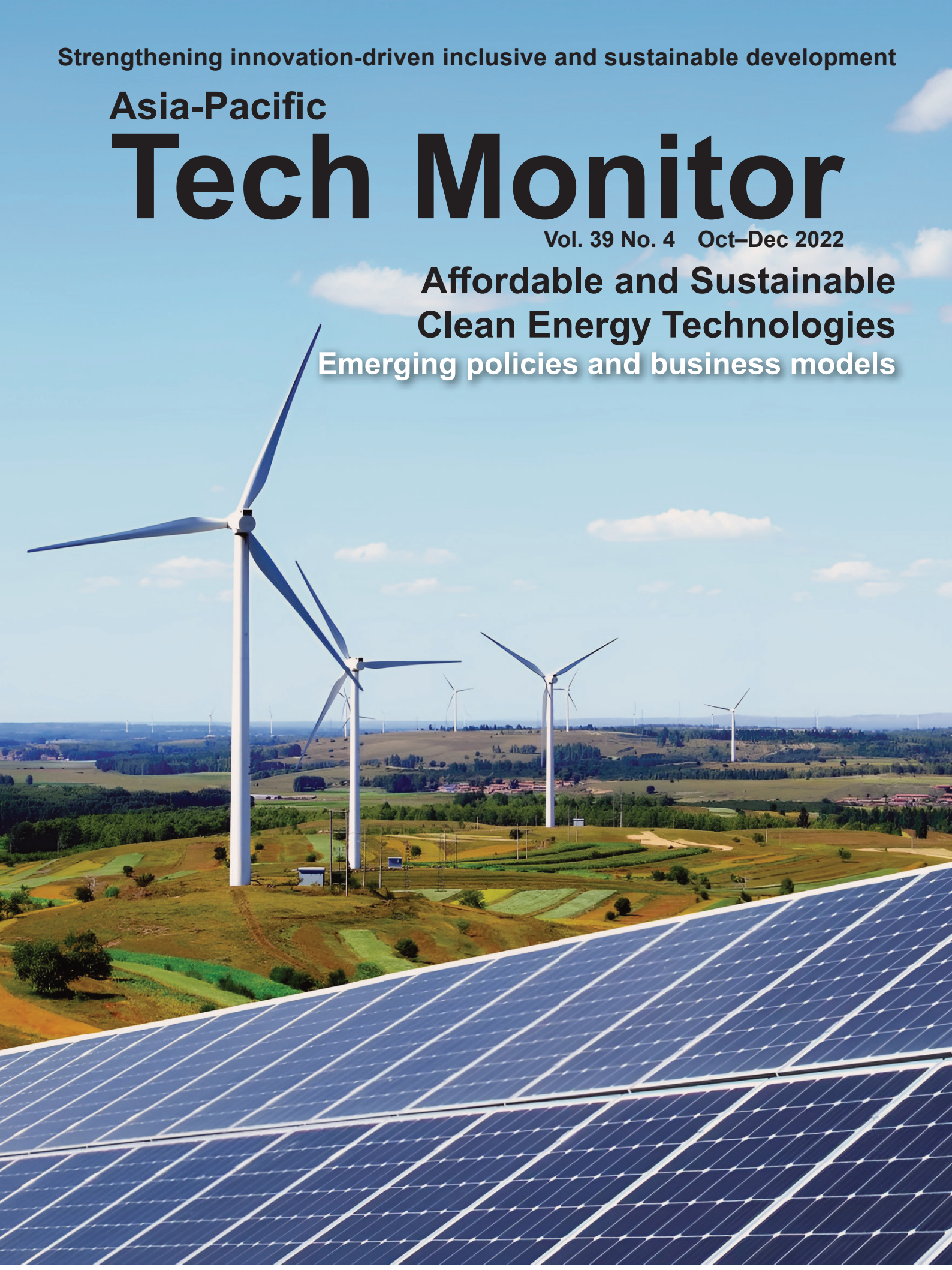
Strengthening innovation-driven inclusive and sustainable development

Asia-Pacific Tech Monitor

Vol. 39 No. 4 Oct–Dec 2022

Affordable and Sustainable Clean Energy Technologies

Emerging policies and business models



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. 4 ❖ Oct–Dec 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.

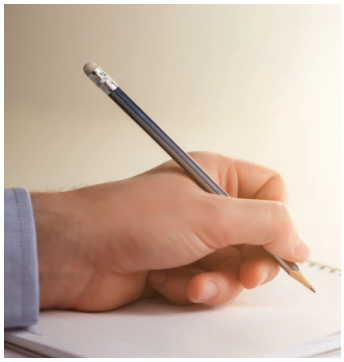
Web: https://apctt.org/techmonitor

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: apctt.techmonitor@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

Transition to clean and renewable energy has become imperative to curb the rising GHG emissions and achieve Sustainable Development Goal 7 to ensure affordable, reliable and sustainable energy by 2030. To achieve these goals, countries need to upscale the use of renewable energy sources by upgrading existing clean energy technologies through enabling policies, regulatory frameworks and business models.

The Asia-Pacific region, while being a hub for manufacturing and production, has a wide range of energy-intensive economic activities resulting in large consumption of fossil fuels. The rapidly surging energy demand in the region offers immense opportunities to adopt modern renewable energy sources and innovative technologies for clean energy such as solar photovoltaics (PV), wind energy and green hydrogen in production, manufacturing and service sectors. Renewable energy sources can also play a critical role in facilitating universal access to modern energy in the Asia-Pacific region. The share of renewable energy in total electricity production has increased to 25% in Asia and 34% in the Pacific region in 2021. Still, there are challenges in the adoption of renewable energy sources due to a lack of enabling policies, investments and availability of technologies. Vast potential for the generation of clean energy remains to be tapped.

Countries across the region are progressing towards developing policies and regulations to encourage renewable energy generation, conservation strategies and technological innovations to make renewable energy options accessible and affordable for end users. Examples of enabling policy instruments and tools to promote renewable energy expansion and utilization are net metering, feed-in tariffs (FiTs), renewable energy certificates (RECs) and renewable portfolio standards (RPS).

Innovative, low-cost and easy-to-adopt clean energy technologies can be instrumental in facilitating the clean energy transition in the Asia-Pacific region. Such technologies exist but are not yet accessible in some countries that face the twin challenge of combating climate change and achieving economic growth. Transfer, adoption and commercialization of renewable energy technologies in the region can help countries not only achieve their national targets of climate change mitigation but also achieve self-sufficiency for energy sources.

Strategy for the growth of affordable clean energy requires sustained commitment by the national governments through adopting innovative policy instruments and initiatives to promote renewable energy expansion and utilization. There are many successful case studies and models of affordable clean energy options that have demonstrated their economic viability, linkages to social development as well as sustainability. These models can be successfully replicated in different geographical locations and socioeconomic settings.

This issue of *Asia-Pacific Tech Monitor* discusses opportunities to enhance the accessibility and affordability of sustainable energy options in the Asia-Pacific countries. It features articles on the promotion of energy resilience for renewable energy infrastructure and clean energy initiatives, programmes and networks.

Preeti Soni
Head, APCTT

ASIA-PACIFIC

BANGLADESH

New patents bill passed

The parliament enacted Bangladesh Patents Bill 2022, aiming to make a century-old patents law more time-befitting and to safeguard intellectual property rights.

The law, among others, extends the validity period of patents from 16 years to 20 years.

Analysts say this would attract foreign investment as the Bill protects intellectual property and works as a safeguard in stopping generic versions of new products or innovations from coming up.

Sheikh Faezul Amin, additional secretary (policy, law and international co-operation) to the industries ministry, said the new law included provisions that enable joint registrations, if needed.

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 commercial use within the borders of Bangladesh and in order to protect public order and ethics, a number of other issues have been left out of patent protection, including innovation.

A registrar office has been set up to issue or cancel patents of any single inventor or joint inventors of a technical innovation under the proposed law.

Mohammad Golam Sarwar, assistant professor of the Department of Law, University of Dhaka, said that the patent law needs regular updates as per the current trends.

The new patent law will facilitate compliance with agreements on the Trade-Related Aspects of Intellectual Property Rights (TRIPS) and other global standards relating to patents and innovation.

The TRIPS agreement requires member countries to make patents available for any invention, whether products or processes, in all fields of technology without discrimination, subject to the normal tests of novelty, inventiveness, and industrial applicability.

He said the Bill would ensure the right balance between pharmaceutical innovation and access to medicine following the introduction of any pharmaceutical products.

Further, he said that the Bill will protect intellectual property rights while inspiring innovators and businesses to invest more in better innovations and technologies.

Naser Ezaz Bijoy, president of the Foreign Investors' Chamber of Commerce and Industry, supported modernisation and simplification of patent acts, which may be effective in protecting intellectual property and enabling international practices.

However, he emphasized on proper implementation of the law so that confidence grew among foreign investors over the protection of their intellectual property.

https://www.thedailystar.net/

Industry-Design Bill to protect intellectual property rights

The Bangladesh Industry-Design Bill, 2022, was placed in the parliament in a bid to protect the intellectual property rights of industrial design.

The Minister of Industries, Nurul Majid Mahmud Humayun, placed the bill in the house, and was sent to the respective Parliamentary Standing Committee for further examination.

The Committee was asked to submit its report within 30 days.

A registrar office will be there to issue or cancel patents of any single inventor or joint inventors of any technological innovation under the proposed law.

The Bill is enacting by splitting the Patents and Designs Act, 1911, as there is a huge number of diversified affairs under the century-old law.

There is also a provision in the draft law that the owners will get compensation, and such cases will be dealt with by civil courts.

The owners will be given the patent of any innovation for 20 years after receiving the application, and then it will become public.

https://www.tbsnews.net/

CAMBODIA

"Go Digital Cambodia" website launched

The Ministry of Posts and Telecommunications (MPT) launched the "Go Digital Cambodia" website as part of Cambodia's future digital government policy and to promote digital hubs of information and inclusivity.

A statement from the MPT said, "In order to promote the development of digital knowledge and the effective use of digital systems in daily life the ministry has organised the Go Digital Cambodia programme in line with the 'Digital Government of Cambodia Policy 2022-2035.'"

The digital transformation has been rapid in the Kingdom, with the pace of change impacted by the pandemic as businesses, individuals, and government departments raced to adopt contactless and easier means of conducting business, allowing for digital payments and online interactions as a "way of life."

The launch of **godigital.gov.kh** aims to offer "a hub for gathering information, data and digital knowledge, including online security, digital tools, social media platforms, online shopping and financial technology portals."

The website aims to promote the following:

- **Digital enablers:** To open up opportunities for everyone to be more engaged, participated, and involved.
- **Digital literacy and capability:** To raise and build up knowledge and skills to be aware and know how to use digital technology confidently and safely, and ethically.
- **Digital accessibility**: To enable digital inclusion and inclusive communication for everyone.

https://www.b2b-cambodia.com/

CHINA

China's new catalog of industries to spur foreign investment

China released a new version of a catalog of industries to encourage foreign investment, and continue to incentivize foreign businesses toward advanced manufacturing, the service sector and the central and western regions as the world's second-largest economy unswervingly pushes for high-level opening-up.

The series of moves from the central government signaled that the path toward Chinese modernization means opportunities for the world and injecting much-needed stability into the global society, while also rebutting what some doomsayers hyped as "foreign capital flee" from China due to policy uncertainties they noted.

The 2022 version contains 1474 items, adding 239 and revising 167 items compared with the 2020 version. Of these, the national list has 519 items, an increase of 39 and modifying 85 items. The regional list tailored for central and western China has 955 items, adding 200 and revising 82 items compared with the 2020 version, which was approved in late 2020 and came into force in January 2021.

The new catalog is effective from January 1, 2023.

"The revised catalogue is an important measure to stabilize foreign investment under the current situation, which is not only conducive to promoting high-level opening-up and speeding up the building of a new development pattern, but also further helps stabilize foreign investment, optimize investment structure and shores up expectation and confidence of foreign capital," the National Development and Reform Commission (NDRC), China's top economic planner, said in a statement.

One of the major revisions is that the new national catalog adds and expands on new clauses on encouraging investment components and parts as well as equipment building to improve the industrial and supply chain. Further emphasis is placed on adding or expanding items that concern the professional design, technology services, and development, so as to facilitate the integrated development of services and manufacturing industries.

Also, the list designed for central and western regions expands the scope of industries in which foreign investment is encouraged, taking into account local comparative advantages in labor and special resources.

https://www.globaltimes.cn/

China's Innovation Index up by 8%

Th official data showed that China's Innovation Index, the barometer of the country's innovation capability, continued to climb in 2021.

According to the National Bureau of Statistics (NBS) data, the index, introduced in 2005, increased by 8 percent from the 2020 level to 264.6 in 2021.

Total R&D expenditure witnessed a jump of 14.6 percent year on year to reach around 2.8 trillion yuan ($390.53 billion), maintaining double-digit growth for six consecutive years.

The number of domestic patents granted surged 26.9 percent to nearly 4.47 million.

The data showed that sci-tech innovation had further promoted the country's green development. Last year, the energy consumption per unit of gross domestic product (GDP) edged down 2.7 percent from the previous year.

Coal consumption accounted for 56 percent of the total energy consumption, edging down 0.9 percentage points, while that of clean energy went up 1.2 percentage points to 25.5 percent.

https://news.cgtn.com/

China's R&D spending intensity builds up

China's research and development (R&D) spending intensity, or the expenditure on R&D as a percentage of its gross domestic product, built up to 2.44 percent in 2021, shows a yearly statistical bulletin.

The rate, jumping from 1.91 percent in 2012, ranks the top among developing countries and is higher than the European Union's average level, said Liu Huifeng, a researcher from the Chinese Academy of Science and Technology for Development.

According to the country's R&D bulletin in 2021, in 2021, China invested 2.8 trillion yuan ($405 billion) in R&D, rising 14.6 percent over that of 2020. Of the total, over 2 trillion yuan, or nearly 77 percent, was funded by the enterprises.

As per the bulletin, the country's investment in basic research in 2021 totaled to 181.7 billion yuan, a 23.9 percent year-on-year increase. It accounted for 6.5 percent of the overall R&D spending, maintaining a 6-plus percentage growth for three consecutive years.

Provincially, the R&D spending in Guangdong, Jiangsu, Beijing, and Zhejiang stood in the first echelon, exceeding 200 billion yuan each.

A slew of provinces in central and western China, including Hubei, Hunan, Sichuan, and Henan, rose to the 100-billion-yuan club in R&D spending, according to the bulletin.

https://www.chinadaily.com.cn/

Economic growth gains speed

Amid the shift toward innovation-driven development, China has made significant progress in industrial upgrading, moving from a focus on light, export-oriented industries to more capital-intensive, self-contained ventures, kickstarting new growth drivers and business forms, a recent report showed.

According to the report, released by the National Bureau of Statistics, in 2021, the industrial output of major high-tech manufacturers made up 15.1 percent of the total value-added industrial output; 5.7 percentage points higher than 2012.

In addition, the output of new energy vehicles in 2021 was 28.2 times higher than that of 2014, while industrial robot output was 12.5 times higher than the 2014 figure.

China's services sector is also in the process of transformation. In 2021, the added

value of information transmission, software and information technology services accounted for 7.2 percent of the added value of the services sector, up 2.5 percentage points from 2012.

