and Related Technology Sharing. *Faculty Scholarship at Penn Law*. Retrieved from https://scholarship.law.upenn.edu/faculty_scholarship/1766?utm_source=scholarship.law.upenn.edu%2Ffaculty_scholarship%2F1766&utm_medium=PDF&utm_campaign=PDFCoverPages
- ✓ IEA. (2020). *Projected Costs of Generating Electricity 2020*. Paris: International Energy Agency.
- ✓ IEA. (2021). *Energy Technology Perspectives 2020*. Paris: International Energy Agency.
- ✓ IPCC. (2007). *Climate Change 2007: Working Group III: Mitigation of Climate Change*. Geneva : Intergovernmental Panel on Climate Change.
- ✓ Janardhanan, N. (2019, December 01). Co-innovation of Clean Technologies: A Panacea for Climate Change? *Energy Review Newsletter*, pp. 2-6.
- ✓ Janardhanan, N. (2021). India's Energy Transition: Is China and Inhibitor or a Catalyst? In A. Mori, & A. Mori (Ed.), *China's Carbon-Energy Policy and Asia's Energy Transition* (pp. 195-209). London: Routledge.
- ✓ Janardhanan, N., Ikeda, E., Zusman, E., & Tamura, K. (2020). *Co-innovation for Low Carbon Technologies: The Case of Japan-India Collaboration*. Hayama: Institute for Global Environmental Strategies.
- ✓ Janardhanan, N., Pham, N.-B., Hibino, K., & Akagi, J. (2021a). Japan's low-carbon technology collaboration with Southeast Asia: Co-innovation and Co-benefits. In H. Farzaneh, E. Zusman, & Y. Chae (Eds.), *Aligning Climate Change and Sustainable Development Policies in Asia* (pp. 10-25). Singapore: Springer.
- ✓ Janardhanan, N., Zusman, E., Tamura, K., Ikeda, E., Sethi, G., & Pal, P. (2021b). *Co-innovation of low-carbon technologies for Small and Medium Enterprises: a framework for strengthening technology cooperation between Japan and India*. Hayama: Institute for Global Environmental Strategies.
- ✓ JCM Joint Committee. (2013). *JC Members*. Retrieved from https://www.jcm.go.jp/mn-jp/jc_members
- ✓ JCM Mongolia. (2017). *Joint Crediting Mechanism Guidelines for Developing Project Design Document Form and Monitoring Report*. Retrieved from https://www.jcm.go.jp/rules_and_guidelines/mn/file_04/JCM_MN_GL_PDD_MR_ver03.1.pdf
- ✓ Kirchherr, J., & Urban, F. (2018). Technology transfer and cooperation for low carbon energy technology: Analysing 30 years of scholarship and proposing a research agenda. *Energy Policy, 119* (August), 600-609.
- ✓ Lee, H., & Tan, H. (2007). Technology Transfer, FDI and Economic Growth in the ASEAN Region. *Journal of the Asia Pacific Economy, 11*(June), 394-410.
- ✓ Leliveld, A., & Knorringa, P. (2017). Frugal Innovation and Development Research. *The European Journal of Development Research volume, 30*(2018), 1-16.
- ✓ Lema, A., & Lema, R. (2016). Low-carbon innovation and technology transfer in latecomer countries : Insights from solar PV in the clean development mechanism. *Technological Forecasting and Social Change*. doi:https://doi.org/10.1016/j.techfore.2015.10.019
- ✓ Lema, R., & Lema, A. (2012). Technology transfer? The rise of China and India in green technology. *Innovation and Development, 2*(1), 23-44.
- ✓ Lema, R., Iizuka, M., & Walz. (2015). Introduction to low-carbon innovation and development: insights and future challenges for research. *Innovation and Development, 5*(2), 173-187.
- ✓ Maniak, R., & Midler, C. (2008). Shifting from co-development to co-innovation. *International Journal of Automotive Technology and Management, 8*(4), 449-468.
- ✓ Mayrhofer, J. P., & Gupta, J. (2016). The science and politics of co-benefits in climate policy. *Environmental Science & Policy, 57*(2016), 22-30.
- ✓ Ministry of the Environment, Government of Japan. (2021a, September 27). *List of JCM Financing Programme by Ministry of Environment, Japan (FY2013〜2021)*. Retrieved from Global Environment Centre Foundation: https://gec.jp/jcm/en/wp-content/uploads/2021/09/20210927_list_en.pdf
- ✓ Murun, T., & Tsukui, A. (2020a). *Joint Crediting Mechanism (JCM) contributions to Sustainable Development Goals (SDGs)*. Hayama: IGES.
- ✓ Ockwell, D., & Mallett, A. (2012). *Low-CarbonTechnology Transfer: From Rhetoric to Reality*. London: Routledge.
- ✓ Pigato, M., Black, S. J., Dussaux, D., Mao, Z., McKenna, M., Rafaty, R., & Touboul, S. (2020). *Technology Transfer and Innovation for Low-Carbon Development. International Development in Focus*. Washington, DC.: World Bank.
- ✓ Singh, K. (2021, May). Interview: US-India Energy Cooperation. *Energy Review*,

