

Climate Mitigation Technologies

Technology name	Technology description	Key features and benefits	Sectors	Use case (if any)
Solar panels	Solar panels absorb solar energy and convert into electricity and heat.	<p>Renewable energy source applicable in centralised and decentralised settings.</p> <p>FIT schemes in ASEAN countries benefit companies that generate excess solar energy</p>	Cross- sector	Max's Isabela, a Filipino restaurant installed rooftop solar modules ¹ . Solar power capacity in Southeast Asia has more than doubled between 2019 and 2020, increasing from 10.4 GW to 22.9 GW ² .
LED lighting	Electric light that produces light using light-emitting diodes.	Standard LED bulbs can be up to 80% more energy efficient than conventional bulbs ³	Cross- sector	During 2014-2016, the Southeast Asian LED lighting market share has increased significantly, and the penetration rate is expected to grow from 25% to 37%. ⁴ LED lights are sold in Laos , Philippines , Vietnam , Thailand , and Indonesia

¹ <https://www.solaready.ph/post/max-s-restaurant-big-sustainable-effort>

² <https://www.schroders.com/en/bm/asset-management/insights/alternatives/what-investors-need-to-know-about-southeast-asias-solar-energy-boom/>

³ <https://ukenergylighting.co.uk/how-does-led-lighting-help-the-environment/>

⁴ <https://www.ledinside.com/node/25219>

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Automatic Monitoring & Targeting (aM&T) Sub-metering Systems	aM&T sub-metering systems measure energy consumption, record and distribute metered energy data, and analyse and report on energy consumption.	Help users to save energy by identifying energy wastage which they can then take steps to reduce	Cross-sector	Such automatic meter systems are sold in Thailand, Indonesia, Vietnam, Philippines etc. ⁵ , and used in residential premises in Indonesia ⁶ and Vietnam ⁷ as well.
Refrigeration equipment using Hydro-Fluoro-Olefins (HFO)	Hydro-Fluoro-Olefins (HFO) are refrigerants that have very short atmospheric lifetimes and have extremely low global warming potential (GWP). There are three HFOs available: R-1234yf, R-1234ze(E) and R-1233zd(E).	Lower GWP refrigerants emitted will help to mitigate global warming	Cross-sector	A Thai retailer converts its stores from using R-404A to R-448A as a refrigerant. The latter has a GWP of 1,273 while the former has GWP of 3,943. ¹⁰ Today, water cooling chillers with R-1233zd(E) refrigerant which has GWP of 1 is sold in Singapore ¹¹ and Malaysia. ¹²

⁵ <https://www.yokogawa.com/id/solutions/solutions/energy-management/energy-monitoring/>

⁶ <https://www.power-grid.com/smart-grid/meter-replacement-projects-boost-meter-makers-in-southeast-asia/#gref>

⁷ <https://www.enlit-asia.com/grids/digitalisation-grids/technology-utilization-in-collection-analysis-and-exploration-of-automated-meter-reading-data-at-evnhcmc/>

¹⁰ https://www.honeywell-refrigerants.com/europe/?press_release=tesco-lotus-selects-honeywells-solstice-n40-refrigerant-to-lower-global-warming-potential-and-carbon-emissions-for-900-stores-in-thailand

¹¹ <https://www.carrier.com/commercial/en/uk/news/news-article/first-uk-installation-of-carrier-chillers-on-r-515b-enables-art-gallery-to-meet-environmental-commitments.html>

¹² https://www.techhaus.advp.com/index.php?ws=showproducts&products_id=2753836&cat=Air-Conditioning-Refrigeration&subcat=Honeywell-Refrigerants#openproducts

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	Refrigerants are emitted as fugitive emissions ⁸ from cooling equipment and facilities. ⁹ Refrigerants with higher GWP will result in further global warming when emitted.			
Hybrid vehicles	Hybrid cars have combustion engines that run on gasoline and an electric motor with an attached rechargeable battery pack for electric-powered driving.	Lower fossil fuel combustion than vehicles using internal combustion engines.	Cross-sector	Hybrid and electric vehicle penetration only accounted for 0.3%, 1.3%, and 9%, respectively, in the total new passenger vehicle sales in Indonesia, Malaysia, and Thailand. ¹³
Electric two/ three wheelers	Electric powered two and three wheelers include electric motorbikes, scooters and rickshaws.	No fossil fuel combustion.	Cross-sector	In Vietnam, UNEP is working with the University of Transport Technology on a similar project. In March 2019, Honda Vietnam provided 50 electric scooters to the project to help identify policy and regulatory hurdles to electric vehicle adoption. ¹⁴