Heavy R&D emphasis

Government and industry have both pivoted in the last decade toward the promotion of scientific and technological innovation as a more sustainable engine of growth.

In 2021, 2.8 trillion yuan ($390.8 billion) was invested in research and development, 1.7 times more than in 2012. The ratio of R&D expenditure to overall GDP stood at 2.44 percent, nearing the average for the Organization for Economic Cooperation and Development countries.

At the end of 2021, the country had a total of 330,000 high-tech enterprises and 4,762 "little giants," a state designation for small and medium-sized enterprises that specialize in strategically important industries such as software or artificial intelligence, spent a high proportion of operating capital on R&D, and are able to aid the country in creating fully domestic supply chains.

The number of authorized patents, a significant barometer for the pace of innovation, registered an average annual growth of 15.5 percent over the past decade.

The government has also made an effort to optimize mechanisms for financing technology firms. The sci-tech innovation board was launched in 2019 on the Shanghai Stock Exchange, and the Beijing Stock Exchange opened for trading in 2021, providing more financing channels for small and medium-sized, innovation-focused firms.

Burgeoning digital biz

One of the most landmark changes in China over the past decade has been the creative blurring of the real and digital economies.

Cashless transactions have largely replaced cards and wallets and e-commerce has taken up an increasing proportion of the country's consumer market. Online retail sales of physical goods exceeded 10.8 trillion yuan in 2021, accounting for 24.5 percent of the total retail sales of consumer goods, the report noted.

https://www.ecns.cn/

INDIA

Green investment jumped 125% FY22

Investment in the *renewable energy* sector in India surged more than 125 percent year-on-year to touch a record $14.5 billion in the financial year 2021-22 (FY22), a report released on Thursday by the Institute for Energy Economics and Financial Analysis (IEEFA) said.

This brings into sharp focus the bets placed by companies on this segment.

Conglomerates such as Reliance Industries (RIL) and the Adani group have ambitious plans to ramp up their *renewable energy* capacity. Acquisitions and bond issues by a host of companies, including RIL and Adani, constituted 75 percent of the total value of an investment in FY22, surpassing FY20 levels, as reported by IEEFA. At that time (FY20), the total investment in the sector stood at $8.4 billion, while FY21 saw a fall in investment activity due to COVID-19, with the total deal value touching $6.4 billion.

The largest deal in FY22 was SB Energy's exit from the Indian market with a sale of assets worth $3.5 billion to Adani Green Energy (AGEL), part of the Adani group, in October 2021. Around the same time, Reliance New Energy Solar, a subsidiary of RIL, picked up REC Solar Holdings for $771 million. Among bond issues, key ones included those of companies such as Vector Green, AGEL, ReNew Power, Indian Railway Finance Corporation, and Azure Power, IEEFA said.

"The increase in *renewable energy* investment comes on the back of the revival in electricity demand from the Covid-19 lull and commitments by corporations and financial institutions to net-zero emissions and to exit fossil fuels," Vibhuti Garg, energy economist, and lead, India, IEEFA, said.

India added 15.5 gigawatts (Gw) of renewable energy capacity in FY22, which brought the total installed renewable capacity (excluding large hydro projects) to 110 Gw as of March 2022.

Even with the surge in investment, renewable energy capacity would have to grow at a much faster rate to reach the target of 450-500 Gw, set out by the government, by 2030, IEEFA said.

IEEFA says for a sustainable energy transition, the government would have to roll out "big bang" policies and reforms to accelerate the deployment of renewable energy.

"This means not only increasing investment in wind and solar power capacity, but also in creating an entire ecosystem around renewable energy," Garg said.

"Investment is needed in flexible generation sources such as battery storage and pumped hydro as well as expansion of transmission and distribution networks. At the same time, modernisation and digitalisation of the grid is required with focus on the domestic manufacturing of modules, cells, wafers and electrolysers. Apart from promoting electric vehicles, there is also a need to push rooftop solar aggressively," she said.

https://www.business-standard.com/

Kerala government to reimburse tech license cost to startups

Kerala has launched a scheme to reimburse the expense incurred by the nascent start-up ventures to procure technology licenses from government research institutions in the country to commercialize and scale up their products.

Under the project titled "Technology Transfer Scheme," implemented through Kerala Startup Mission (KSUM), the government will reimburse up to ₹10 lakh to startups purchasing or sourcing technology from government research institutions and working on them to develop products that could be commercialized.

KSUM CEO, Anoop Ambika, said this scheme will help startups in the state to gain greater access to the know-how required for turning their ideas into marketable products.

KSUM, in a release said, it has invited applications from eligible startups to avail the benefits offered by the scheme.

"This is a highly rewarding scheme that will encourage our startups to innovate on their ideas without bothering about the cost involved," Ambika said.

As part of the fiscal support scheme, 90 percent of the technology fee paid by startups to the research institutions from where technology licenses are purchased or sourced will be reimbursed.

The eligible startups with an active registration with KSUM can submit online applications via the KSUM portal: https:tartupmission.kerala.gov.in/schemes/technology-commercialisation.

https://www.livemint.com/

Increase in FDI equity inflows in R&D sector

In the calendar year 2021, India attracted $343.64 million in Foreign direct investment (FDI) equity inflow, a 516 percent increase over the previous calendar year 2020 ($55.77 million).

In the Research and Development (R&D) industry, FDI is allowed via a 100 percent automatic route, subject to any applicable laws, regulations, security requirements, and other restrictions.

Following Telangana and Haryana in order of FDI Equity recipients in R&D for calendar year 2021 is Karnataka. Telangana, Karnataka, Haryana, Andhra Pradesh, and Tamil Nadu experienced growth of more than 250 percent in 2021 compared to 2020.

https://www.thestatesman.com/

MALAYSIA

Budget allocation to boost role of science, technology, and innovation

The RM1.062 billion allocation under the 2023 Budget, with RM668 million allocated for management expenditure and RM393 million for development expenditure, will boost the role of science, technology, and innovation (STI) toward strengthening the country's economy and competitiveness.

Science, Technology, and Innovation Minister Datuk Seri Dr Adham Baba said the allocation was an increase of 17 percent compared to 2022 and it was a clear message that the role of STI would continue to be strengthened in line with the country's target to become a high technology nation by 2030.

"The Ministry of Science, Technology and Innovation (Mosti) is also committed to intensify efforts to implement the initiatives that have been planned with the spirit of 'Merakyatkan Sains, Menginsankan Teknologi.'"

"Mosti is not only about research and development (R&D) but it also includes STI culture at the grassroots level," he said in a statement.

He said that the 2023 Budget is a responsive budget in ensuring that all Malaysians get greater impact and benefits, especially in the creation of job opportunities, among others, through the empowerment of local start-up companies.

Dr Adham said Mosti would receive an allocation of RM176 million for the commercialization of STI in line with the government's efforts to increase the commercialization of local R&D outcomes.

A total of RM107 million was allocated for STI research to continue the national vaccine development while RM3 million was allocated to the Yayasan Inovasi Malaysia (YIM) to implement the Malaysia Social Innovation (MyIS) programme.

To further boost the growth of the country's start-up ecosystem, he said RM50 million had been provided to support potential start-up companies.

He added that the Cradle Fund, an agency under Mosti, will provide the support that includes financing, talent development, innovation, policy, and regulations as well market environment for start-up companies.

Dr Adham said that starting next year, the government would implement the Local R&D Products and Services Programme with an allocation of RM18 million. — Bernama

https://www.malaymail.com/

PAKISTAN

Renewable Energy Scheme showing remarkable progress

According to an official document of the Ministry of Finance, the Renewable Energy scheme has made remarkable progress till May 31, 2022. It says that as of August 22, 2022, the total disbursements of ₹93 billion have been availed by the *participating financial institutions (PFIs)*. Under the current revised scheme, financing is available for *power generation* of up to 50MW, using alternative/renewable energy sources including solar, wind, hydro, biogas, biofuels, bagasse cogeneration, and geothermal as fuel. Renewable energy scheme comprises three categories. Under the first category, financing of up to ₹6 billion is available for prospective sponsors that are desirous of setting up renewable energy power projects with capacity of more than 1MW and up to 50MW for generating electricity for own use or selling to national grid or the combination of both. Financing is available at the rate of 6 percent with maximum tenor of 12 years. Under the second category, financing of up to ₹400 million is available for the projects with a capacity of up to 1MW for borrowers including domestic, agricultural, commercial, and industrial, who are desirous of installing renewable energy projects/solutions for the generation of electricity for own use and/or selling to distribution companies under net metering regulations of National Electric Power Regulatory Authority (NEPRA). Under this category, the financing is available at the rate of 6 percent and maximum tenor is 10 years.

Under the third category, financing of up to ₹2 billion is available for renewable energy investment entities (RE-IEs), that are desirous of installing renewable energy equipment (only solar and wind) on lease basis, rental basis, deferred payment sale,

or selling of electricity to ultimate owners/users. Under this category, financing is also available at the rate of 6 percent and maximum tenor is 10 years. Experts told WealthPK that the switching over to renewable sources of energy can help Pakistan achieve sustainable growth because the availability of the energy and growth of the economy are interdependent. Pakistan direly needs to use local resources to generate energy because dependence on imported fuel for the generation of energy leads to economic losses, while the provision of cheap electricity will enable the industries to decrease their cost of production and increase exports. The government is also focusing to construct renewable energy projects to decrease the burden on foreign exchange. The government has approved the construction of solar power projects of 2000MW in the public sector to generate low-cost and environment-friendly electricity. It will reduce the country's dependence on power projects running on costly fuels also burdening the foreign exchange reserves.

https://technologytimes.pk/

REPUBLIC OF KOREA

Korea to invest in R&D for 12 strategic technologies

Korea will funnel 4.12 trillion won ($2.9 billion) into research and development next year to promote 12 selected strategic technologies as part of the country's long-term future growth plan, the science ministry said.

The Ministry of Science and ICT said in a report released at a meeting with President Yoon Suk-yeol that the country has picked 12 strategic technologies to focus its capacity and efforts to maintain growth momentum in the influential and emerging sectors.

The 12 technologies are semiconductors and displays, rechargeable batteries, advanced mobility, next generation nuclear power, advanced biology, aerospace and ocean engineering, hydrogen, cybersecurity, artificial intelligence, next generation communications, advanced robotics, and quantum technology.

The report stated that 4.12 trillion won has been set aside for the project next year, up from 3.74 trillion won in 2022.

Local companies and organizations who are engaged in R&D and international cooperation projects related to the 12 technologies and train top-level human resources in the fields will be funded by the government.

The ministry will help them pass state-led preliminary economic feasibility studies through a fast-track process, it added.

https://www.koreatimes.co.kr/

Investment for R&D digitalization

South Korea will spend 200 billion won ($144 million) on digital integration strategy projects over the next 5 years to shorten the time researchers take to solve complex problem surrounding new technologies by decades, according to the Ministry of Science.

According to the ministry, the government will use the financial support for projects that integrate artificial intelligence, digital twin, and big data into developing diagnoses of diseases such as intractable cancer and dementia, nine new materials and prediction models of changes in space.

The ministry plans to increase the number of smart laboratories such as AI robot material labs and bio foundry facilities.

The government will look to strengthen support for advancing the infrastructure of collecting, sharing, and utilizing research data by setting up and operating a quality checking center for research data.

The ministry will develop over 40 data analysis models for various research purposes including designing antibodies and diagnosing diseases through reviewing protein data as well as predicting synthesis probabilities based on material data.

In order to secure core research personnel, the ministry will expand data science education for 1000 masters and doctorate students by 2028. The ministry will also provide AI education for some 8000 researchers at government-funded research institutes through 2027.

https://www.koreaherald.com/

South Korea ranks second in R&D spending-to-GDP ratio

South Korea's corporate R&D (Research & Development) spending accounted for 1.5 percent of GDP (gross domestic product), a recent report showed.

Korean information and communication technology (ICT) companies' R&D spending-to-GDP ratio stood at 1.48 percent on average, according to the report entitled "Internet Economy Outlook 2012" released by the OECD (Organization for Economic Cooperation and Development). This has put Korea at the third ranking among the 38 surveyed countries after Finland (1.62 percent) and Taiwan (1.52 percent). There were only four countries whose ratio exceeded 1 percent including Korea, Finland, Taiwan and Israel (1.14 percent). This is followed by Sweden (0.75 percent), the US (0.67 percent), Japan (0.52 percent), Iceland (0.46 percent), Singapore (0.43 percent), Ireland, and Denmark (0.37 percent, respectively).

"Taiwan, Finland, Japan, Korea, Singapore and Sweden tend to concentrate their R&D budget on the ICT manufacturing industry while Denmark, Iceland, Ireland, Israel and the UK on the ICT service industry," noted the report.

Meanwhile, Korea was also placed among the top ranks in terms of the share of the ICT industry in the R&D spending.

https://www.mk.co.kr/

THAILAND

New Incentives for investor retention, relocation, and hydrogen vehicles

Thailand Board of Investment (BOI) announces new incentives for investor retention, relocation, and hydrogen vehicles.

In a follow up to its new five-year strategy, the Thailand BOI announced new incentive packages including, for the first time, a set of special privileges to support

expansion by longstanding investors, a comprehensive relocation program covering headquarters as well as research and manufacturing facilities, and a first package for investment in sustainable activities such as the manufacturing of hydrogen vehicles and the setup of electric vehicle (EV) battery swapping stations.

The measures, approved at a meeting of the BOI held, also include premium incentives for industries involving innovation and high technology such as biotech, nanotech, and advanced materials, support measures for the research and production of novel food, the addition of new economic corridors, or special investment zones, in four regions of Thailand, and the introduction of a special mechanism to improve the ease of doing business by addressing pain points flagged by investors.

The 2023-2027 Investment Promotion Strategy announced in October aims to help restructure the country's economy and ensure Thailand is innovative, competitive, and inclusive as it competes in the post COVID-19 world.

The strategy sets to encourage technological advancement, the transition to green and smart Industries, talent development, as well as creativity and innovation, to strengthen the country's status as a regional hub for business, trade, and logistics.

The strategy also sets five sectors of strategic importance to industrial development as priority industries, namely the bio-circular-green (BCG) sector, the EV supply chain, electronics manufacturing, the digital economy, and creative industries.

https://hydrogen-central.com/

VIET NAM

Vietnam accelerates investment in artificial intelligence

The Vietnamese government issued a national strategy on the research, development, and application of artificial intelligence (AI) until 2030, aiming to gradually turn Viet Nam into an *innovation and AI hub* in ASEAN and the world. The strategy targets to build ten prestigious AI trademarks in the region and develop three national big data and high-performance computing centers.

According to a *report*, domestic tech powers and innovative startups in Viet Nam are also accelerating their investment in AI research and new applications in new business models. The leading information technology service company in Viet Nam recently announced that it would spend VNĐ300 billion (US$13.16 million) on AI research and development over the next five years. The company has invested in related research and development since 2013. It formed a diverse ecosystem of products, solutions, and platforms to help businesses and organizations optimize their operations, improve their performance and deliver superior customer experience.