p. 2. Retrieved from https://drive.google.com/file/d/1AZdTerfCv4Z5CQBb67NneRoqwf1234kM/view?usp=sharing

- ✓ UNEP. (2020). *Assessment report of the technology and assessment panel.* Nairobi: UNEP.
- ✓ UNFCCC. (1997). *The Clean Development Mechanism.* Retrieved February 12, 2022, from https://unfccc.int/process-and-meetings/the-kyoto-protocol/mechanisms-under-the-kyoto-protocol/the-clean-development-mechanism
- ✓ Wang, F., Harindintwali, J. D., Yuan, Z., Wang, M., Wang, F., Li, S., & Yin, Z. (2021). Technologies and perspectives for achieving carbon neutrality. *The Innovation, 2*(4), 1-22.
- ✓ WEF. (2015, October 1). *Scaling Technologies to Decarbonize Energy.* Retrieved February 12, 2022, from https://www3.weforum.org/docs/WEF_GAC_Decarbonizing_Energy_White_Paper.pdf
- ✓ WIPO. (2014, March 1). *Patent Pools And Antitrust – A Comparative Analysis.* Retrieved February 1, 2022, from https://www.wipo.int/export/sites/www/ip-competition/en/studies/patent_pools_report.pdf
- ✓ Zhou, C. (2019). *The Legal Barriers to Technology Transfer Under the UN Framework Convention on Climate Change: The Example of China* (1 ed.). (C. Zho, Ed.) Singapore: Springer Nature Singapore Pte Ltd.

Technology Networks, Resources and Offers

National Technology Networks and Resources

BHUTAN

CSI Technology Request Database

https://www.dcsitechnology.bt

This technology transfer database center serves as a one-stop database for accessing all technology requests and for the exchange of technology offers within and outside Bhutan. The database includes all the contact information of local suppliers, including descriptions of equipment. All the cottage and small-scale entrepreneurs and startups can obtain the following benefits from using CSI (Cottage and Small Enterprises) Online Technology Request Database System. It provides information on the technologies available for transfer (technology offers) and the technologies needed (technology requests).

The online database facilitates the exchange of technology offers and requests both in Bhutan and at the global level. The database search engine is connected to selected international database centers. The establishment of CSI Technology Request Database was supported by the Asian Pacific Center of Technology Transfer (APCTT) of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP).

INDIA

CSIR Compendium of Technologies

https://drive.google.com/file/d/10VWMxkKo3La83ea0r2_NNY-ksHomIpk2/view

The CSIR Compendium of Technologies 2021 has been compiled by the National Institute of Science Communication and Policy Research of Council of Scientific and Industrial Research (CSIR-NIScPR), India. The compendium is a compilation of technology details provided by different CSIR laboratories of India at TRL (Technology Readiness Level) 6 and above. The compendium is based on the validation of these technologies by experts. The CSIR-NIScPR executed this exercise based on laboratory inputs and the final selection was based only on expert assessment. A total of 467 technologies at TRL 6 and above were identified for assessment, out of which 154 technologies were not considered for this compendium as they were generic. However, these technologies might have potential in rural entrepreneurship. This compendium shortlists 313 CSIR technologies that are promising (TRL 6 and 7) and market-ready (TRL 8 and 9).