⁸ The IPCC defines fugitive emissions as “emissions [of greenhouse gases] that are not produced intentionally by a stack or vent” and stipulates that they may “include leaks from industrial plants and pipelines” (IPCC, 2006)

⁹ <https://www.epa.gov/sites/default/files/2015-07/documents/fugitiveemissions.pdf>

¹³ <https://sg.finance.yahoo.com/news/asean-hybrid-electric-vehicle-markets-120300514.html>

¹⁴ <https://www.unep.org/news-and-stories/story/paving-way-electric-mobility-south-east-asia>

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Agricultural drone ¹⁵	Drones are used as a precision agriculture technology to monitor and map crop parameter data. Such data helps farmers to make more informed decisions in optimising the application of fertilisers, pesticides, and troubleshoot irrigation systems.	Drones help to increase agriculture productivity and reduce the use of fertilisers and pesticides emitting GHG	Agriculture	Since 2017, DJI agricultural drone was used for pesticide sprays across banana plantations in Hanoi, Vietnam ¹⁶ . Grow Asia is raising awareness and adoption of agricultural drone among ASEAN countries. ¹⁷
Farm management software	This solution allows farmers to easily organise every aspect of farm management to augment productivity and farm operations. It also provides real-time insights over their crops, staff, farm activities, tools and equipment.	Farmers could optimise usage of agriculture inputs, improve productivity and be pre-empted of unexpected weather conditions. Agriculture companies sourcing from farms could track and trace their supply chain including the contract farmers' impact on the environment.	Agriculture	AGRIVI, a farm management solution provider is scaling the use of software in Malaysia and adapting it to local needs with their partner RHE Solutions ¹⁸ . Similarly, CropIn an agri-focused Saas platform is working with True Digital Solutions to build a comprehensive solution for digital farming ecosystem to enhance transparency, efficient cultivation management and financial self-sufficiency. The partnership

¹⁵ <https://www.globalagtechinitiative.com/in-field-technologies/drones-uavs/the-role-of-drone-technology-in-sustainable-agriculture/>

¹⁶ <https://ag.dji.com/newsroom/dji-ag-news-en-southeast-asia>

¹⁷ <https://www.growasia.org/post/2019/06/28/agriculture-drone-landscape-and-adoption-in-south-east-asia>

¹⁸ <https://www.agrivi.com/news/partnership-with-rhe-solutions-strengthens-agrivi-presence-in-asia/>

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				aims to impact 6 million farmers in Thailand ¹⁹ .
Biogas digestors	Biogas digestors generates biogas using organic waste as feedstock e.g. palm oil mill effluent (POME)	Through the use of biogas to run farm operations, farmers could generate less GHG from combusting traditional fuels such as diesel.	Agriculture	Biogas production in Vietnam so far has been largely funded by non-governmental organizations and limited to small-scale production developed across the country ²⁰ .
Biochar ²¹	Biochar is a fine-grained, highly porous charcoal that helps soil to retain nutrients and water. The soil additive also serves as a slow-release fertilizer when charged with nutrients. Biochar can be created easily and economically in farms by using a kiln and pruned wood.	Aside from limiting the use of synthetic fertilizers which emits substantial GHG, biochar is an incredibly high-value carbon capture technology and results in the capture of approximately 50% of the carbon in wood for thousands of years.	Agriculture	In Philippines, Marcventures Mining and Development Corp. (MMDC) advocated the extensive use of biochar by using it to remediate mining grounds and convert them into arable lands for agriculture ²² .