Other tech powers such as state-run organizations, Viettel and VNPT, VNG, and Vingroup are also investing heavily in AI. To improve the R&D capacity of AI technology, Viettel and Vingroup has invested in supercomputer technologies to solve highly complex problems in mathematics while accelerating the development of AI technology. Vingroup has also boosted investment in technology and has applied AI technology in healthcare, smart automobiles, and self-driving cars.

Although global tech giants are ahead of Vietnamese tech companies in AI R&D, the participation of Vietnamese companies is a good sign, the report said. It has created a driving force for AI. Experts noted that the investment and development of AI technology by major corporations has attracted Vietnamese experts and AI engineers from all over the world, while seminars with the participation of foreign experts are organized regularly, forming a strong AI community in the country.

By 2030, Viet Nam plans to set up 50 interconnected open databases in economic sectors in service of the effort. To achieve this, the country is fine-tuning legal documents, creating a legal framework regarding AI, and promoting international cooperation in the field. Further attention should be paid to human resources training and building a database that is synchronous with computing infrastructure.

https://opengovasia.com/

Viet Nam's Digital Technology Industry Estimated US$148 Billion

The digital technology industry is a driver of Viet Nam's economy. Viet Nam now has 70,000 digital technology firms, three years ahead of the target set for 2025. The number of digital enterprises in Viet Nam increased from 45,600 in 2019 to 68,800 in September this year.

Long spoke at the Make in Viet Nam Forum 2022, a national forum on the development of digital technology enterprises. It is one of the biggest annual events for Viet Nam's digital technology industry. It attracted about 1000 delegates, including experts, domestic and foreign technology enterprises, and startups in the field of technology in Viet Nam.

At the forum, enterprises shared information about global information technology trends, and proposed solutions to develop sustainable Vietnamese digital technology enterprises. They discussed mastering the domestic market and enhancing the country's value in the global value chain. On the sidelines of the forum, a hybrid exhibition displayed and offered participants opportunities to experience Make-in-Vietnam digital technology products, that are expected to serve the development of the digital government, economy, and society.

The country's ICT industry's revenue was estimated at US$109.5 billion over the first nine months of 2022, a year-on-year increase of 13%. As OpenGov Asia *reported*, the revenue of the ICT industry in the third quarter of this year saw an increase of US$37 billion compared to the figure recorded in the first half of the year.

https://opengovasia.com/

ASIA-PACIFIC

AUSTRALIA

Cost-effective way to recycle solar panels

New research has proposed a cost-effective way to recycle solar panels to help handle an increasing volume of retired photovoltaic (PV) cells expected by the end of the decade. In a paper published by a team from the University of New South Wales, researchers outlined a process to collect and extract valuable materials from solar arrays to see if it was technically, economically, and environmentally feasible.

The process involves collecting solar arrays, stripping them of their aluminium frame, shredding the cells, and using an electrostatic separation to collect valuable materials including silver and copper, reducing the panels to 2%-3% of their original weight. The reclaimed material would then be shipped directly to a refinery for purification and processing.

A lead author of the study, Dr Pablo Dias, said it showed it was possible to run a low-volume facility capable of managing 1000 tonnes of solar panels a year. This is roughly equivalent to 50,000 panels a year, or about 4100 panels a month. "This is something someone can pick up elsewhere, it doesn't use any chemicals, it doesn't emit any pollution or hazardous pollution. It produces dust from crushing the panels, but you have dust collectors there," Dias said.

Dias said smaller-scale facilities were important as they could process material closer to their source before sending it on, reducing emissions from transport. "You could do this in a suburb in South Australia, concentrate the valuable material and then send it directly to the refiners who do extracting and purifying the metals," he said. He has also since moved to put the research into practice via a start-up company, Solarcycle, which is building a facility in Texas in the United States. It is expected to be operational by November.

https://www.theguardian.com

New light on solar cell development

An increase in the efficiency of solar panels may be on the horizon, as research from The Australian National University (ANU) reduces their current limitations. ANU researchers have found a way to improve the performance of silicon photovoltaic (PV) or solar cells. This is done through the addition of "passivating contacts" between the metal and silicon parts of the solar cell, making it more productive. "These findings will help push the performance of silicon solar cells closer to their theoretical limit," Mohamed Ismael, lead ANU researcher and PhD candidate said.

"Transition metal oxides such as titanium oxide have many qualities that make them ideal as passivating contact layers," Dr Lachlan Black said. "This isn't a new idea, but the way in which we combined these layers has produced better results and higher operating voltages than anything previously reported." The research team is hoping to develop the technology to a point where it can be applied to industrial solar cells on a large scale.

"If successful, we could see our technology in almost all new solar panels installed on your roof or utility-scale solar plants," Dr Black said. Some practical issues still need to be addressed before the technology can be implemented, but the PV community is already working to solve these challenges. "Improving the efficiency of solar cells guarantees more clean energy at a reduced cost. This not only helps to address climate change, but opens up new economic opportunities for this low-cost clean energy," Ismael said.

https://www.eurekalert.org

CHINA

Microcapsules for storing solar energy

In a recent breakthrough, researchers from China and USA synthesized PMC microcapsules showing unprecedented photothermal conversion and heat transfer by using n-Octadecane (ODE) as the PCM core and a silicon carbide (SiC) nanoparticle-doped crosslinked polystyrene (CLPS) as the outer shell. "Phase change microcapsule materials have been the focus of our research. In a previous study, we found that a single organic shell has defects in thermal conductivity and stability, while a single inorganic shell is not satisfactory in compactness and coverage. Therefore, we began to focus on doping organic shells with inorganic nanoparticles to obtain organic-inorganic hybrid shells," explains Prof. Jifen Wang from Shanghai Polytechnic University, China, one of the authors of the study, which was published online on 29 September 2022 in *Energy Storage and Saving*.

In their work, the team prepared a series of four microcapsules using a method called "suspension polymerization." They then characterized the microcapsules using scanning electron microscopy, energy-dispersive X-ray spectroscopy, and Fourier transform infrared spectroscopy. The results indicated that the microcapsules were spherical and the nano-SiC particles were embedded in the CLPS shells, aiding the heat transfer and photothermal conversion efficiency of the microcapsules.

The team next tested the thermal properties of the microcapsules and found that they showed superior photothermal conversion and thermal conductivity compared to the non-doped samples. Among the four types of doped microcapsules, the one with 1.25 wt% nano-SiC doping demonstrated the best performance, with a 54.9% photothermal conversion efficiency, a whopping 146% higher its non-doped counterpart!

With such encouraging results, the novel PCM microcapsule shells could provide a solid framework for further research on energy materials with excellent solar energy storage and conversion efficiency. The study also opens new doors to the practical application of multifunctional phase change microcapsules. "These microcapsules can have significant potential applications as energy storage materials in solar energy devices, intelligent thermal

insulation equipment, and energy-saving buildings," says Prof. Wang.

https://www.eurekalert.org

Offshore wind turbine

China's home-developed 13.6-megawatt offshore wind turbine has rolled off the production line in East China's Fujian Province recently, marking the country's breakthrough in the research and manufacturing of the high-end equipment in the sector. With propeller diameter of 252 meters, the wind turbine covers a swept area of 50,000 square meters, which is equivalent to seven standard soccer fields, the *People's Daily* reported on Saturday.

The single unit could produce clean energy of 63.5 million kilowatt-hours annually, meeting the annual electricity needs of more than 30,000 three-people households. It will greatly save energy and reduce carbon emission. It's estimated to reduce the consumption of coal by 19,000 tonnes and reduce carbon dioxide by 48,000 tonnes a year, according to the report. The wind turbine has the largest single-unit capacity in the Asia-Pacific region and the largest propeller diameter in the world. The application of the offshore wind turbine would drive up the industrial upgrading of the country's wind power sector and boost the transformation of the country's energy structure, according to *People's Daily*.

https://www.globaltimes.cn

Selenium solar cell

Researchers from the Wuhan National Laboratory for Optoelectronics (WNLO) in China have fabricated a selenium (Se) solar cell with a selenium-tellurium (Se-Te) absorber, which they claim can optimize the selenium bandgap, thus improving the overall cell efficiency. "Selenium element is a promising light-harvesting material for solar cells because of the large absorption coefficient and prominent photoconductivity," the scientists said. "However, the efficiency of Se solar cells has been stagnated for a long time owing to the suboptimal bandgap (> 1.8 eV) and the lack of a proper electron transport layer."

The researchers built the cell with an indium tin oxide (ITO) substrate, an electron transport layer (ETL) made of zinc-oxide (ZnO), a Se-Te absorber alloyed by using 70% of Se and 30% of Te, and a gold (Au) metal contact. "Alloying selenium with tellurium, which has the same crystal structure and a narrow bandgap, can tune the bandgap and increase the melting point, thus expanding the absorption spectrum and improving the quality of the selenium solar cell films," said the lead author, Chao Chen.

The research group pointed out the ZnO ETL as another decisive factor contributes to increasing the overall cell efficiency. It is reportedly able to slightly react with selenium to enhance its interfacial adhesion and to reduce dangling bonds, and thus, reduce interfacial defects. It tested the device under standard illumination conditions and found its power conversion efficiency reached 1.85%.

"The efficiency of ZnO/$Se_{0.7}Te_{0.3}$ solar cells has more than doubled after nine months in the air," Chen also said, noting that the next steps in the research are to prepare high-quality Se-Te alloy films, eliminate holes and vacancy defects, and optimize device structure.

The scientists said that, thanks to the Se-Te absorber, the cell open-circuit voltage decreased as expected, while the short-circuit current did not always increase due to the current loss at long wavelengths. In addition, they found the fill factor was rather low because of the cliff at the interface and the leakage according to the small shunt resistance. "We mainly focused on the device and analyzed its air stability, defect properties and recombination mechanism, for the sake of providing guidance for the further performance optimization," they said.

https://www.pv-magazine.com

INDIA

Sustainable battery ecosystem

As the popularity of electric vehicles (EVs) grows in India, there are concerns on the environmental impacts of the waste they could leave behind, highlighting the need for appropriate disposal and recycling of EV batteries and associated waste. Some solutions are brewing in Bengaluru, known as the information technology (IT) capital of India, where technocrats and startups, have, over the past few years, been developing innovations to reduce the carbon footprint as well as the hazardous impact on the environment and human health, of EVs and their waste.

One such effort is toward developing indigenous alternatives to the imported lithium-ion batteries, a key component of EVs. Akshay Singhal, Kartik Hajela, and Pankaj Sharma came together in 2015 and co-founded Log9 Materials in Bengaluru. The startup earlier was involved in material science focusing on innovations in nanoparticles and graphene materials. While Singhal and Hajela are alumni of the Indian Institute of Technology (IIT)-Roorkee, Sharma is a former scientist from IIT-Delhi.

The trio, through their venture, has developed a lithium-ion battery for EVs, which uses the nanomaterial lithium titanate (LTO) chemistry. This advanced battery, they say, has a shelf life of 15 years and can charge nine times faster, and has nine times better performance than the standard lithium-ion batteries.

"In India the lithium-ion batteries are used for EVs but they do not seem to be crafted for countries with hot climates like India.

We started working on advance nano materials that could reduce the degradation of Li-ion cells during charge discharge cycles and by now have commercialised the LTO chemistry in the market. With lithium titanate nano particles, the batteries are charged in a very short time, last nine times longer than conventional batteries and also can withstand temperatures up to 230 degrees Celsius. The conventional lithium-ion batteries start degrading by anywhere between 60 degrees to 100 degrees," Sharma told *Mongabay-India*.

Log9 already has several clients, including EV manufacturers. Its LTO batteries are already commercialized for three-wheeler and four-wheeler vehicle

categories. The company has also set up a 50-megawatt hour (Mwh) commercial level lithium-ion cell production facility based on LTO technology and are commissioning their battery pack facility with a capacity of 2-gigawatt hour (Gwh) battery production capability.

Another effort in Bengaluru is to mitigate the quantum and effect of EV battery waste by reusing discarded batteries. Darshan Virupaksha is the co-founder of a Bengaluru-based battery startup called Nunam. The startup initially experimented with reuse of laptop batteries. Now, the team is working on reusing discarded batteries of EVs for other electric energy needs, including for electricity needs in rural and low-income areas. The recycled batteries have so far been used to light up carts of street-side vendors, small shopkeepers, and more as well as meeting some of the energy needs of a BSNL Telecom Tower at Jayanagar in Bengaluru. The recycled battery initiative has been funded by a Government of Karnataka grant which supported pilot projects and has received further support from research and renewable energy organizations such as TERI (The Energy and Research Institute) and the Selco Foundation.

Another Bengaluru-based startup, Metastable Materials, was founded by an IIT-Roorkee alumnus, Shubham Vishwakarma, in the light of increased battery wastes due to the rise of EVs in the country. Vishwakarma calls his company an urban mining company as it is involved in the extraction of valuable materials out of urban waste items like EV batteries.

The startup claims that 90 percent recovery of the crucial components of the batteries like copper, aluminium, cobalt, nickel, lithium, and others make it into re-use by other industries, leading to reduced flow of battery wastes into waste sites in cities. The startup says it is using a patented technology to eliminate the use of chemicals and reduce the generation of waste in recycling of lithium-ion batteries that is allegedly done when using the conventional methods.

https://india.mongabay.com

JAPAN

Three-junction III-V solar cell

Researchers led by Japan's National Institute of Advanced Industrial Science and Technology (AIST) have fabricated a three-junction solar cell based on indium gallium phosphide (InGaP), gallium arsenide (GaAS) and copper, indium, gallium and selenium (CIGS) with a mechanical stacked design. "We are currently increasing our efforts to improve the cell efficiency and the development of the mass production technology," researcher Kikuo Makita told *pv magazine*, noting that this kind of cell has the potential to achieve efficiencies close to 35%.

The scientists built the cell with a two-junction InGap-GaAs upper cell with a bandgap of 1.49 eV, based on a rear-emitter heterojunction structure developed by Japanese manufacturer Sharp, and a CIGS bottom device with a bandgap of 1.01 eV, with improved surface roughness. They connected the cells through a modified smart stack with palladium (Pd) nanoparticles and adhesive.

The research group improved the bottom cell's surface via wet etching. They used a bromine-based solution and modified its thin transparent conducting oxide (TCO) layer. "Surface roughness leads to an increase in the gap width at the bonding interface," they explained, noting that this roughness, combined with the TCO thickness may lead to reflection loss. "Therefore, in this study, we focused on minimizing surface roughness and TCO thickness."

The academics tested the performance of the cell under standard illumination conditions. They found it achieved a power conversion efficiency of 29.3% for the aperture area (31.0% for the active area), an open-circuit voltage of 2.97 V, a short-circuit current density of 12.41 mA/cm^2, and a fill factor of 0.80. They said the obtained efficiency of 29.3% is superior to that of the group's previous results. They claimed it was the highest value ever reported for any two-terminal GaAs-CIGSe-based multi-junction solar cell.

"We examined the costs of the cells using Smart stack technology and, according to our simulation, they may result in a final module cost of US$ 2/W," Makita said. "GaAs cell cost, CIGSe cell cost, bonding cost, and modulization cost are 86%, 7%, 3%, and 4%, respectively." The GaAs cell, especially the GaAs substrate and GaAs epi-growth, is the main factor affecting device-fabrication costs.