CSIR Technology Showcase

https://techindiacsir.anusandhan.net/online/Control.do

CSIR Technology Showcase is the online resources portal of the Council of Scientific & Industrial Research (CSIR) of India. Having pan-India presence, the CSIR has a dynamic network of 38 national laboratories, 39 outreach centers, 3 innovation complexes, and 5 units. The CSIR's R&D expertise and experience is embodied in about 4,600 active scientists supported by about 8,000 scientific and technical personnel. The portal provides information on CSIR technologies, patents, success stories, and social interventions.

CSIR Technologies for COVID-19 Mitigation

https://drive.google.com/file/d/1DxoHfMnjY2kfIVr516UeQAUejByEi0ol/view?usp=sharing

About 60 technologies for COVID-19 mitigation are listed in this compendium developed by different CSIR laboratories across India and they have already been transferred to industry partners. The COVID-19 technologies are licensed on a non-exclusive basis, and the industrial partners have engaged with the CSIR in the larger interest of taking these technologies to the needy in a short time.

Technology Offers and Opportunities

High-speed charging electro cars with solar technologies

Sector
Renewable energy technologies

Country
Republic of Uzbekistan

Areas of Application
With the help of solar photovoltaic systems with energy storage systems adapted to the climatic conditions of Uzbekistan, it is possible to install a fast charger for electric vehicles operating in parallel with the local power grid in remote areas of Uzbekistan. Excess energy generated by solar photovoltaic systems with energy storage systems is used as an energy source in the establishment of small service stations.

Description

The electric vehicle charging system consists of a 19,680 W photovoltaic module, a 20 kW hybrid inverter, and a 38.4 kW lithium-ion battery energy storage system (EST). The inverter controls the flow of electricity between different power sources. It has an array of photovoltaic modules and two DC ports connected to the EST and two AC ports connected to the local mains and the electric car charger, respectively. Photovoltaic module power can be used to charge an electric vehicle, store energy in batteries, or transmit power to the grid. The energy stored in the EST can be used to charge the electric vehicle or connect it to the mains. Photovoltaic modules can provide electricity to charge an electric vehicle via the EST and a local area network. An automatic control strategy has been developed to maximize the energy of the photovoltaic modules used for charging and to reduce the demand for electricity. Depending on the availability of network power, the charging station is connected to the network and individual operating modes are developed when the photovoltaic module is connected to the mains in the operating mode. If more power is needed, the rest of the power is supplied by batteries or the mains. If the photovoltaic module is not connected, the energy is stored in the battery, and if the battery is fully charged, the excess power is transferred to the mains.

Benefits

The developed system can be used in various fields: in transport and electricity networks, for fast and safe charging of electric vehicles, for private entrepreneurs engaged in the installation of medium-power and distributed generation facilities, and others. It can be used by senior students and masters in higher and secondary education, and researchers working in this field.

In the country, each high-speed electric vehicle charging solar technology generates 32,000 kWh of electricity per year and autonomously supports an average of 950 electric vehicles.

The structure housing the system can be used as a parking lot that protects five cars from the sun.

Environmental Aspects

Each system installed in the country saves 11.2 thousand cubic meters of gas per year and prevents the release of 19.8 tons of industrial gas.

Development Status

The first high-speed charging station for electric vehicles using solar technology has been launched in Uzbekistan.

The characteristics of the power supply system that affect the parameters of the charger were studied. The charging system has been developed for simultaneous power supply from the power grid and solar photovoltaic power plant.

The technology was developed on the basis of the European standard GB / T 20234.2—2015 "Connecting device of conductive charging of the car", and UZ-Q / SD-C-0482-2016 "Connecting device of conducting car charger.

Legal Protection

A utility model has been applied for a fast-charging system for electric vehicles connected to the mains and operating in parallel with a solar photovoltaic plant with an energy storage system: FAP 2021 0323 dated 19.10.2021.

Technical Specifications

- The main controller is a 32-bit industrial-grade microprocessor.
- Level 1 gauges are used to accurately measure the charging capacity of electric vehicles.
- The device is equipped with an additional temperature sensor to prevent the internal temperature from rising and even has the ability to completely stop the charger and signal unusual temperatures.

Transfer Terms

- The device meets the requirements of existing regulations in Uzbekistan.
- Our specialists can troubleshoot equipment malfunctions.
- The device is relatively cheap to produce in series, as it saves on transportation costs (logistics, customs, and other fees).
- The device can be quickly delivered and repaired, and the components are produced in-house .