¹⁹ <https://economictimes.indiatimes.com/tech/startups/cropin-true-digital-tie-up-for-agritech-solutions-in-southeast-asia/articleshow/85450836.cms?from=mdr>

²⁰ <https://www.mdpi.com/2079-9276/9/11/133/pdf>

²¹ <https://www.adb.org/news/features/qa-how-can-agribusiness-help-fight-climate-change>

²² <https://business.inquirer.net/214089/mining-firm-taps-into-potential-of-biochar>

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Selective breeding	Selective breeding is a breeding programme that tries to improve the breeding value of the population by selecting and mating only the best fish (largest, heaviest, those with the desired colour, etc.) in the hope that the select brood fish will be able to transmit their superiority to their offspring.	Selective breeding for increased production is expected to enhance efficiency of resource utilisation (feed, energy and land) of a production system, through correlated changes in feed efficiency or shorter production period ²³	Agriculture	Selective breeding is in the R&D phase in Southeast Asia, e.g., genetic variation of Asian seabass in Indonesia ²⁴
Combined heat and power (CHP) unit	CHP units simultaneously generate heat and power (usually electricity) in a single process. With on-site power production, losses are minimized and heat that would otherwise be wasted is applied to facility loads in the form of process heating, steam, hot water, or even chilled water.	Emissions from fuel combustion in CHP are converted into thermal energy and electricity, minimising GHG emissions especially if fuel input is organic waste e.g. bagasse from cane sugar, woody biomass and pulp and paper wastes.	Manufacturing	Cane sugar production in Vietnam uses CHP to produce steam and electricity. Its by-product, bagasse, is used as inputs for power generation. ²⁵ CHP units are also sold in Thailand , Indonesia , and the Philippines .

²³ <https://edepot.wur.nl/371362>

²⁴ <https://iopscience.iop.org/article/10.1088/1755-1315/763/1/012010>

²⁵ <https://vietnamcirculareconomy.vn/en/showcase/bagasse-fired-power-generation/>

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Boiler retrofit equipment	Industrial boilers are used in a wide range of industries (e.g. automotive, appliances, food and beverage, chemical etc.), especially in processes like drying, heating, sterilising, power generation etc. Retrofitting is a relatively affordable means to reduce emissions from boilers than boiler replacement	Retrofits include burner system upgrades to more efficient ones, and addition of O2 trim which monitors oxygen levels, and addition of waste heat recovery system. These help to reduce energy usage.	Manufacturing	Boiler retrofitting at a pulp and paper plant in Thailand has increased boiler reliability and reduce emissions ²⁶ . Boiler retrofitting is also done in Indonesia, the Philippines and Vietnam ²⁷ . Boiler retrofit projects in Laos were implemented, with aid from international funders ²⁸ .
Waste heat recovery system	By installing WHR systems, waste heat from industrial processes in chemical, food, textile and other industries can be captured and reused in other processes.	Saves energy and reduce emissions	Manufacturing	WHR system installation in a Vietnamese textile company enabled it to reduce coal consumption by 50% ²⁹ . WHR system services are also available in Thailand , Indonesia , and the Philippines . WHR in Laos were installed, with aid from international funders ³⁰ .

²⁶ <https://www.taichyun.com.tw/case-studies/esp-retrofit-concrete-rooftop-at-recovery-boiler/>

²⁷ <https://www.energytransitionpartnership.org/resource/diagnostic-analyses-report-of-energy-efficiency-development-in-three-countries/>

²⁸ <https://www.unido.org/news/laos-new-boiler-pays>

²⁹ <http://vneec.gov.vn/tin-tuc/activities/t7806/industrial-waste-brings-big-benefits.html>

³⁰ <https://gggi.org/project/project-reference-profiles-lao-pdrla11-waste-energy-recovery-program-at-industrial-facilities/>

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Variable speed drive (VSD)	A variable speed drive (VSD), is an electronic device that controls the characteristics of a motor’s electrical supply. Therefore, it is able to control the speed and torque of a motor, achieving a better match with the process requirements of the machine it is driving ³¹ . They are widely used to control the speed of AC motors, like conveyor systems, blower speeds, pump speeds, machine tool speeds, & other applications that require variable speed with variable torque ³²	As VSDs could regulate speed and torque of a motor, it helps to save energy consumption and provide motor protection.	Manufacturing	VSD transformers and applications are found in Thailand ³³ , the Philippines ³⁴ , Indonesia ³⁵ and Malaysia ³⁶
Wood composite	Wood composites include a range of different derivative wood products that could replace steel and cement given its superior properties.	Lower embodied carbon than traditional steel and cement. Although wood composite commonly contain plastic, their climate impact is low if the	Construction	MAXISWOOD is a Thailand-based contractor supplying and installing building façade

³¹ <https://etl.beis.gov.uk/products/motors-drives>

³² <http://www.vfds.org/applications.html>

³³ <https://www.xylem.com/en-th/products--services/pumps-packaged-pump-systems/monitoring-control-equipment/control/speed-control/hydrovar-5th-generation/>