"In our project, device epitaxial lift-off (ELO) and substrate reuse techniques are studied to reduce the GaAs substrates costs," Makite said. "In addition, the AIST has developed a hydride vapor phase epitaxy (H-VPE), which is a new growth method for GaAs cells. H-VPE is a low-cost technique compared to the general metal-organic chemical vapor deposition (MOCVD) technique. We think that the development of these fabrication technologies contributes to the cost reduction of expensive GaAs cells."

The researchers presented the cell design in "Mechanical stacked GaAs//$CuIn_{1-y}Ga_ySe_2$ three-junction solar cells with 30% efficiency via an improved bonding interface and area current-matching technique," which was recently published in *Progress in Photovoltaics*. The cost of producing solar cells based on compounds of III-V element materials – named according to the groups of the periodic table that they belong to – has confined such devices to niche applications, including drones and satellites, where low weight and high efficiency are more pressing concerns than costs in relation to the energy produced.

https://www.pv-magazine.com

REPUBLIC OF KOREA

Microalgal strain for biofuel production

A state-run research body in the Republic of Korea has discovered a method to quickly cultivate a microalgal strain from cyanobacteria, known as blue-green algae, that can produce twice as much biofuel as other microorganisms due to rapid proliferation. The study opened the way for researchers to commercialize cyanobacteria-based carbon-neutral fuels.

A research team from the National Institute of Biological Resources (NIBR) would conduct additional studies to reveal the characteristics of the microalgal strain identified as *Pseudanabaena mucicola* GO0704 and lay the foundation for genetic engineering research to increase productivity, according to the Ministry of Environment. "Microalgae also have a greenhouse gas reduction effect that absorbs carbon dioxide, making it a promising next-generation biofuel material," Kim Chang-mu, a senior NIBR researcher, said in a statement released by the ministry on November 3. "We will study how to use it as a biofuel through various research."

GO0704, which contains ethanol and diesel, can be used as biofuels, but optimal growth conditions have not been known. NIBR researchers discovered optimal culture conditions by applying the volatile fatty acid-treated mixotrophic cultivation of GO0704 for the enhancement of biofuel production. The treatment of butyric acid or acetic acid enhanced the growth of cells, resulting in the production of high amounts of biodiesel and bioethanol.

The optimal incubation period was shortened by four days when sodium acetate was added, and the production of biofuels per day more than doubled when butyric acid was added, the institute said, adding that the method can dramatically reduce biofuel production costs because acetic acid or butyric acid is a cheap substance that can be obtained when organic substances such as food waste are decomposed.

https://www.ajudaily.com

Inverted perovskite solar cell

Researchers at South Korea's Ulsan National Institute of Science and Technology (UNIST) have developed an inverted perovskite solar cell with a vertically oriented passivation layer. It relies on two-dimensional Ruddlesden–Popper perovskites (RPP), which are known for their excellent stability. The scientists said they were able to achieve a "highly ordered" passivation layer by gauging the deposition rate of the RP phase perovskite, which has a direct influence on its crystallographic orientation. "We demonstrate the use of a highly oriented butylammonium RP perovskite as a surface passivation layer with bottom-up growth on the bulk perovskite absorber layer via vacuum deposition," they explained. "In this process, the crystal formation time directly affects the crystallographic orientation of the passivation layer."

They built the cell with an indium tin oxide (ITO) substrate, a hole transport layer (HTL) made of poly-triarylamine (PTAA), methylammonium lead iodide (MAPbI3) perovskite layer, the RPP passivation layer, an electron acceptor made of phenyl-C61-butyric acid methyl ester (PCBM), a zinc-oxide (ZnO) layer, and a silver (Ag) metal contact. They said the 2D perovskite layer passivates the bulk perovskite defects and promotes charge transport efficiency. The champion cell designed with this configuration achieved a power conversion efficiency of 21.4%, which the academics described as the highest ever achieved for perovskite solar cells formed by vacuum deposition. They described the cell in "A vertically oriented two-dimensional Ruddlesden–Popper phase perovskite passivation layer for efficient and stable inverted perovskite solar cells," which was recently published in *Energy & Environmental Science*. "Our findings provide a new perspective toward further improving the performance of perovskite solar cells by mitigating nonradiative recombination pathways in perovskites," they said.

https://www.pv-magazine.com

SAUDI ARABIA

Smart glass windows that can polarize sunlight

Basem Shihada, an associate professor of Computer Science at the King Abdullah University of Sciences and Technology (KAUST), had been exploring data encoding into an artificial light source when he wondered if the same could be done with sunshine. "I was simply hoping to use a cell phone camera to record a video of the encoded light stream to try to decode the video to retrieve the data; that's when I thought, why not do the same with the sunlight?" Shihada said in a statement. "This would be much easier and can be done over the cell phone camera too. So we began to explore sunlight as an information carrier."

According to his study, "considerable amounts of ambient light remain unexploited and are mainly used for illumination purposes. Such light can be modulated to transmit data offering a complementary solution for wireless communication." Sunshine streaming through a window could easily be harnessed for wireless data transmission to electronic devices.

Shihada and his team of KAUST researchers immediately got to work and designed a smart glass system (switchable glass) that can regulate sunlight passing through it. The system would encode data into the light that can be detected and decoded by devices in the room. Not only is the system innovative, but it also offers a greener mode of communication in comparison to conventional Wi-Fi or cellular data transmission.

The devised system comprises two parts—a light modulator that can be embedded in a glass surface and an in-room receiver. "The modulator is an array of our proposed smart glass elements known as Dual-cell Liquid Crystal Shutters (DLSs)," Osama Amin, a research scientist in Shihada's labs, said. The liquid shutter array would require only one watt of power to operate, its function being to encode signals into the light as it passes, acting like a filter. The power would be supplied using a small solar panel.

Sahar Ammar, a student in Shihada's team, explained that data is usually encoded by varying the light intensity. "But if the frequency of these intensity changes is too low, it can be detected by the human eye and cause an uncomfortable flicker effect," she said. Therefore, the DLS is designed in such a way that it can manipulate polarization. "Change in light polarization is imperceptible to the eye, eliminating the flicker problem," Ammar said. "The

communication system works by changing the polarization of the incoming sunlight at the modulator side. The receiver can detect this change to decode the transmitted data."

According to the team, the designed setup can transmit data at 16 kilobits per second. "We are now ordering the necessary hardware for a testbed prototype implementation. We would like to increase the data rates from kilobits to mega- and gigabits per second," Shihada added.

https://interestingengineering.com

SINGAPORE

Cheap wind harvester

While wind energy systems can come in some pretty big forms, scientists at Nanyang Technological University (NTU), Singapore, have been working on a low-cost solution at the other end of the spectrum. The team has developed an inexpensive device sensitive enough to capture energy from a light breeze and turn it into electricity, generating enough to run a small commercial sensor.

The harvester is small, low-cost, and measures around 15 × 20 cm (6 × 8 in). It consists of a cantilevered beam attached to a middle plate made of layers that harness energy through the triboelectric effect, in which different materials become electrically charged as they separate, in this context caused by vibrations from the wind. We've seen this type of triboelectric technology deployed in other advanced wind harvesters, such as wearable devices that generate energy from the wind as you walk.

The NTU team's device is instead designed to be mounted on the exterior of buildings in urban environments. In their testing, the scientists showed it could harvest energy from a light breeze and can generate up to 290 microwatts of electricity, produce up to 3 volts and also store electricity for use when there is no wind.

In one experiment, they used the device to power 40 LEDs consistently from a wind speed of 4 meters (13 ft) per second. In another, it was used to power a sensor that wirelessly relayed room temperature data to a mobile phone. The team is continuing work to improve the performance of the device, and are filing a patent as they pursue commercialization of the technology.

"As a renewable and clean energy source, wind power generation has attracted extensive research attention," said Professor Yang Yaowen, who led the research. "Our research aims to tackle the lack of a small-scale energy harvester for more targeted functions, such as to power smaller sensors and electronic devices. The device we developed also serves as a potential alternative to smaller lithium-ion batteries, as our wind harvester is self-sufficient and would only require occasional maintenance, and does not use heavy metals, which if not disposed of properly, could cause environmental problems."

https://newatlas.com

EUROPE

NORWAY

Thermal battery to store solar power

SINTEF, an independent research organization in Norway, has developed batteries based on PCM, which are able to store wind and solar power in the form of heat via a heat pump. PCM can absorb, store, and release large amounts of latent heat over defined temperature ranges. They have often been used at the research level for PV module cooling and the storage of heat.

"The heat battery can use any heat source as long as a fluid carries the heat to/from the heat battery," researcher Alexis Sevault told *pv magazine*. "For example, district heating is also coupled to our demo unit, for more flexibility in winter. In that case, water is the heat transfer fluid, since it is very well suited for most buildings. Our technology can also be used in industrial processes, using pressure heat transfer fluid, for example, pressurized CO2 for refrigerated or freezing industrial processes."

The scientists embedded what they described as a "bio-battery" in a silver-colored container that hosts 3 tonnes of a type of PCM – a liquid biowax based on vegetable oil. It is reportedly able to melt at body temperature and becomes a solid, crystalline material when it gets "cold" below 37°C. The heat storage system also contains a heat exchanger for heat extraction. "This is achieved with the help of 24 so-called cushion plates that release heat to the process water which serves as an energy carrier that removes the heat from the storage system," the scientists explained. "Together, the PCM and the plates enable the heat bank to be both compact and efficient."

The PCM absorbs large amounts of heat by changing its physical state from solid to liquid, and then releases it when the material hardens. The battery is then able to heat cold water and release it toward a building's radiators and ventilation systems, thus supplying heated air.

"The PCM-based heat storage system is delivering exactly the performance we expected," Sevault said, noting that his team tested the device for more than a year at the ZEB laboratory operated by the Norwegian University of Science and Technology (NTNU). "We're utilizing as much as possible of the building's self-produced solar energy. We're also finding that the system is very well suited to so-called peak shaving."

According to the group's analysis, charging the bio-battery before the coldest parts of the day may help significantly reduce power consumption from the grid while taking advantage of fluctuations in the spot price. "The system is thus much less sophisticated than a traditional battery – but it isn't suitable for all buildings. As a new technology, investment costs remain high," the group said.

According to Sevault, the proposed storage technology is much simpler than conventional batteries, as it does not require any rare materials, with a long expected lifetime and little need for maintenance. "That being said, the specific cost in euros per kilowatt-hour is already comparable

or lower than regular batteries, without being mass-produced yet," he stated, without providing further details.

Other researchers at SINTEF recently developed a high-temperature industrial heat pump than can work with pure water as its work medium, and reportedly reach a temperature of up to 180°C. The machine, which the research group describes as the "world's hottest heat pump," can be used with different industrial processes that rely on steam as an energy carrier and can reduce a facility's energy consumption by between 40% and 70%, as it enables the recovery of low-temperature waste heat, according to its creators.

https://www.pv-magazine.com

SPAIN

Underground heat exchanger to cool down solar panels

Researchers at the University of Alcalá in Spain have developed a cooling technique for solar modules that uses an underground, single-phase, closed-loop heat exchanger circuit that acts as a natural heat sink. "Our analyses, made for various types of residential and commercial installations, show that the system is economically viable with investment amortization periods that range between five and 10 years," researcher Ignacio Valiente Blanco told *pv magazine*.

The cooling technique involves the application of a heat exchanger onto the back side of a solar panel to remove excess heat. This heat is transferred underground by a coolant fluid that is refrigerated by another U-shape heat exchanger introduced in a borehole at a depth of 15 meters, filled with natural water from the aquifer in the underground. "The cooling system needs extra energy to activate the pump of the coolant," the researchers explained. "As it is a closed-circuit, the potential energy difference between the bottom of the borehole and the solar panel does not impact the power consumption of the cooling system."

The scientists tested the cooling system at an off-grid PV installation, which they described as representative of a typical solar farm with single–axis tracking systems. The array consists of two 270 W modules supplied by Spain's Atersa. They feature a temperature coefficient of –0.43% per degree Celsius.

The heat exchanger of the solar panel is mainly composed of a set of six plastically deformed, flattened U-shaped copper tubes, each measuring 15 mm in diameter. The tubes are all thermally isolated by polyethylene foam and are connected to common 18-mm-diameter inlet and outlet collectors. The research group used using a constant coolant flow rate of 3 l/min or 1.8 l/min per square meter of solar panel.

The experiment showed that the cooling tech could reduce the operating solar module temperature by between 13°C and 17°C. It also improved module performance by around 11%, which means that during an entire day, the cooled panel would provide 152 Wh more than its uncooled counterpart, according to the study. The academics introduced the cooling system in "Efficiency Improvement of Photovoltaic Solar Modules by Cooling Using an Underground Heat Exchanger," which was recently published in the *Journal of Solar Energy Engineering*.

https://pv-magazine-usa.com

SWITZERLAND

Transparent solar cells

In a paper published in the journal *Nature*, researchers from Switzerland's École Polytechnique Fédérale de Lausanne detail the way in which they helped DSCs harvest energy from the full visible light spectrum. DSCs, a type of low-cost, thin film solar cell, use photosensitized dye attached to the surface of a wide band gap semiconductor to convert visible light into energy. Despite their financial and physical practicality, they're not as efficient as conventional solar cells, which delegates both light absorption and energy generation to the semiconductor. This means that even though energy-generating windows have technically been possible for a while, the devices wouldn't have been worth the resources.

This new efficiency record could change that. The team in Switzerland enhanced DSCs' efficiency by meticulously controlling the assembly of dye molecules on the cells' nanocrystalline mesoporous titanium dioxide (TiO_2) films. Pre-adsorbing a single layer of hydroxamic acid derivative on the film's surface allowed the scientists to improve the molecular packing and performance of two custom-designed sensitizers. These sensitizers were found to be capable of harvesting light from the entire visible spectrum.

During a simulation of standard air mass 1.5 sunlight—the air mass coefficient typically used to measure solar cells' performance—the enhanced DSCs achieved a power conversion efficiency (PCE) of 15.2 percent. Considering the fact that 12.3 percent was the best-known DSC PCE in 2019, that figure is impressive, especially when you factor in that the enhanced cells maintained operational stability over 500 hours of testing. Better yet, when the scientists tested their enhanced DSCs on devices with a larger active surface area, they achieved a groundbreaking PCE range of 28.4 to 30.2 percent.

The team believes the enhanced DSCs could pave the way for energy-generating windows, skylights, and greenhouses in the near future. They could even find a place in low-power electronic devices, which would then use ambient light as an energy source.

https://www.extremetech.com

UK

Inverted perovskite solar cell

Researchers from the University of Surrey in the United Kingdom have fabricated an inverted perovskite solar cell by using a surface modulator that reportedly facilitates superior passivation on perovskite surfaces, increasing overall cell efficiency. As the surface modulator, the scientists tested two organic halide salts known as 4-hydroxyphenethylammonium iodide (HO-PEAI), and 2-thiopheneethylammonium iodide

(2-TEAI). "These modulators can affect the surface energy of the perovskite films," they explained.

They noted that the two compounds can dramatically reduce non-radiative interfacial recombination. This can have a significant impact on electrical performance in perovskite cells, with implications for open-circuit voltage, short-circuit current, fill factor, and ultimately, power conversion efficiency. They reported that "2-TEAI showed a stronger interaction than HO-PEAI, forming a quasi-2D structure on the perovskite surface without further annealing."