Target Countries

Uzbekistan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and India

Estimated cost (US$)

Sales price of the product: 47.5 mln. UZS (USD 4250, USD 1 as of May 10, 2022 = 11 190.00 UZS)

Together with the solar photovoltaic system: 450 mln. UZS (USD 40,200, USD 1 as of May 10, 2022 = UZS 11,100.00)

Assistance Sought from Potential Partner

We are ready to cooperate with all manufacturers. However, due to the lack of staff and raw materials at the institute, we offer to work with professional companies in the field of electronics.

Contact

100084, Toshkent Shahri, Chingiz Aytmatov Street House 2B, Building 2, Uzbekistan
Tel.: +998 (71) 235-03-77,
E-mail: info@nires.uz
www.nires.uz/,

Development of a basic corset called "SASH" in the treatment of intervertebral disc herniation

Sector
Medical technologies

Country
SASH CORSET LLC, Uzbekistan, Bukhara Region, Romitan District

Area of Application
1. Employees of all state enterprises who work in a chair for 4-5 hours

2. Pharmacies

3. Centers for neurology and vertebraology

4. Private clinics

Description
The basal corset works for the rapid, effective, and uncomplicated treatment of lumbar osteochondrosis and disc herniation, which results from degenerative and disturbing changes in the pulp nuclei of the intervertebral discs.

The essence of the base corset is that it wraps around the waist like a mandrel, supports the center of the hips of the waist brace, and leads to keeping the body upright. Mobilization helps to strengthen the addition of power to the weak among them. The development of the corset has helped in import-substitution for treating severe injuries and reduction of demand for the drug.

Advantages
Nowadays, there are many types of such corsets, and their specific disadvantages are enough. For example, orthopedic corsets ($ 22) only serve to maintain the accuracy of the spine and prevent scaliosis, but they are almost useless in disc herniation. A bandage ($ 5) protects this belt from additional loads and helps distribute the load properly. Fixation corsets ($ 13) fix the lumbar region at the spine, mainly to prevent additional misalignment of the lumbar region. Apparently, almost all of these tools are used for secondary prophylactic purposes and to prevent post-disease complications, but they cannot cure disc herniation. Their function and coating are also simple and that's why some corsets come at low prices. The basic corset we have developed is used not only for fixation purposes but also in the treatment of the early stages of spinal disc herniations and degenerative and dysplastic diseases of the spine, and in the prevention of similar diseases.

Environmental Aspects
When the project is developed, patients with disc herniation and those suffering from the disease will be protected, the people who usually work sitting on a chair will also be protected from future pathological conditions.

Development Status
Equipment such as inventory, equipment, a vertical machine for the production of corset fabric is purchased and transported to the building tower, other equipment, tools and raw materials are produced in the building is developed and the quality, metal temperature, operating mode, degree of adaptation in the lumbar areas are measured. To do this, a statistical product quality indicator is developed, a recipe is found that is the best and strongest, and a corset is produced on the basis of a single production mode.

Legal Protection
The corset is copyrighted as a new and unique innovative technology.

FAP 20190002

Intellectual Property Agency of the Republic of Uzbekistan

Technical Specifications
At present, we have all the required inverters and raw materials, which meet the requirements of economic savings. Currently, the amount of equipment and necessary inverters required for the project is 154 million. The main workforce of the company is 8 people.

Transfer Terms
The project will be implemented in the innovative zone in Rometan District of Bukhara Region.

Currently, an enterprise has been established to implement this project—SASH KORSET LLC.

Bukhara branch of the National Bank

H / R 20208000205419904001

STIR: 308730107 MFO: 0001

Target Countries
The project is currently being developed only for the market itself.

Estimated Cost (US$)
Two hundred orthopedic corsets and 200 fixation corsets will be produced at the expense of the Ministry of Innovation Development.

- The cost of one orthopedic corset is **$** 13,7.
- The selling price of one orthopedic corset is **$** 22.
- The cost of one fixation corset is **$** 19,5.
- The selling price of one piece of fixation corset is **$** 280,000.

The project has a production capacity of 500 units per year.

Assistance Sought from Potential Partner
Currently, there is no need for support from other organizations to sign the contract. In the future, the issues of scientific and economic cooperation with clinical centers of neurology and vertebrology in foreign countries are being considered.