³⁴ <https://ph.rs-online.com/web/c/automation-control-gear/electric-motors/inverter-drives/>

³⁵ <https://bambangdjaja.com/products/distribution-variable-speed-drive-transformer/>

³⁶ https://www.myfmecorp.com/index.php?ws=showproducts&products_id=2525160

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	They could be used in deck flooring, railing, fencing, etc.	plastic material used is recycled or the wood composite is recycled ³⁷ .		using composite timber sourced from recycled wood. ³⁸
Cool roofs	Cool roofs are roofing systems that provide protection from solar heat gain in warm climates through high solar reflectance, because the roofs are prepared, covered or coated with materials that have special characteristics such as cool roof coating paint.	Help to better manage rising temperatures. Cool roofs can increase the albedo of the urban environment if widely applied, presenting a relatively high heat island mitigation potential ³⁹ .	Construction	From 2019 to 2021, cool roofs have been produced and implemented in 8 provinces and 15 cities in Indonesia by Universitas Pendidikan Indonesia ⁴⁰ which successfully reduce room temperature of buildings.
Smart-tinting glass (aka. Switchable glass, smart glass)	The smart-tinting glass shuts out heat from solar radiation and provide daylighting control. ⁴¹	Help to save energy in cooling and lighting, and better manage rising temperatures.	Construction	Smart-tinting glass is used in developed ASEAN cities e.g. Manila, Bangkok, Jakarta ⁴²

³⁷ <https://impactful.ninja/how-sustainable-is-wood-plastic-composite/>

³⁸ <https://maxiswood.com/>

³⁹ <https://www.research-collection.ethz.ch/handle/20.500.11850/258216>

⁴⁰ <https://qs-gen.com/universitas-pendidikan-indonesia-cool-roof-team-launches-becool-solution-to-overcome-global-warming/>

⁴¹ <https://prismpub.com/smart-glass-options-for-creating-a-sustainable-glare-free-environment/>

⁴² <https://www.gauzy.com/smart-glass-locations/>

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Recycled concrete	Recycled concrete is a concrete aggregate manufactured using pre-existing concrete from demolished structures, sidewalks and roadways.	Lower impact on climate than using traditional concrete made from aggregate extraction	Construction	Recycled concrete is currently used in limited ways e.g. replace Graded Granite Aggregate Base (GGAB) Course in road construction in Singapore ⁴³ . Further applications are explored by a consortium funded by Royal Academy of Engineering; they are investigating the development of sustainable, durable, cost-effective, green concrete by utilising recycled aggregates in Southeast Asia. ⁴⁴
Closed-loop scrubber system	<p>These devices scrub the gas emissions from vehicles like airplanes and ships to remove a range of pollutants, from carbon dioxide to sulfur dioxide.</p> <p>As opposed to open-loop scrubbers, these closed-looped scrubbers will remove accumulated impurities from wash water</p>	Retrofitting ships with closed-loop scrubber system helps to remove greenhouse gas emissions from vehicle exhaust gases, and prevent discharge of toxic scrubber wash water into the ocean.	Transport	Closed-loop scrubbers can be installed in Malaysia, Singapore, Indonesia, Thailand, the Philippines and Vietnam ⁴⁶ .

⁴³ <https://www.samwoh.com.sg/success-stories/case-studies/research-projects/528-evaluation-of-the-use-of-recycled-concrete-aggregate-in-structural-concrete-full-scale-live-assessment-of-a-new-three-storey-commercial-building.html>

⁴⁴ <https://www.plymouth.ac.uk/research/materials-and-structures-research-group/recycled-aggregate-concrete-in-south-east-asia>

⁴⁶ <https://www.alfalaval.sg/about-us/our-company/alfa-laval-in-sea/>

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	which is side product from the scrubbing process. ⁴⁵			
AdBlue aka. Diesel exhaust fluid	AdBlue is a fluid which is automatically sprayed into a car's exhaust system to reduce the nitrous oxide emissions of diesel engines in cars. It is usually topped up during car servicing or by consumers directly.	Helps to reduce nitrous oxide emissions from usage of diesel vehicles	Transport	AdBlue is sold in Vietnam ⁴⁷ , the Philippines ⁴⁸ , Indonesia ⁴⁹ and Thailand ⁵⁰
Advanced rudders and propellers	These advanced rudders and propellers have one or more of these properties than older models: smoother and easier manoeuvrability,	Modern designs have become highly efficient, resulting in fuel savings and lower emissions	Transport	Carbon-reducing propellers are produced in Indonesia ⁵¹ , Vietnam, the Philippines ⁵² .