The scientists built the p-i-n structured cell with poly-TPD coated indium tin oxide (ITO) substrate, a hole transport layer made of carbazole (2PACz), the perovskite layer, the 2-TEAI modulator, an electron acceptor made of phenyl-C61-butyric acid methyl ester (PCBM), a bathocuproine (BCP) buffer layer, and a silver (Ag) metal contact. The salts were deposited onto the surface of perovskite films through a facile spin-coating process without annealing. Through different measurements, the research team ascertained that the surface modulator does not alter the absorption spectra of perovskite films.

"The 2-TEAI induces a deeper valence band edge, which is expected to provide a stronger hole-blocking effect at the perovskite/PCBM interface and thus is more beneficial for reducing the interfacial recombination," the group said. "Based on these results, we believe the 2-TEAI would enhance the open-circuit voltage of manufactured perovskite solar cells."

The solar cell achieved a power conversion efficiency of 21.85%, which the scientists described as the highest reported efficiency for inverted perovskite solar cells that use 2PACz as the hole transport layer. The device also achieved an open-circuit voltage of 1.2 V, a short-circuit current of 21.93 mA cm^{-2}, and a fill factor of 0.83. For comparison, a reference perovskite solar cell without the modulator achieved an efficiency of 19.95 and was able to retain only 53% of the initial efficiency after 180 minutes.

"The findings suggest that the role of the modulator is more than surface passivation," the scientists concluded. "Our study will provide insight into the selection and molecular design of post-treatment materials for highly efficient and stable perovskite solar cells."

https://www.pv-magazine.com

NORTH AMERICA

USA

New system converts sewage to biogas

Researchers have developed a new method to convert leftover sludge to biogas, lowering waste treatment costs and helping the environment. A Washington State University research team has tested a pre-treatment technology in waste management systems, adding an extra step to typical treatments and using oxygen-containing high-pressure steam to break down sewage sludge. It was found that they were able to convert more than 85% of the organic material to biogas, which can be used to produce electricity or upgraded to renewable natural gas (RNG) for the natural gas grid or for local use.

The work, funded by the U.S. Department of Energy, was published in the journal *Waste Management*, under the title "Improved valorisation of sewage sludge in the circular economy by anaerobic digestion: Impact of an innovative pre-treatment technology."

The researchers treated the sludge at a high temperature and pressure with oxygen added before the anaerobic digestion process. The oxygen acts as a catalyst under high pressure, subsequently breaking down the polymers in the material. The pre-treatment process has been studied for several years, previously being used to break down straw and woody materials. The team was not sure whether the process would work to produce biogas from the sewage sludge, due to different compositions such as lipids and proteins. However, they were positively surprised by the outcome. Now, the team is working with Clean-Vantage, a Richland-based clean technology start-up company active in the pre-treatment area, and the Pacific Northwest National Laboratory (PNNL), which is doing a techno-economic analysis of the new process.

Adding the new pre-treatment step improves the anaerobic conversion of sewage sludge at the wastewater treatment facility from the current less-than-50% conversion rate. The new method also produces 98% more methane than the current practice, which can be used as biogas.

Birgitte Ahring, professor in the Gene and Linda Voiland School of Chemical Engineering and Bioengineering and leader of the study, stated: "It was shown to be extremely efficient, and that's very exciting. This can be applicable and something we could begin to explore in Washington state. Not wasting waste, but using its potential instead, has major advantages."

Now, the researchers are scaling up the work in their pilot facility located at WSU Tri-cities to further demonstrate the process. The team is studying how to efficiently convert biogas to more valuable renewable natural gas by a new bioprocess. Although the biogas created can be used to produce electricity, producing renewable natural gas could allow rural communities to generate local transportation fuel for fueling their municipal vehicles.

https://www.innovationnewsnetwork.com

Flow battery technology

The research team has founded a startup company, Flux XII LLC, in Madison to commercialize their long-duration grid energy storage solution with the help of the University's technology transfer office. University of Wisconsin-Madison researchers have developed a new "flow battery" technology that stores energy in organic salts dissolved in benign water.

The team hopes to scale and demo their solution with regional partners, which

they believe will enable safer and more adaptable clean energy than current grid energy storage products.

This team's story began in 2015 when Dr. Wenjie Li started researching aqueous (water-based) redox flow batteries as a chemistry Ph.D. student at UW-Madison. "I wish my research can really contribute to creating a better world. Having been trained as an electrochemist, redox flow battery is a pathway where I can apply my knowledge and skills to deliver affordable and renewable energy to everyone," Dr. Li said when asked what motivated him to begin research on this topic.

Grid batteries act as an energy insurance plan while increasing savings by optimizing solar (or wind) usage with your utility's policies. The current market relies on lithium-ion technologies for emerging grid-scale battery applications, the same technology used in rechargeable computers and phones.

Professor Dawei Feng, who worked on lithium-ion battery materials as a Stanford postdoc from 2017-2018 and began research at UW-Madison as an assistant professor in Materials Science and Engineering in 2019, says lithium-ion batteries for the grid "just don't make sense," referencing their fire risk and short-duration (6-hour) limitation for end-users.

Patrick Sullivan, who also performed summer undergraduate research on lithium-ion batteries in 2018 and has been a UW-Madison Chemistry Ph.D. student in Dawei's lab since 2019, is passionate about the sustainability of new technologies after having learned to comprehensively evaluate solutions through a UW-Madison Energy Analysis and Policy graduate certificate.

Sullivan notes the supply chain constraints and international mining concerns of lithium-ion materials. "There's really just not enough Lithium for both the grid and electric vehicle markets, and we may just make the global sustainability crisis worse if we aren't careful," Sullivan said.

With these passions and experiences, the team formed a natural collaboration in 2019 to develop a better grid energy storage solution. Instead of relying on rare foreign metals, the team researches sustainable "organic redox molecules" that can be produced domestically from inexpensive, readily available materials. These organic salts are then dissolved in water and pumped through the battery to store energy while eliminating concerns over fire risk. These materials have been researched in academic labs for the past decade. Still, commercial progress has been slow due to scientific trade-offs in material properties that are ultimately detrimental to either energy efficiency, energy density, or cost.

Since 2019, with the help of postdoc synthetic expert Dr. Xiuliang Lyu and funding from WARF, Development to Product (D2P), and UW System grants, Dawei's University research lab has screened over 500 different flow battery chemistries. The lab has published some of these results in peer-reviewed academic journals and patented related materials that overcome the decade-long performance hurdles. Dawei contributes impactful research progress to their expertise in designing, synthesizing, and evaluating organic materials. At the same time, Sullivan believes their passionate and collaborative team allows them to be more creative.

Both agree that this is just the beginning, as they are now forming partnerships to move the technology beyond a "lab research project." In September 2022, the team set up a 1 kW flow battery prototype at UW-Madison, roughly 1000 times larger than what they typically use to test their materials. With the support of UW-Madison and regional industry partners, the Flux XII team aims to demo a 20 kW flow battery device with a regional customer sometime in late 2023 at a discounted price. This demo – a "lego block" to building larger systems – will validate this exciting technology to help spur safe and secure clean energy adoption in the region.

https://www.tdworld.com

New biogas process

A Washington State University (WSU) research team has developed a new method to treat sewage sludge and turn it into biogas—methane—that could help reduce the cost of waste treatment and help the environment, according to a WSU press release. The process involves adding oxygen-rich, high-pressure steam to help break down and convert as much as 85% of the sludge to biogas, which can be burned in the same way natural gas is burned, to generate heat and electricity, the press release said.

Most wastewater treatment plants in the United States use an anaerobic digestion process in which bacteria, with no oxygen present, break down sewage waste. However, according to the press release, the process is inefficient and creates a fair amount of sludge, much of which is dried and carted to landfills. The high-pressure steam is added before anaerobic digestion, the press said, allowing oxygen to act as a catalyst in breaking down complex molecules.

"This is not a very high-tech solution," said Birgitte Ahring, an engineering professor at WSU. "It's actually a solution that can be useful even at small scale. The efficiency has to be high or else you cannot warrant adding the extra costs to the process." WSU is working with Richland-area clean-tech startup Clean-Vantage to help further develop and commercialize the technology, which was funded through a grant from the U.S. Department of Energy.

https://www.chronline.com

Promotion of Energy Resilience for Renewable Energy Infrastructure in the Asia-Pacific Region

Kampanart Silva*, Pidpong Janta, Nuwong Chollacoop

National Energy Technology Center (ENTEC), 114 Thailand Science Park
Phaholyothin Road, Klong Nueng, Klong Luang, Pathum Thani 12120, Thailand

*Corresponding author
Email: kampanart.sil@entec.or.th

Abstract

Energy resilience is a concept to build the capacity of energy infrastructures against disasters and climate change. There are several energy resilience initiatives in the Asia-Pacific region at both policy and grassroots levels. APEC Energy Working Group issued APEC Energy Resiliency Principle which is a policy document that identifies factors, initiatives, and stakeholders that will improve energy resilience against disasters. ASEAN started its efforts at the grassroots level with the ASEAN Energy Resilience Assessment Guideline that can be used as a guide for an assessment of a solar power system. ASEAN brought energy resilience up to the policy level when it issued the 7th ASEAN Energy Outlook in which a chapter has been dedicated to the discussion on measures to enhance the resilience of the energy sector. Inclusion of energy resilience in the Philippine Energy Plan and the actual energy resilience assessment of a solar power plant in Thailand serve as practical examples of energy resilience initiatives in the region. Both of the examples have been discussed in this paper.

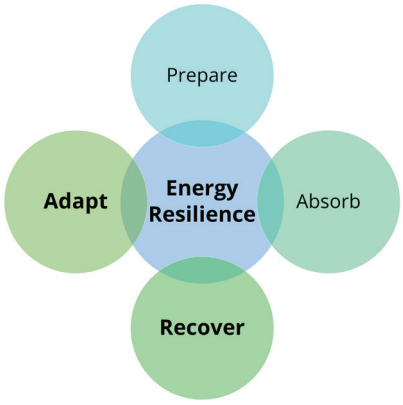
Introduction

Resilience has gained increasing interest among countries and international organizations as it is believed to strengthen the adaptive capacity of critical infrastructure. The term "resilience" appeared in at least two important Sustainable Development Goals (SDGs) by United Nations (2015), Goal 11: Sustainable Cities and Communities which suggests cities and human settlements to adopt integrated policies and plans toward resilience against disaster and create financial scheme and technical support for building resilient infrastructures, and Goal 13: Climate Action which recommends nations to cultivate resilience and adaptive capacity against climate-related hazards and natural disasters. Glasgow Climate Pact which is the result of the 2021 United Nations Climate Change Conference (COP26) (UNFCCC, 2022) also acknowledged the importance of resilience as it ensures global recovery after calamities and emphasized the urgency of creating actionable supporting scheme in terms of finance, capacity building, and technology transfer to enhance and strengthen resilience against climate change. Priority 3: Investing in disaster risk reduction for resilience under Sendai Framework (United Nations, 2015) introduces a similar idea. It emphasizes the role of public and private sectors in investment in disaster risk reduction to enhance resilience of individuals in economic, social, health, and cultural aspects.

Above-mentioned global commitments have proved that climate change and disasters can bring about great impacts to individuals and critical infrastructures. Particularly for the energy systems, the concept of resilience plays an important role in coping with the impacts. It is a key concept that contributes to the enhancement of climate adaptability of energy infrastructure and facilities. A number of global initiatives show strong interest and willingness to adopt the concept of energy resilience to strengthen and prepare energy infrastructures. This approach is helping these energy infrastructures to withstand impacts from climate change that are increasing in severity. The rise of energy resilience has led to several initiatives in the Asia-Pacific region at both policy and grassroots levels, and this article provides a glimpse of these initiatives along with the ways to promote the concept at different levels.

Energy resilience

The concept of energy resilience (also known as energy resiliency) is a strand of the resilience concept that was originally introduced by Holling (1973). Energy resilience is vague in definition, and the way it has been defined and interpreted varies from one discipline to another. Introduced and originated in ecology, resilience emphasized a system's ability to withstand disturbance by absorbing the impacts that occurred and can still restore to pre-disturbance conditions (Sharifi, 2016). One of the widely adopted definitions of energy resilience is *the ability to prepare for and adapt to changing conditions, and withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents* (Presidential Policy Directive 21, 2013). This ideal concept has further developed to four basic elements of energy resilience: *plan/prepare*, *absorb*, *recover,* and *adapt*, as shown in Figure 1.



Source: Roege et. al., 2014.

Figure 1. Basic elements of energy resilience concept

Though a common understanding about energy resilience has somehow been agreed upon, many of the studies or initiatives are still at the stage of a conceptual framework and the development of metrics or criteria for resilience assessment. Thus, several countries in the Asia-Pacific region realized the necessity of raising awareness of the concept in a larger pool of audience and putting it into practice in energy systems in their own countries. The study of the concept of energy resilience has emerged and received even more attention as the concept can be integrated not only at the policy level where resilience policy can be enforced to build adaptive capabilities of critical energy infrastructure against disruptive events, but also at the operational level where energy resilience assessment can be performed for energy infrastructures, in particular renewable energy systems, to understand the gaps to be fulfilled in order to maintain the functionality of the system during undesired disruptions. The initiatives to promote energy resilience in the Asia-Pacific region at policy and grassroots levels have been discussed further.

APEC Energy Resiliency Principle

Asia-Pacific Economic Cooperation (APEC) first introduced the concept of energy resilience in 2015 in the Cebu Declaration (Asia Pacific Energy Portal, 2015), where APEC Economies affirmed the importance of energy resilience to promote energy security and achieve sustainable development in 2015 APEC Energy Ministerial Meeting with the theme of "Towards an Energy Resilient APEC Community." Energy resilience was believed to help secure stable energy supply by effectively dealing with natural and man-made disasters which have been recognized as a continuous challenge of the region. Later, the APEC Energy Working Group (EWG) established Energy Resiliency Task Force (ERTF) to enable focused discussion on the concept. ERTF is co-chaired by the Philippines and the United States (DOE, n.d.). ERTF Secretariat launched APEC Energy Resiliency Principle (ERTF Secretariat, 2020) in the 59th APEC EWG Meeting in August 2020 in Malaysia. APEC Energy Resiliency Principle defines energy resiliency as the ability and quality that enables for energy systems to withstand extreme natural and manmade disasters and to recover and return to normal conditions in a timely and efficient manner and to build back better. The Principle focuses on identifying the framework and a comprehensive set of factors, initiatives, and stakeholders that will improve energy resiliency against disasters. It recommends that governments establish regulations, standards, and guidelines for energy resiliency plans, and encourages the energy supply industries, other industries, and general energy consumers to formulate and implement energy resiliency plans. It also suggests financial institutions to evaluate, invest, and finance public and private projects that help enhance energy resiliency. Finally, the Principle advocates APEC Economies to balance cost, risk and performance of energy resilient infrastructure with asset management systems (ISO, 2014), adopt emerging technologies, and take voluntary measures to share best practices on energy resiliency enhancement among stakeholders.