Contact
Tel.+998 99 7305874
Email. ibod.ismoilov.1992@mail.ru

Technology for the production of concrete blocks using industrial waste (ash) from thermal power plants

Sector
Construction

Country
The Republic of Uzbekistan

Areas of application
These blocks can be used in the construction of residential and commercial buildings. The main goal of the project is to prevent the environmental impact of industrial waste generated by thermal power plants and the production and accumulation of large amounts of cheap concrete blocks.

Description
There is a shortage of cheap and high-quality blocks for multi-storey houses and various residential and non-residential buildings under construction in Piskent District. The launch of the project will solve these problems. The role of aerated concrete blocks is important in the production of energy-efficient building materials:

- The use of highly energy-efficient building materials will lead to the production of a new type of building material, zolo beton blocks.
- Using industrial waste, these blocks improve the territorial ecological situation.
- Using industrial waste as raw material is cost-effective.

Advantages
The main materials are as follows: ash, 50-65 per cent; cement, 20-25 per cent; lime, 8-15 per cent; aluminum paste, 0.02-0.04 per cent; caustic soda, 0.02-0.04 per cent; and basalt fiber.

Environmental Aspects
Production of cheap concrete blocks prevent the impact of large quantities of industrial wastes from thermal power plants on the environment.

Development Status
Phase 1. The main materials are as follows: ash, 50-65 per cent; cement, 20-25 per cent; lime, 8-15 per cent; aluminum paste, 0.02-0.04 per cent; caustic soda, 0.02-0.04 per cent; and zolo beton with basalt fiber. In order to obtain a high-quality block product, the terms of reference and the design of an energy-saving device are being developed.

Phase 2. Carrying out industrial experimental testing. Determination of technological parameters. The detected defects in the device were eliminated.

Step 3. The finished experimental test device will be introduced at the production enterprise of the Association "Uzpromstroymaterialy" and the act will be issued.

Legal protection

1. In order to prepare the project for commercialization, the adaptation of the production line has been completed.
2. Preliminary experimental samples were developed under the project.
3. GOST (interstate standard) and hygienic certificates as well as technological regulations are being drawn up for the received test batch.

Technical specifications

Portland cement, gravel, caustic soda, aluminum powder, secondary polymers are the main raw materials.

Transfer terms

Under the terms of transfer, income is determined by the sales volume and the financial result by the amount of profit. Given the market demand for zoloblok mainly in the hot season, seasonal fluctuations in demand are observed during the forecast period. At the same time, the dynamics of sales growth should be planned due to the increase in equipment capacity utilization.

Target countries

Tajikistan, Turkmenistan, Kazakhstan, Russia, India, and Afghanistan

Estimated cost (US $)

$ 500 000

Assistance from potential collaborators

In the framework of potential cooperation, the project should pay special attention to the development of production and logistics infrastructure. When organizing the logistics infrastructure, it is necessary to determine the number of objects (warehouse complexes) with a certain geographical location and take into account the stocks of products stored everywhere. The logistics infrastructure should include buildings, transport systems, production facilities, which will be necessary for the implementation of logistics activities, increasing the competitiveness of the blocks produced.

Contact

Limited Liability Company "STROY KARAT DPK", STIR 307089438, Piskent District, Tashkent Region, Khaydarov Rural Citizens' Counsel, Tel: +99899 8182488.

Tech Events

2022

Sep 21–23
Singapore

ISWA 2022 World Congress
Contact: ISWA 2022 World Congress Secretariat
E-mail: secretariat@iswa2022.org
https://iswa2022.org/

Sep 20–22
Bangkok, Thailand

Sustainable Energy Technology Asia (SETA) 2022
Contact: Ms. LiliGeng
Tel: +66 2 107 1944
E-mail: lili@gat.co.th
https://www.setaasia.com/

Sep 14–16
Bangkok, Thailand

ASEAN Sustainable Energy Week
Contact: Ms. JittrapornKulwanich
Informa Markets in Thailand
428 Ari Hills Building 18th Floor, Phaholyothin Road, Samsennai, Phayathai. Bangkok, Thailand 10400
Tel: +66 2036 0500 ext. 244 & 235
Fax: +66 2036 0588
E-mail: Jittraporn.K@informa.com; asew-th@informa.com
Website: www.asew-expo.com

Oct 12–14
Kuala Lumpur, Malaysia

International Greentech & Eco Products Exhibition & Conference Malaysia (IGEM)
Contact: Conference Secretariat
Tel: +603-8921 0800
E-mail: igem@mgtc.gov.my
https://www.igem.my/about-igem-2022/