⁴⁵ <https://liqtech.com/water-treatment-solutions/marine-filtration/marine-scrubber-water-treatment-system/how-does-a-closed-loop-scrubber-work/#:~:text=A%20closed%20loop%20scrubber%20is,by%20as%20much%20as%2098%20%25.>

⁴⁷ <https://www.ubuy.vn/en/brand/adblue>

⁴⁸ <https://shopee.ph/Pure-Blue-ADBLUE-DEF-Ready-To-Use-20Liters-i.190935011.10328135380>

⁴⁹ <https://www.desertcart.id/brand/adblue>

⁵⁰ <https://thaiengineeringgases.com/diesel-exhaust-fluid/>

⁵¹ <https://www.tescoindomaritim.com/pages/shipbuilding.php>

⁵² http://navalex.com/downloads/Michigan_Wheel_NAKASHIMA_Product_Lineup.pdf

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	avoiding vibration or reducing rotational losses to increase efficiency, asymmetric rudder design, allowing the rotational energy from the propeller to be used more efficiently compared to a conventional rudder.			
Vertical warehouse systems and lift technologies	Using technologies such as Automated Storage and Retrieval Systems (ASRS) and electric stackers, goods can be stored using the full height of a warehouse.	Maximise space utilisation to reduce energy consumption.	Wholesale and retail trade	Thung Hua Sinn (THS) Group adopted an ASRS in Thailand which saved space and time in warehouse operations. ⁵³ In Philippines, RM Food Inc. implemented a space saving dynamic storage system in its factory. ⁵⁴ Electric stackers are also sold in Indonesia ⁵⁵ and Vietnam ⁵⁶ .
Route optimisation software	Using advanced algorithms, route optimisation systems help companies to optimise routes for fleets	Improved efficiencies in inbound and outbound	Wholesale and retail trade	Lazada in Indonesia adopted cloud-based route planning ⁵⁷

⁵³ <https://www.prestarstoragesystem.com/automated-storage-retrieval-system-asrs-thailand/>

⁵⁴ <https://www.prestarstoragesystem.com/dynamic-storage-system-philippines/>

⁵⁵ <https://www.tokopedia.com/find/electric-stacker>

⁵⁶ <https://www.goldbell.com.vn/en/material-handling-equipment/electric-forklifts>

⁵⁷ <https://loginextsolutions.com/blog/how-tech-enabled-logistics-would-be-at-center-of-e-commerce-growth/>

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		transportation help to reduce fleet usage		
Sustainable packaging	Advanced packaging materials that have lower carbon footprint such as plant-based packaging	Lower carbon footprint than using traditional plastic packaging	Wholesale and retail trade	<p>Vietnam-based healthy snack brand Lecka uses packaging made of paper, cellulose and corn starch⁵⁸.</p> <p>Equo is a woman-owned and led Vietnamese startup that makes straws and other utensils made of coffee and wood, sugarcane food containers and cups, reusable totes, and compostable bags for grocery, retail, and home use. Products are 100% plastic-free, biodegradable, and compostable.</p>
Lower carbon product lines	Retailers and wholesalers can offer lower-carbon products which could appeal to an increasingly climate-conscious client base.	Reduce the companies' downstream emissions	Wholesale and retail trade	<p>Pomelo a Thailand-based apparel retailer offers products made from recycled polyester, vegan leather, etc.⁵⁹.</p> <p>More Meat is a woman-owned and led plant-based startup in Thailand using innovative protein modification technology and bioactive ingredients such as plants and</p>

⁵⁸ <https://lecka.eco/pages/sustainability>

⁵⁹ <https://www.pomelofashion.com/sg/en/lookbooks/sustainability>

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				<p>fungi. More Meat operates as a B2B enterprise serving restaurants and hotels.</p> <p>Piñatex by woman-owned and led Ananas Anam is a leather alternative made from cellulose fibers extracted from pineapple leaves. The material is a synthetic leather made from pineapple waste, from pineapples harvested in the Philippines.</p>