APEC EWG has taken several follow-up actions, under ERTF, based on the APEC Energy Resiliency Principle. Japan, another active member of the ERTF, proposed two projects to put the Principle into practice. One was the Workshop on Energy Resilience Principle (APEC, 2020) to promote the dissemination of the Principle, build the capacity of the energy sector, and draft a Guideline based on experience and views of APEC Economies to match the Guideline with the local context of each APEC Economies. The other was the APEC Energy Resiliency Enhancement Project (APEC, 2021) which aimed to develop an energy resiliency evaluation model, create Energy Resiliency Sectoral Guidelines for energy infrastructure companies, and raise awareness of energy resiliency in the region. Apart from these activities that are directly linked to the APEC Energy Resiliency Principle, there was also a Workshop on Improving Energy Resiliency in Off-grid Areas in APEC Member Economies, led by the Philippines, that resulted in Guidelines to Develop Energy Resiliency in APEC Off-Grid Areas (APEC Energy Working Group, 2017) which will contribute to the enhancement of energy resiliency of marginalized and off-grid communities. The United States held an APEC Workshop on Promoting Resilience in the Energy Sector, which led to the solutions to promote resilience in the energy sector against climate change (APEC Energy Working Group, 2018).

The issuance of the APEC Energy Resiliency Principle along with the establishment of ERTF and other supporting initiatives show the eagerness in the APEC energy sector to work at the policy level to enhance the resilience of energy infrastructure in the Asia-Pacific region. APEC EWG also tries to engage all relevant stakeholders and suggest the mechanisms to make the Principle practical by developing an evaluation model, creating guidelines, and holding training sessions.

ASEAN Energy Resilience Assessment Guideline

On the other hand, efforts to promote energy resilience in the Association of Southeast Asian Nations (ASEAN) start at the grassroots level. National Energy Technology Center (ENTEC), Thailand, tailored the Self-Guided Reference for Practitioners of National Renewable Energy Laboratory (NREL) (Stout et al., 2019), by introducing

the change over time of the risk and modifying some assessment items to match ASEAN local context (see Figure 2), and used it to conduct four energy resilience assessments of four different renewable energy systems, including a state-owned on-grid solar power plant, a rural solar microgrid, a commercial biomass power plant, and a community biogas plant. Based on the assessments and the findings from a bibliometric study (Janta et al., 2022), it was concluded that the assessment would better fit a solar power plant compared to other renewable energy systems. The assessment framework was further adjusted to suit the assessment of solar power plants in ASEAN.

ENTEC, with the support of the Office of the Permanent Secretary of the Ministry of Higher Education, Science, Research and Innovation (MHESI), made energy resilience a 2021 annual priority of the ASEAN Committee on Science, Technology and Innovation (COSTI) to address the United Nations' Sustainable Development Goals (UN SDGs) (COSTI, 2021). ENTEC then developed the ASEAN Energy Resilience Assessment Guideline (ENTEC, 2022) and had it endorsed by the ASEAN Sub-Committee on Sustainable Energy Research (SCSER) at the 50th SCSER Meeting, and consequently by COSTI at the 82nd COSTI Meeting, both in October 2022 (COSTI, 2022). The Guideline is recommended to be used for energy resilience assessment of a solar farm in ASEAN, though it can also be applied to a large-scale solar rooftop or a large-scale solar carpark. The Guideline has been used to assess the 50 MW_{AC} Gambang Solar Power Plant of Universiti Teknologi MARA (UiTM) (ENTEC, 2022) and the 2.8 MW_{AC} UiTM Penang Solar Rooftop and Solar Integrated Carpark (ENTEC, 2022).

As the ASEAN Energy Resilience Assessment Guideline is positioned to promote the assessment at the grassroots level, it includes the standard operation procedure (SOP) for energy resilience assessment which is accompanied by a detailed description of each step to help the assessment team go through the assessment from the beginning to the end. As shown in Figure 2, the assessment starts from the identification and scoring of threats, followed by the assessment of impacts from those threats, identification, and scoring of the vulnerability of the system and its surroundings. The risk pairings and their scores are then obtained by multiplying the threat and vulnerability scores; these scores will be evaluated for changes over time. Finally, energy resilience solutions are proposed, and the feasible ones are selected for implementation at the site by the owner. Another emphasis of the Guideline is the active participation of the stakeholders. The assessment team (usually composed of technical experts) will basically facilitate the assessment while the operators, the owners, and other direct stakeholders will perform the assessment. The Guideline contains sample worksheets to be used during the assessment as well as instructions for performing it with stakeholders. This ASEAN Guideline can complement the effort of APEC EWG to promote the concept of energy resilience at the policy level by encouraging actual energy resilience assessment in ASEAN Member States (AMS) which will result in various energy resilience solutions to be implemented in solar power plants in ASEAN.

Energy Resilience in the 7th ASEAN Energy Outlook

Lately, ASEAN has also started to incorporate the concept of energy resilience at the policy level. The 7th ASEAN Energy Outlook (AEO7) issued by ASEAN Centre for Energy (ACE) (ACE, 2022) in October 2022 includes a dedicated chapter to discuss the measures for energy resilience. AEO7 explores the scenarios to fulfill the targets set forth in the ASEAN Plan of Action for Energy Cooperation (APAEC) (APAEC Drafting Committee, 2020) to increase the renewable energy share in the total primary energy supply and in the installed power capacity to 23% and 35%, respectively, and reduce the energy intensity by 32% based on 2005 level, by 2025. AEO7 also incorporates the facts that several AMS made challenging commitments at the 2021 United Nations Climate Change Conference of Parties (COP26) (Safrina, 2021) and that AMS have to build back stronger and more sustainable from the COVID-19 pandemic.

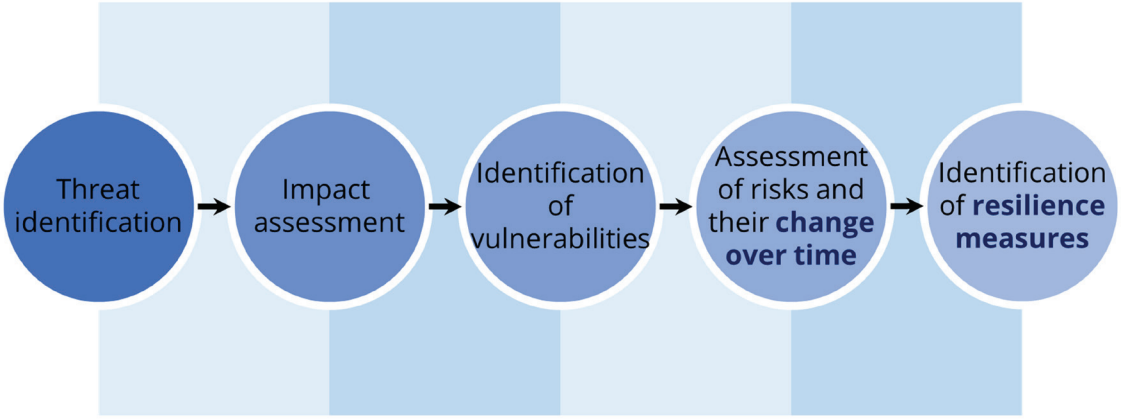


Figure 2. Energy resilience assessment flow

To enhance the energy resilience of the region, AEO7 explores the technologies for grid integration and the strategies to enhance the ability of dispatch of renewable energy in order to deal with a larger share of variable renewable energy (VRE). It suggests the utilization of fossil fuels during energy transition as they can be a strategic reserve for AMS to ensure energy resilience and an emergency supply against unexpected events. It also covers important topics to ensure resilient energy transition, including necessary transformation to improve industrial efficiency, consideration of financing clean energy to achieve carbon neutrality, and management of safety and social acceptance of nuclear power.

Practical Examples of Energy Resilience Initiatives in the Asia-Pacific Region

This section discusses the practical examples of energy resilience enhancement activities being conducted in the Asia-Pacific region. The subsection on energy resilience in the Philippine Energy Plan shows the realization of the APEC Energy Resiliency Principle at the national level while the subsection on energy resilience assessment of an actual solar farm in Thailand demonstrates the practicality of the ASEAN Energy Resilience Assessment Guideline. Note that though both examples happened before the establishment of the Principle and the Guideline, they can serve as good showcases on how the Principle and the Guideline can be put into practice to support future usage of the two new documents.

Energy Resilience in Philippine Energy Plan

The Philippines is one of the top-runner countries in the application of energy resilience concept in its policy making. Philippine Department of Energy (DOE) issued a Department Circular in 2018 on Adoption of Energy Resiliency in the Planning and Programming of the Energy Sector to Mitigate Potential Impacts of Disasters, the so-called Energy Resiliency Policy (DOE, 2018). It aims to build the capacity of energy infrastructure to adapt and withstand disruptive events, to be able to reconstruct and rehabilitate after being damaged by the events, to have standards and practices to ensure rapid restoration, and to develop resiliency standards for future energy facilities. It requires energy supply industries to submit the Resiliency Compliance Plans (RCPs) which include structural and nonstructural measures to ensure an appropriate response to and recovery after disasters and strengthen the preparedness of the energy infrastructure. Apart from the self-funding by the energy supply entities, the Energy Resiliency Policy also encourages the government to help finance the implementation of RCPs. It also documents the creation of the Task Force on Energy Resiliency to facilitate the policy and requires DOE to issue appropriate guidelines to support the implementation of the Circular.

Thanks to the issuance of the Energy Resiliency Policy, the latest 2020-2040 Philippine Energy Plan (DOE, 2022) includes resiliency and security of energy infrastructures as one of the strategic focus areas. The document includes policies, strategies, and measures formulated and/or implemented by DOE to improve the energy resiliency of energy infrastructure and facilities. It starts with the assessment of RCPs submission with a plan to join hands with the United States Agency for International Development (USAID) to evaluate the submitted RCPs to determine common and smart practices and identify gaps and challenges. It then summarizes the preparedness and response of the energy sector against emergencies, large disasters, compound disasters, and COVID-19 which can act as a list of best practices for energy supply industries. The document also indicates the ways to rehabilitate damaged energy facilities through the Build Back Better Principle and the plan of DOE to find pragmatic financing solutions for energy resiliency development, for example, an insurance mechanism.

The integration of the concept of energy resilience into the policy making of the Philippine energy sector is apparently in line with the APEC Energy Resilience Principle. The government plays a role to establish an energy resiliency policy which starts with the requirement for the development of RCPs by energy supply industries and includes guidance on how to enhance the resiliency of energy infrastructure and facilities in the updated national energy plan. The energy supply industries also gradually submit the RCPs which will be reviewed to extract good practices and recommend relevant changes. A study team is also being established to consider financing schemes for public and private investment in energy resiliency enhancement.

Energy Resilience Assessment of Solar Power Plant in Thailand

A state-owned 700 kW_{AC} solar farm at Asian Development College for Community Economy and Technology (adiCET), Mae Rim Campus, Chiang Mai Rajabhat University (CMRU), to demonstrate the feasibility of solar power plants in a governmental entity was chosen for the case study of energy resilience assessment (adiCET and ENTEC, 2021). Various stakeholders joined the assessment, including the operating team, the Dean and the Vice Dean of the College, the faculties and the students of adiCET, and the representatives from respective faculties in Mae Rim Campus who are the users of the electricity from the solar farm. The top five threats identified by the stakeholders based on the information on historical events gathered by the operating team appear in the left column of the risk matrix shown in Figure 3. Surprisingly, most threats are man-made, except for the invasion by animals which can increase due to climate change and bushfire, which is a compound disaster (drought and arson). Stakeholders were asked to use the framework shown in Figure 4 to assess the impacts of respective threats. Based on the threats and the associated impacts, stakeholders identified the top five vulnerabilities that appear on the top row of the risk matrix shown in Figure 3. Risk pairs were considered one by one, and the irrelevant pairs were omitted (those appear in black). The risk score was calculated by multiplying the threat score to vulnerability score. Darker pink color

of the risk cell shows a higher risk score. Note that all the scores were intentionally omitted. Top eight risk pairs were selected based on the risk scores. Table 1 shows the extensive list of resilience solutions that the stakeholders proposed to address the risks of the 700 kW_{AC} CMRU Solar Power Plant. As most resilience solutions can address multiple risks, they were sorted by the most highly associated threat for simplicity. Then, the assessment team evaluate the changes over time in the loss of opportunity to sell electricity due to the top risk pairs and the changes over time when the resilience solutions were applied to alleviate the risks. The reduction of opportunity loss was compared with the investment required for the solutions to determine their feasibility. Resilience solutions in orange characters which are economically viable were selected. Most of them were associated with the improvement of operation and maintenance schemes and procedures which can be done relatively easily by the operating team. The rest were the installation or storage of inexpensive equipment which made them feasible. The entire results were shown to the CMRU Executives for their consideration. It led to the approval of the installation of fire belts which is among the costliest resilience solutions that cannot be covered by adiCET.

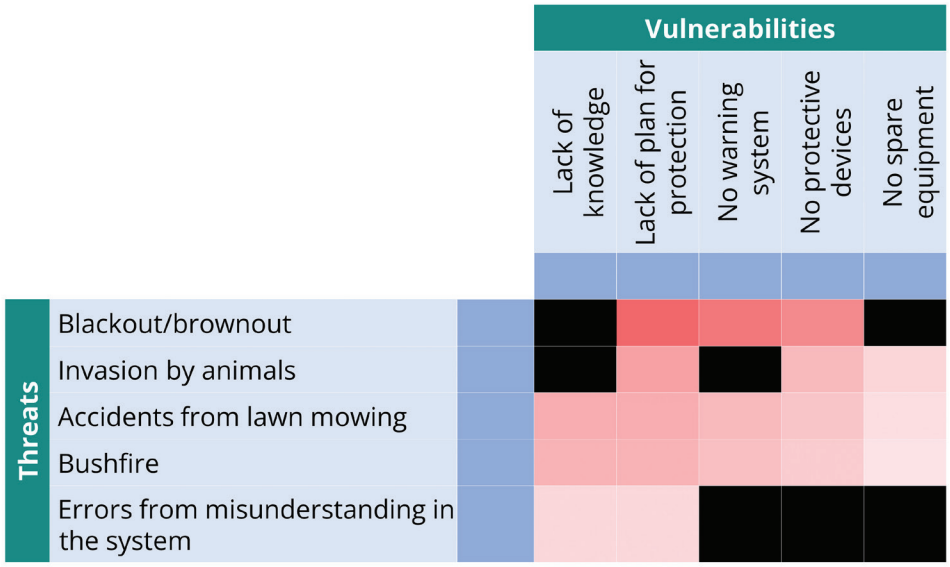


Figure 3. Risk matrix for 700 kW_{AC} CMRU Solar Power Plant

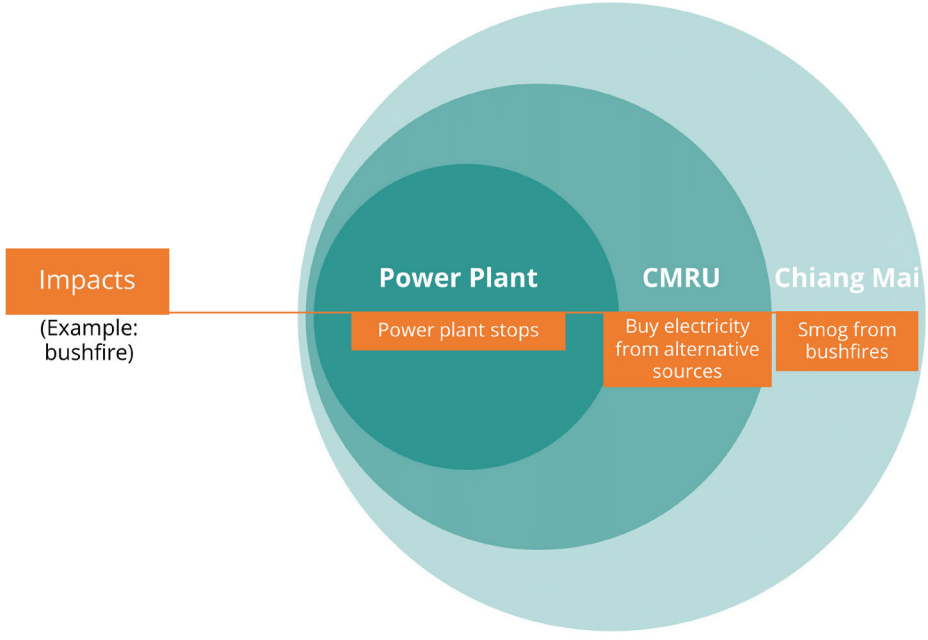


Figure 4. Impact assessment framework for 700 kW_{AC} CMRU Solar Power Plant

Threat	Resilience solutions	
Blackout/brownout	**Without equipment failure** • Installation of energy storage system • Installation of islanding system • Installation of warning system • Collaboration with PEA • Installation of diesel generator	**With equipment damage** • Planning for preventive maintenance • Emergency planning • Maintenance & repair training, and storing spare parts & devices
Invasion by animals	• Installation of animal protection equipment • Periodic lawn mowing / branch cutting	• Maintenance & repair training, and storing spare parts & devices
Lawn mowing accidents	• Installation of sign for lawn mowers	• Storing spare parts & devices
Bushfires	• Fire belts	• Installation of fire monitoring system