Oct 18–19
Manila, Philippines

The 8th International Conference on Low Carbon Asia
Contact: Conference Secretariat
De La Salle University
Dasmariñas
DBB-B City of Dasmariñas Cavite Philippines 4115
E-mail: secretariat@iclcaconf.com
https://iclcaconf.com/

Oct 26–28
Singapore

Asia Clean Energy Summit 2022
Contact: ACES Secretariat
Tel: +65 6338 8578
E-mail: secretariat@asiacleanenergysummit.com
https://www.asiacleanenergysummit.com/

Oct 27–28
Chi Minh City, Viet Nam

ASEAN Wind Energy 2022
Contact: Mabel Gu
Tel: +86 21 6419 9537 - ex 8168
E-mail: Mabel@leader-associates.com
https://www.aseanwindenergy.com/

Oct 28–30
Changzhou, China

6th Asian Conference on Artificial Intelligence Technology (ACAIT 2022)
Contact: Conference Secretariat
Tel: 023-62561406
E-mail: xb@cqut.edu.cn
http://www.acait.cn/

Nov 01–03
Tokyo, Japan

11th Asian Conference on Sustainability, Energy & the Environment (ACSEE2021)
Contact: The International Academic Forum (IAFOR)
Sakae 1-16-26 – 201
Naka Ward, Nagoya, Aichi,
Japan 460-0008
E-mail: acsee@iafor.org
https://acsee.iafor.org/

Nov 02–05
Singapore

11th International Conference on Innovative Smart Grid Technologies (ISGT-Asia 2022)
Contact: IEEE Power & Energy Society (PES)
445 Hoes Lane, Piscataway, New Jersey, 08854-1331 USA, Piscataway
United States
Tel: +1-732-562 3883
E-mail: ieeeisgt2022@gmail.com
https://ieee-isgt-asia.org/

Nov 04–06
Kyoto, Japan

7th Asia Conference on Environment and Sustainable Development (ACESD 2022)
Contact: Nancy Liu
Conference Secretary
Tel: +86-28-86512185
E-mail: acesd@iacsitp.com
http://www.acesd.org/

Nov 18–20
Guangzhou, China

5th International Conference on Smart Grid and Energy
Contact: Sara Young
Tel: +86-155-7490-6062
E-mail: icsge2018@vip.163.com
http://www.icsge.org/

Nov 19–21
Hong Kong, China

2nd International Conference on Smart City and Green Energy
Contact: Jennifer Zeng
Conference Secretary
E-mail: icscge@academic.net
http://www.icscge.org/

Dec 14–16
Semarang, Indonesia

4th International Conference on Innovation in Science Technology (ICIST 2022)
Contact: Jl. Prof. Soedarto, SH,
Conference Secretariat
E-mail: contact@icist.asia
https://icist.asia/2022/

2023

Jan 06–08
Beijing, China

4th Asia IoT Technologies Conference (AIOTT 2023)
Contact: Ms. Teri Zhang
Tel: 86-13290000003
E-mail: aiott_conf@yeah.net
http://www.aiott.net/

Mar 24–26
Singapore

4th Asia Conference on Renewable Energy and Environmental Engineering (AREEE 2023)
Contact: Nancy Liu
Conference Secretary
AREEE Conference Secretariat
Tel: +86-28-86512185
E-mail: areee@iacsitp.com
http://www.areee.org/

Aug 24–25
Colombo, Sri Lanka

4th World Conference on Waste Management 2023
Contact: Mr. KeerthiChandana
Tel: +94 117 992 022
E-mail: secretariat@wastemanagementconferences.com
https://wastemanagementconferences.com/