Table 1 List of selected resilience solutions for 700 kW_{AC} CMRU Solar Power Plant

By following the procedure indicated in the ASEAN Energy Resilience Assessment Guideline, the assessment team could facilitate an assessment that was done by the direct stakeholders. The evaluation of changes of risks over time helped the assessment team identify the feasible resilience solutions. The assessment also led to the implementation of several solutions that can significantly contribute to the resilience enhancement of the 700 kW_{AC} CMRU Solar Power Plant. This case study demonstrates the capability of the Guideline to promote energy resilience enhancement activities at the grassroots level.

Way forward

The Asia-Pacific region has been promoting the concept of energy resilience at the policy level to equip the energy infrastructure and facilities with an ability to withstand, respond to, recover from, and adapt to disruptive events, including rapid onset events such as disasters and slow onset events like climate change. As both APEC and ASEAN have energy resilience included in their energy-related documents: APEC Energy Resilience Principle and a chapter to discuss measures to ensure energy resilience in the 7th ASEAN Energy Outlook, the next step would be to propagate the concept to national energy plans of that Asia-Pacific countries. In this sense, the government has a very important role in putting energy resilience into practice as the energy supply industries will be opted to start including the concept in their operation when the government put it as a requirement. In addition, government would also need to create a supporting mechanism to finance the investment for energy resilience enhancement in order to accelerate the process.

On the other hand, promotion of energy resilience enhancement at the grassroots level is also inevitable. ASEAN Energy Resilience Assessment Guideline will serve as a good guidance for solar farm owners who want to build their capacity against disruptive events. As the APEC Energy Working Group is also developing guidelines for energy resilience enhancement that take into account local context and conditions in respective sectors, energy enterprises would start initiatives to enhance the resilience of their infrastructure and facilities accordingly when the guidelines are available. Workshops or training to facilitate the practical usage of these guidelines would be beneficial for energy enterprises in the Asia-Pacific region. Apart from capacity-building programs for the transfer of clean energy technology, the Asian and Pacific Centre for Transfer of Technology (APCTT) may consider expanding its scope to cover the capacity-building programs to facilitate resilient and sustainable usage of such technology.

With the promotion of energy resilience at both policy and grassroots levels, the Asia-Pacific region will be able to enhance the resilience and the adaptability of energy infrastructures against disruptive events, especially renewable energy systems which are relatively vulnerable to disasters and climate change. Therefore, it will also contribute to the increase in the regional share of renewable energy. The concept of energy resilience will perfectly synchronize the efforts to address Goal 7: Affordable and Clean Energy and Goal 13: Climate Actions of the United Nations' Sustainable Development Goals.

Acknowledgment

The authors would like to express their gratitude to Mr. Michael Sinocruz and Ms. Magnolia Olvido, Energy Policy and Planning Bureau, Philippine Department of Energy (DOE), for sharing the information on the Philippine Energy Plan, Asst. Prof. Dr. Worajit Setthapun, Asst. Prof. Dr. Hathaithip Sintuya, and Mr. Nattapat Leeraphun, Asian Development College for Community Economy and Technology (adiCET), Chiang Mai Rajabhat University (CMRU), for jointly organizing the energy resilience assessment at the 700 kW_{AC} CMRU Solar Power Plant, and Assoc. Prof. Ir. Dr Nofri Yenita Dahlan, Dr. Azlin Azmi, and Dr. Nurfadzilah Ahmad, Solar Research institute (SRI), Universiti Teknologi Mara (UiTM), for the collaboration on energy resilience assessment of UiTM solar facilities.

References

- ✓ ACE (2022). "The 7th ASEAN Energy Outlook," *ASEAN Centre for Energy (ACE)*, https://aseanenergy.org/the-7th-asean-energy-outlook, accessed 3 Nov. 2022.
- ✓ adiCET and ENTEC (2021). "Energy Resilience Assessment 700 kW Solar Power Plant @adiCET, CMRU: Study on Development of Methodology for Assessment and Enhancement of Resilience in Electricity Generating System," *Workshop on Enhancing Climate Adaptation Capacity of ASEAN Energy Systems through the Concept of Energy Resilience, Bangkok,* 17 Jun. 2021.
- ✓ APEC (2020). "Workshop on Resilience Principle," *Asia-Pacific Economic Cooperation (APEC)*, https://aimp2.apec.org/sites/PDB/Lists/Proposals/DispForm.aspx?ID=2717, accessed 3 Nov. 2022.
- ✓ APEC (2021). "APEC Energy Resiliency Enhancement Project," *Asia-Pacific Economic Cooperation (APEC) Secretariat*, https://www.apec.org/docs/default-source/projects/tendersrfps/2022/rfp_ewg-09-2021a_-apec-energy-resiliency-enhancement-project_-final.pdf, accessed 3 Nov. 2022.
- ✓ APAEC Drafting Committee (2020). "ASEAN Plan of Action for Energy Cooperation (APAEC) 2016-2025 Phase II: 2021-2025," *ASEAN Centre for Energy (ACE)*, https://aseanenergy.org/asean-plan-of-action-for-energy-cooperation-apaec-phase-ii-2021-2025, accessed 3 Nov. 2022.
- ✓ APEC Energy Working Group (2017). "Guidelines to Develop Energy Resiliency in APEC Off-Grid Areas," *Asia-Pacific Economic Cooperation (APEC)*, https://www.apec.org/docs/default-source/publications/2017/5/guidelines-to-develop-energy-resiliency-in-apec-off-grid-areas/toc/main-report.pdf, accessed 3 Nov. 2022.
- ✓ APEC Energy Working Group (2018). "Promoting Resilience in the Energy Sector," *Asia-Pacific Economic Cooperation (APEC)*, https://www.apec.org/docs/default-source/publications/2018/11/promoting-resilience-in-the-energy-sector/218_ewg_promoting-resilience-in-the-energy-sector.pdf, accessed 3 Nov. 2022.
- ✓ Asia Pacific Energy Portal (2015). "Cebu Declaration," *2015 APEC Energy Ministerial Meeting, Cebu, Philippines*, https://policy.asiapacificenergy.org/sites/default/files/Cebu%20Declaration%20and%20Instructions_APEC%20FINAL.pdf, accessed 3 Nov. 2022.
- ✓ COSTI (2021). "Report of the 79th Meeting of ASEAN Committee on Science, Technology and Innovation," *Virtual Meeting,* 15-16 Jun. 2021, unpublished.
- ✓ COSTI (2022) "Report of the 82nd Meeting of ASEAN Committee on Science, Technology and Innovation," *Virtual Meeting,* 19-20 Oct. 2022, unpublished.
- ✓ Department of Energy, Philippines (n.d.). "Philippines co-chairs APEC task force on Energy Resiliency." *Department of Energy, Philippines*, https://www.doe.gov.ph/press-releases/philippines-co-chairs-apec-task-force-energy-resiliency, accessed 3 Nov. 2022.
- ✓ DOE (2018). "Adoption of Energy Resiliency in the Planning and Programming of the Energy Sector to Mitigate Potential Impacts of Disasters," *Department of Energy, Philippines*, https://www.doe.gov.ph/sites/default/files/pdf/issuances/dc2018-01-0001.pdf, accessed 3 Nov. 2022.
- ✓ DOE (2022). "2020-2040 Philippine Energy Plan: Towards Sustainable and Clean Energy Future," *Department of Energy, Philippines*, https://www.doe.gov.ph/sites/default/files/pdf/pep/PEP%202022-2040%20Final%20eCopy_20220819.pdf, accessed 3 Nov. 2022.
- ✓ ENTEC (2022). "ASEAN Energy Resilience Assessment Guideline," *National Energy Technology Center (ENTEC)*.
- ✓ ENTEC (2022). "Energy Resilience Assessment Report – Gambang Solar Power Plant of Universiti Teknologi MARA (UiTM)," unpublished.
- ✓ ENTEC (2022). "Energy Resilience Assessment Report – Penang Solar Rooftop and Solar Integrated Carpark of Universiti Teknologi MARA (UiTM)," unpublished.
- ✓ ERTF Secretariat (2020). "APEC Energy Resiliency Principle," *Asia-Pacific Economic Cooperation (APEC)*, http://mddb.apec.org/Documents/2020/EWG/EWG59/20_ewg59_023.pdf, accessed 3 Nov. 2022.
- ✓ Holling C. S. (1973). "Resilience and Stability of Ecological Systems," *Annual Review of Ecology and Systematics*, Vol. 4, pp. 1-23.
- ✓ ISO (2014). "Asset management – Overview, principles and terminology," *Online Browsing Platform (OBP)*, https://www.iso.org/obp/ui/#iso:std:iso:55000:-ed-1:v2:en, accessed 3 Nov. 2022.
- ✓ Janta P., Thapmanee K., Vithean K., Silva K., and Chollacoop N. (2022). "Comparing ASEAN and Global Focuses and Trends in Energy Resilience Research using Bibliometric Analysis," *The 36th Conference of the Mechanical Engineering Network of Thailand*, pp. 867-872.
- ✓ Presidential Policy Directive 12 (2013). "Critical Infrastructure Security and Resilience," *Office of the Press Secretary, The White House*, https://obamawhitehouse.archives.gov/the-press-office/2013/02/12/presidential-policy-directive-critical-infrastructure-security-and-resil, accessed 3 Nov. 2022.
- ✓ Roege P., Collier A., Mancillas J., McDonagh J., and Linkov I. (2014). "Metrics for energy resilience," *Energy Policy*, Vol. 72, pp. 249-256.
- ✓ Safrina R. (2021). "COP26: ASEAN's Commitment in the Energy Sector," *The ASEAN Post*, https://theaseanpost.com/article/cop26-aseans-commitment-energy-sector, accessed 3 Nov. 2022.
- ✓ Sharifi A. and Yamagata Y. (2016). "Principles and criteria for assessing

urban energy resilience: A literature review," *Renewable and Sustainable Energy Reviews*, Vol. 60, pp. 1654-1677.

- ✓ Stout S., Lee N., Cox S., Elsworth J., and Leish J. (2019). "Power sector resilience planning guidebook – A self-guided reference for practitioners," *National Renewable Energy Lab (NREL), Golden, CO (United States)*.
- ✓ United Nations (2015). "Sendai Framework for Disaster Risk Reduction 2015 – 2030," *United Nations Office for Disaster Risk Reduction*, https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030, accessed 3 Nov. 2022.
- ✓ United Nations (2015). "Transforming our world: The 2030 Agenda for Sustainable Development," *United Nations*, https://documents-dds-ny.un.org/doc/UNDOC/GEN/N15/291/89/PDF/N1529189.pdf, accessed 3 Nov. 2022.
- ✓ United Nations Framework Convention on Climate Change (2022). "Report of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement," *United Nations Framework Convention on Climate Change*, https://unfccc.int/sites/default/files/resource/cma2021_10_add1_adv.pdf, accessed 3 Nov. 2022.

Clean Energy Initiatives and Programmes in Asia and the Pacific

Compiled by the Asian and Pacific Centre for Transfer of Technology

One Sun One World One Grid (OSOWOG) initiative

https://isolaralliance.org/work/osowog/

The One Sun One World One Grid (OSOWOG) initiative aims to connect different regional grids through a common grid that will be used to transfer renewable energy power and, thus, realize the potential of renewable energy sources, especially solar energy. The initiative brings together a global coalition of governments, international financial and technical organisations, legislators, power system operators, and knowledge leaders to accelerate the construction of the new infrastructure needed for a world powered by clean energy.

Zero-Carbon Energy for the Asia-Pacific Initiative (ZCEAP)

https://iceds.anu.edu.au/research/research-initiatives/zero-carbon-energy-asia-pacific-initiative-zceap

The Zero-Carbon Energy for the Asia-Pacific initiative was established through an investment by the Australian National University (ANU) and is open to work with partners. The initiative aims to push the frontiers that will help future-proof the way Australia trades with the world based on Australia's abundant renewable energy resources.

The initiative consists of six interrelated programs:

1. Hydrogen fuels
2. Renewable metal refining
3. Renewable energy systems
4. Indigenous engagement with renewable energy industries
5. Renewable energy policy and governance in Asia-Pacific countries
6. Regulatory frameworks for renewables-based trade and investment

Clean EDGE Asia

https://www.state.gov/clean-edge-asia/

Clean EDGE Asia aligns government and private sector resources to advance sustainable energy growth in the region. Clean EDGE Asia harnesses the expertise and resources of the U.S. government, private sector, international financial institutions, and like-minded governments to support and accelerate Asia's clean energy transition. In the Indo-Pacific, demand for energy is growing rapidly amid the challenges of relying on aging infrastructure and outdated market mechanisms to deliver power, transportation, and building energy requirements. U.S. engagement to address these challenges in Asia while reducing greenhouse gas emissions will bolster partners' energy security and advance sustainable development goals, including clean and affordable energy to address the climate crisis impacting all nations.

Asia Energy Transition Initiative (AETI)

https://www.meti.go.jp/english/press/2021/0528_002.html

The Government of Japan announced the "Asia Energy Transition Initiative (AETI)," which includes a variety of support for realising energy transitions in Asia.