Oct-Dec 2021

Harnessing fourth industrial revolution technologies for healthcare

Jul-Sep 2021

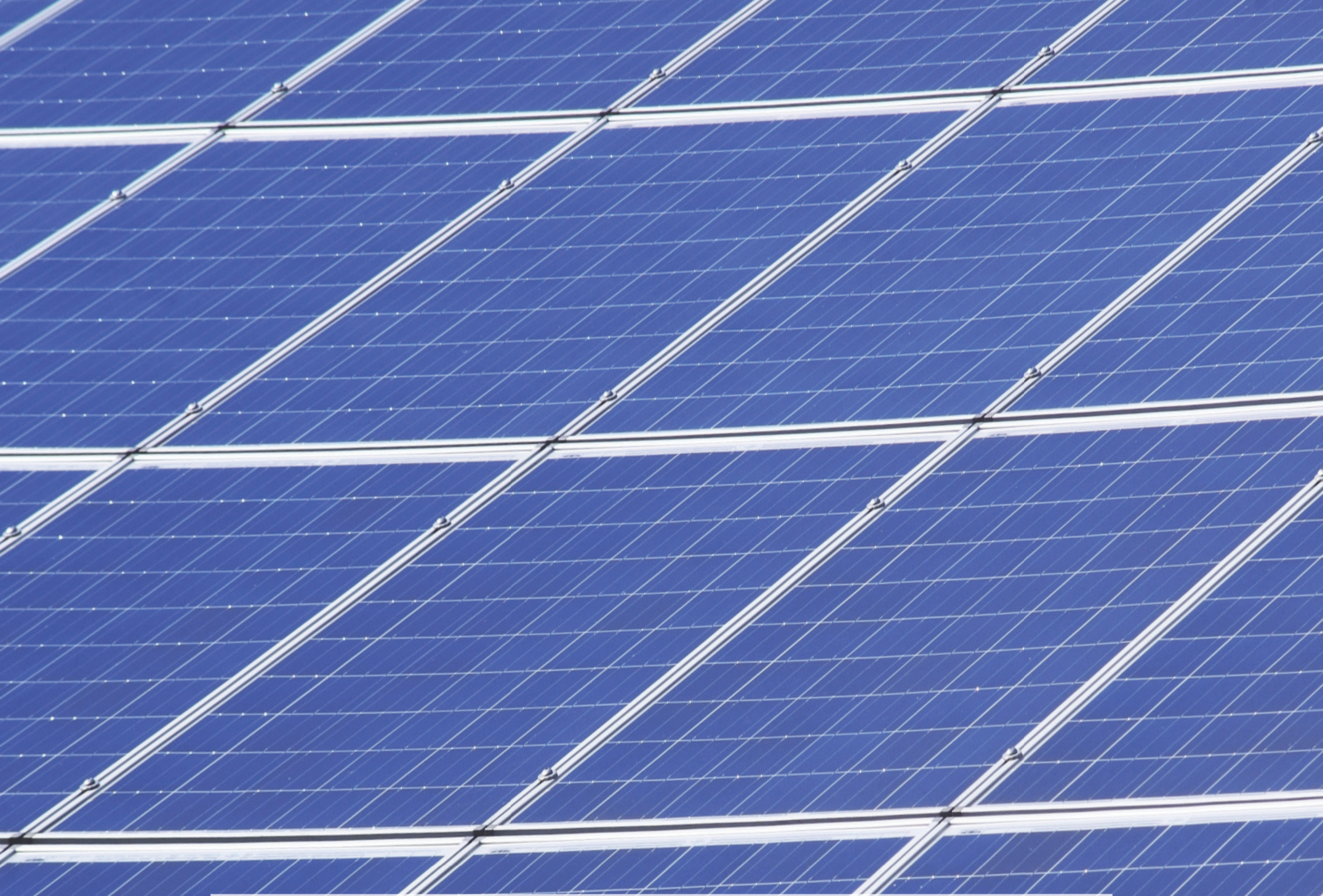
Technologies for adaptation to climate change in Asia-Pacific

Apr-Jun 2021

Fourth Industrial Revolution technologies for inclusive and sustainable development

Jan-Mar 2021

Science technology and innovation for sustainable and resilient recovery from Covid-19 crisis



The Asia-Pacific Tech Monitor has been the flagship periodical of APCTT since 1993. It is an online quarterly periodical featuring theme-based articles which provide trends in technology transfer and development, innovation and technology policies, market, data and analysis with respect to relevant issues, case studies, good practices and innovative technologies. Each issue of Tech Monitor focuses on a special theme and the articles written by authors/experts of national and international repute. The periodical aims enhancing the technology intelligence of relevant stakeholders from member States of ESCAP to meet the challenges of today's dynamic business and technological setting.

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

C2, Qutub Instituitional Area, New Delhi 110016, India

www.apctt.org   postmaster.apctt@un.org   91 11 30973750

unapctt   unapctt