- Support for the development of energy transition roadmaps
- Presentation and promotion of the Asian version of the transition finance
- US$10 billion financial support for renewable energy, energy efficiency, LNG, and other projects
- Support for technology development and demonstration using the benefits of the 2 trillion yen fund (e.g., offshore wind power generation, fuel-ammonia, hydrogen etc.)
- Human resource development on decarbonisation technologies and knowledge sharing
  a. Capacity building of decarbonisation technologies for 1000 people in Asian countries
  b. Workshops and seminars on energy transitions

Responsible Energy Initiative

https://www.teriin.org/project/responsible-energy-initiative

The Responsible Energy Initiative is a future-led collaborative inquiry into how the renewable energy sector in India and Asia can scale in an ecologically safe and socially just way. The Responsible Energy Initiative aims to enable the renewable energy sector in the Asia Pacific region to adopt business models and value chains that are ecologically safe, rights respecting and socially just. The initiative aims to engage with investors, developers, manufacturers, large procurers, together with other pertinent actors in the renewable energy sector to identify, set and action new norms. In India, the core partners for the Renewable Energy Initiative are The Energy and Resources Institute (TERI), Forum for the Future and World Resources Institute (WRI India), with expert support from Landesa, WWF-India, and the Business and Human Rights Resource Centre (BHRRC).

Energy Transition Partnership

https://www.energytransitionpartnership.org/

The Energy Transition Partnership (ETP) pursues energy transition across Southeast Asia, at the regional, national and local levels. ETP engages with private and

public partners to drive change at policy, fiscal, and technology level. The partnership expands financing for investment in renewable energy, energy efficiency, and sustainable resilient infrastructures to deliver joint action in the following areas:

- Aligning policies with climate commitments
- De-risking renewable energy and energy efficiency investments
- Sustainable and resilient infrastructure – smart grids
- Knowledge, skills, awareness, and capacity development

ASEAN Catalytic Green Finance Facility (ACGF)

https://www.adb.org/what-we-do/funds/asean-catalytic-green-finance-facility/overview

The ACGF is an ASEAN Infrastructure Fund initiative supporting governments in Southeast Asia to prepare and finance infrastructure projects that promote environmental sustainability and contribute to climate change goals.

Green finance denotes all financing instruments, investments, and mechanisms that contribute to a "climate plus" approach, impacting on both climate and environmental sustainability goals. Green finance promotes a reduction in greenhouse gases and improved climate resilience, air, and water quality, ecosystems, biodiversity, and use of resources. Green finance solutions to support a green recovery should be at the heart of post-COVID-19 economic planning in the ASEAN region. A green recovery means one that is environmentally sustainable, socially inclusive, and climate resilient.

Scaling Up Renewable Energy Program in Low Income Countries (SREP)

https://www.cif.org/topics/energy-access

The Scaling Up Renewable Energy Program in Low Income Countries (SREP) aims to enable the world's poorest countries to foster transformational change and pursue low-carbon energy pathways. It seeks to increase overall energy access for the populations of partner countries, deliver economic uplift, reduce reliance on fossil fuels, and minimize greenhouse gas emissions.

This program demonstrates the economic, social, and environmental viability of renewable energy, by supporting scaled-up interventions in solar and geothermal power, along with mini-grids, among others. A programmatic approach is needed that builds on existing policies, priorities, and energy initiatives. This involves working with country partners to agree and act on tailored objectives, as well as securing blended financing from multiple sources to enable renewable energy objectives.

Clean, Affordable and Secure Energy for Southeast Asia (CASE)

http://gizenergy.org.vn/en/project/clean-affordable-and-secure-energy-for-south-east-asia-case

The Clean, Affordable and Secure Energy for Southeast Asia (CASE) project aims to support Southeast Asian partner countries in the transition to a future energy system that provides reliable and affordable energy to the people while increasing political ambition to comply with the Paris Agreement. Through a comprehensive approach, including public, private and research organisations, CASE contributes to shifting the narrative of the energy sector in Thailand, Indonesia, the Philippines, and Viet Nam towards an evidence-based energy transition.

South Asia Regional Energy Partnership (SAREP)

https://sarepenergy.net/

The South Asia Regional Energy Partnership (SAREP) is the flagship regional energy program of the United States Agency for International Development (USAID) India. This five-year initiative (2021-26) improves access to affordable, secure, reliable, and sustainable energy across six South Asian countries—Bangladesh, Bhutan, India, Maldives, Nepal, and Sri Lanka—in line with these countries' climate and clean energy priorities.

This program facilitates collaboration among the six countries, to operate and accelerate the transition to clean energy, mitigate climate change, and promote energy security, economic development, self-reliance, livelihood, health, and productivity.

SAREP's activities and outcomes also support and contribute to the Strategic Clean Energy Partnership (SCEP) and the Climate Action and Finance Mobilization Dialogue (CAFMD) under the recently established U.S.-India Climate and Clean Energy Agenda 2030 Partnership. Through this collaboration, India and the U.S. aim to demonstrate swift climate action that is inclusive, resilient, and based on national and regional priorities. Countries in the region will also benefit from each other's experiences through this collaborative program by sharing of the learnings, best practices, and lessons.

International Energy Agency – Technology Collaboration Programme

https://www.iea.org/areas-of-work/technology-collaboration

The Technology Collaboration Programme supports the work of independent, international groups of experts that enable governments and industries from around the world to lead programmes and projects on a wide range of energy technologies and related issues. The experts in these collaborations work to advance the research, development and commercialisation of energy technologies. The scope and strategy of each collaboration is in keeping with the IEA Shared Goals of energy security, environmental protection and economic growth, as well as engagement worldwide.

The breadth of the analytical expertise in the Technology Collaboration Programme is a unique asset to the global transition to a cleaner energy future. These collaborations involve over 6000 experts worldwide who represent nearly 300 public and private organisations located in 55 countries, including many from IEA Association countries such as China, India, and Brazil.

Clean Energy Networks and Technology Platforms

Clean Energy Ministerial (CEM)

https://www.cleanenergyministerial.org/

The Clean Energy Ministerial (CEM) is a high-level global forum to promote policies and programmes that advance clean energy technology, to share lessons learned and best practices, and to encourage the transition to a global clean energy economy. Initiatives are based on areas of common interest among participating governments and other stakeholders. The Framework for the Clean Energy Ministerial, reaffirmed at the twelfth Clean Energy Ministerial in 2021, defines the CEM governance structure and outlines the mission statement, objectives, membership, and guiding principles.

The CEM brings together a community of the world's largest and leading countries, companies, and international experts to achieve one mission—accelerate clean energy transitions.

The CEM is an international clean energy leadership platform, a convening platform, an action platform, and an acceleration platform. It serves as:

- A platform where its members help shape the global clean energy agenda and advance the deployment of specific clean energy technologies and solutions.
- A bottom-up, government-led community for exchanging knowledge and insights, building networks and partnerships, and facilitating coordinated actions on clean energy.
- An implementation vehicle that helps its members achieve specific domestic clean energy objectives.

RE100

https://www.there100.org/

RE100 is the global corporate renewable energy initiative bringing together hundreds of large and ambitious businesses committed to 100% renewable electricity. RE100 accelerates change towards zero carbon grids at scale.

Global Women's Network for the Energy Transition

https://www.globalwomennet.org/

The Global Women's Network for the Energy Transition (GWNET) aims to advance the global energy transition by empowering women in energy through interdisciplinary networking, advocacy, training, and mentoring. GWNET seeks to address the current gender imbalances in the energy sector and to promote gender-sensitive action around the energy transition in all parts of the world.

GWNET facilitates connections among women working in the fields of renewable energy and energy efficiency to advance the energy transition. *Dedicated events* as well as a cutting-edge *women's expert platform* with enhanced features, also encourage networking among GWNET members. GWNET *generates and disseminates information* on the role of women in the energy transition with the goal of creating awareness, strengthening networks and ultimately influencing decision-making.

Energy Policy Tracker

https://www.energypolicytracker.org/

The Energy Policy Tracker covers the 2020–2021 period with data on COVID-19 government policy responses from a climate and energy perspective. The analysis provides a detailed overview of the public finance flows as determined by recovery packages across the G20.

Technology Platforms

E-TechDS – Energy Technology Data Source

https://iea-etsap.org/index.php/energy-technology-data

The IEA-ETSAP E-TechDS is an Energy Technology Data Source that offers consistent sets of data on energy demand and supply technologies to help analysts to build their own MARKAL-TIMES model. MARKAL-TIMES models usually represent the entire energy system (i.e., demand and supply side) of a nation or region.

To put data in the right context, E-TechDS is conceived as a series of Technology Briefs, which provide basic information on the process, status, performance, costs, potential and barriers for key energy technology clusters. Each brief consists of typically 5 to 10 pages including highlights, full text and charts, and a summary data table.

The ETSAP Briefs are intended to offer essential, reliable and quantitative information to energy analysts, experts, policymakers, investors and media from both developed and developing countries.

WIPO GREEN – The Marketplace for Sustainable Technology

https://www3.wipo.int/wipogreen/en/

WIPO GREEN is an online platform for technology exchange. It supports global efforts to address climate change by

connecting providers and seekers of environmentally friendly technologies. Through its database, network and acceleration projects, it brings together key players to catalyze green technology innovation and diffusion. WIPO GREEN consists of an online database and network that brings together a wide range of players in the green technology innovation value chain, and connects owners of new technologies with individuals or companies who might be looking to commercialize, license or otherwise distribute a green technology. In this way, it not only helps to accelerate innovation and diffusion of green technologies but also contributes to the efforts of developing countries in addressing climate change.

McKinsey Platform for Climate Technologies

https://www.mckinsey.com/capabilities/sustainability/how-we-help-clients/mckinsey-platform-for-climate-technologies

The McKinsey Platform for Climate Technologies (MPCT) was launched to help clients plan, execute, and scale the implementation of these critical technologies. MPCT works with the world's leading experts to anticipate the impact of new technologies and challenge conventional approaches to established ones. The focus is on the most critical technologies: those with the potential to transform the sources of energy for every industry, region, and community.

EPO Clean Energy Technologies

https://www.epo.org/news-events/in-focus/clean-energy.html

Climate change is driving innovation in clean energy. New technologies are being developed every day in the race to safeguard life on earth and meet the climate targets set out in the European Green Deal, the UN Sustainable Development Goals (SDGs) and the Paris Agreement.

Inventors are at the forefront of this endeavour. The technical information published in patents describes the most recent technical advances, and can support researchers and innovators with making the next inventive steps. EPO patent examiners and data analysts have compiled some 60 datasets to support scientists and engineers in accessing patent information containing some of the most advanced technical knowledge on clean energy. Areas covered include offshore wind energy, smart solar systems, the optimisation of energy storage technologies and solutions for carbon-intensive industries such as steel and cement production.

The platform is arranged into three broad themes and updated regularly:

- Renewable energy
- Solutions for carbon-intensive industries
- Energy storage and other enabling technologies

Tech Events

2023

Jan 06–08 Beijing, China
2023 4th Asia IoT Technologies Conference (AIOTT 2023)
Contact: Teri Zhang
Email: aiott_conf@yeah.net
http://www.aiott.net/

Jan 28–30 Kuala Lumpur, Malaysia
2023 4th International Workshop on Smart Grid
Contact: Jennifer Zeng
Tel: +86-28-86512185
Email: iwsg@academic.net
http://www.iwsg.org/

Feb 21–22 Bangkok, Thailand
2023 AI Asia Expo
Contact:
Email: sales@aiasiaexpo.com
https://aiasiaexpo.com/

Feb 24–26 Hanoi, Viet Nam
2023 5th International Conference on Smart Grid and Green Energy (SGGE 2023)
Contact:
Tel: +86-18008037269
Email: sgge@ieet.ac.cn
http://www.sgge.org/

Mar 10–12 Singapore
2023 The 7th International Conference on Green Energy and Applications
Contact: Secretary of ICGEA 2023
Email: icgea_secretary@163.com
http://www.icgea.org/

Mar 17–19 Singapore
2023 6th International Conference on Bioenergy and Clean Energy (ICBCE 2023)
Contact: Ms. Echo Xiong
Tel: +86-18117805914
Email: icbceconference@163.com
http://www.icbce.org/

Mar 24–26 Singapore
2023 4th International Conference on Machine Learning and Human-Computer Interaction (MLHMI 2023)
Contact: Ms. Samantha Liu, Conference Secretary
Email: mlhmi.conference@gmail.com
http://www.mlhmi.org/

Mar 24–26 Singapore
2023 4th Asia Conference on Renewable Energy and Environmental Engineering (AREEE 2023)
Contact: Nancy Liu, Conference Secretary
AREEE Conference Secretariat
Tel: +86-28-86512185
Email: areee@iacsitp.com
http://www.areee.org/

Apr 14–16 Tianjin, China
2023 8th International Conference on Renewable Energy and Smart Grid (ICRESG 2023)
Contact: Ms. Coral Lu
Tel: +852-30506862
Email: icresg@cdsherlock.com
https://www.icresg.org/

Apr 14–16 Niigata, Japan
2023 8th International Conference on Control and Robotics Engineering (ICCRE 2023)
Contact: Ms. Hiroko Miyahara,
Conference Secretary of ICCRE
Email: iccre@vip.163.com
http://www.iccre.org/

Apr 21–23 Beijing, China
2023 9th International Conference on Control, Automation and Robotics (ICCAR)
Contact:
Email: iccarconf@outlook.com
http://www.iccar.org/

May 17–19 Bangkok, Thailand
Future Energy Asia 2023
Contact: Yuyuan Chen,
Head of Energy Transition – Asia
Email: YuyuanChen@dmgevents.com
https://www.futureenergyasia.com/

May 22–26 Foshan City, China
10th World Hydrogen Technology Convention
Contact:
Tel: +86-10-82194945/68538687/68539117
Email: admin@whtc2023.com
http://www.whtc2023.com/home

Jun 29 Gwangju, Republic of Korea
2023 International Green Car Exhibition
Contact:
Tel: 062-611-2211,2260,2263
Email: auto@kdjcenter.or.kr
http://www.greencarkorea.com/

July 07–09 Xi'an, China
2023 the 8th Asia-Pacific Conference on Intelligent Robot Systems (ACIRS 2023)
Contact: Ms. Iris QIN, Conference Secretary
Email: acirs_contact@163.com
http://www.acirs.org/

July 21–23 Chengdu, China
2023 6th International Conference on Power and Smart Grid (ICPSG 2023)
Contact: Ms. Teri Zhang, Conference Secretary
Tel: +86-13880104217
Email: icpsg_conf@126.com
http://www.icpsg.org/

Oct 30–31 HCMC, Viet Nam
ASEAN Wind Energy 2023
Contact: Kathy Xi,
Programme and Speakers Enquires
Tel: +86 151 2112 8297
Email: Kathy@leader-associates.com
https://www.aseanwindenergy.com/

Jul-Sep 2022

Regional cooperation for innovation and technology transfer

Apr-Jun 2022

Innovative technologies for air pollution control

Jan-Mar 2022

Technology transfer for sustainable development in the Asia-Pacific

Oct-Dec 2021

Harnessing fourth industrial revolution technologies for healthcare

The *Asia-Pacific Tech Monitor* has been the flagship periodical of APCTT since 1993. It is an online quarterly periodical featuring theme-based articles that 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 are written by authors/experts of national and international repute. The periodical aims to enhance 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 apctt.techmonitor@un.org 91 11 30973750

unapctt unapctt