TOWARDS NET ZERO

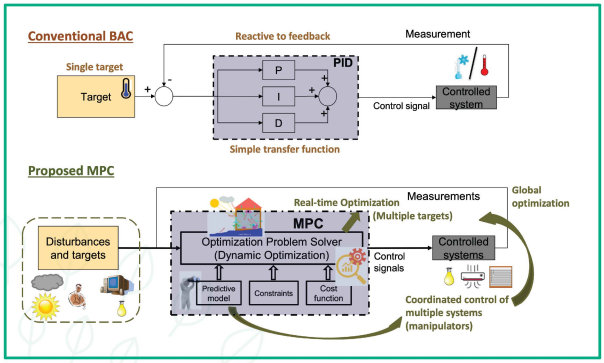
These innovative solutions are developed to support the 80% energy efficiency improvement target (over 2005 levels) of the Singapore Green Building MasterPlan (SGBMP) for best-in-class green buildings by 2030.

Model-Predictive Control for Smart Building Energy Management

Conventional building automation and control (BAC) systems lack the level of intelligence to coordinate the control of complex building systems to achieve multiple targets of energy efficiency and occupant well-being.

The Model-Predictive Control (MPC) solution overcomes such limitations by employing a building model to perform optimal, predictive and coordinated control of various building service systems including air-conditioning and mechanical ventilation, lighting (automated dimming) and shading (automated blinds and electrochromic windows), etc. The technology was testbedded in multiple buildings, achieving 20 – 60% of energy savings while greatly improving occupants' thermal and visual comfort. This solution is a game changer for the BAC market to shift to a much more intelligent level with predictive (instead of reactive) control and real-time optimization.

The solution was developed by NTU with a start-up company created: NRGSense Technologies Pte Ltd.



Funded under Green Buildings Innovation Cluster

Hybrid-Passive Displacement Ventilation Air-Conditioning System

The Hybrid-Passive Displacement Ventilation (PDV) is a chilled water based air-conditioning system that uses high efficiency DC inverter compressor and plate heat exchanger to produce chilled water to serve passive displacement cooling coils, conventional fan coil units or air handling units. The system can provide space cooling with zero or minimal air-side energy. It adopts smart pumps to distribute chilled water to these air terminal equipment with very low pumping energy. Testbedded results show that there is a potential energy savings of about 20%.

As chilled water instead of refrigerant is circulated through the indoor space, it minimises the need for expensive and on-going leak detection system needed for direct refrigerant gas system. As the Hybrid-PDV system operates with chilled water, it will consistently provide comfortable, stable air temperature control during its operation.

Hybrid-PDV system is more suitable for cooling for mid-size office buildings, hotels, hospitals, medical centres, schools, shopping centres and other commercial premises, where occupant comfort is paramount.

The solution was co-created by YiTac Pte Ltd with Ngee Ann Polytechnic/EWTCOI.

Funded under Green Buildings Innovation Cluster

TOWARDS NET ZERO

These innovative solutions are developed to support the 80% energy efficiency improvement target (over 2005 levels) of the Singapore Green Building MasterPlan (SGBMP) for best-in-class green buildings by 2030.

Singapore Building Carbon Calculator

The Singapore Building Carbon Calculator (SBCC) was officially launched on 26 June 2023 during the International Green Building Conference. The SBCC is Singapore's first localised web-based carbon calculator and it is endorsed by BCA as the de facto calculator for embodied carbon accounting under BCA's Code for Environmental Sustainability of Buildings (Edition 4.0) and the Green Mark 2021 Whole Life Carbon Section.

JTC introducing and demonstrating the Singapore Building Carbon Calculator (Photo credits: JTC)

Studies have shown that in Singapore, embodied carbon in buildings can account for up to 40% of emissions over a building's life-cycle. However the concept of embodied carbon is still quite nascent as the focus has been on the remaining 60% - the carbon emitted during the building's operation. Embodied carbon is different from operational carbon in that the latter can be improved over the lifetime of a building. JTC saw a real need to reduce the embodied carbon in buildings and the approach taken was to start by enabling embodied carbon calculations by industry players. With sufficient data, benchmarking exercises could be performed and actionable measures could be devised to gradually reduce carbon over time. The SBCC was built upon an earlier model called the Building Embodied Carbon Calculator (BECC) developed by JTC in collaboration with NUS-ESI, and supported by SGBC and BCA.

JTC's Future of Building and Infrastructure team unveiling the Singapore Building Carbon Calculator (Photo credits: JTC)

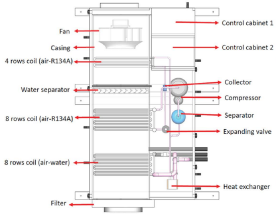
The SBCC was developed to achieve 3 main goals:

1) to increase accessibility and efficiency of carbon accounting,
2) popularise measuring embodied carbon within the built environment,
3) encourage reduction and optimisation of embodied carbon in buildings.

The SBCC can be found at https://carboncalculator.sg/

Funded by MOF RF under B&I CentEx

Dual Cycle Air Dehumidification System for Energy-Efficient Buildings



Chillers consume the largest amount of energy in ACMV system. Ideally chilled water supply temperature should set higher to improve chiller energy efficiency. However, it will also reduce the capability of air dehumidification and result in higher indoor humidity.

Air T&D Pte Ltd and industry partner Enwae Engineering Ptd Ltd have developed a low cost and easy to implement "Dual Cycle Air Dehumidification System" (DCADS). Different from conventional AHUs, DCADS uses higher temperature central plant chilled water or VRF refrigerant to precool the air and then use a high efficiency internal heat pump to dehumidify the air to the required humidity ratio and reheat the air before discharge. DCADS makes full use of the high-efficiency and high-temperature central plant cooling energy to pre-treat the ventilation air by reducing its temperature and humidity. Key benefits of the system are reducing building energy consumption by more than 20% and improving occupant's comfort with low indoor humidity.

Funded under Green Buildings Innovation Cluster

TOWARDS NET ZERO

Singapore aims to achieve net zero by 2050. Under our Singapore Green Plan's Energy Reset pillar, we aim to use cleaner energy sources across all sectors – at least 2 gigawatt-peak of solar energy deployment by 2030; and all vehicles to run on cleaner-energy by 2040.

Renewables

Bi-directional Tidal Turbine Design and Development

A*STAR's Institute of High Performance Computing (IHPC), in collaboration with Bluenergy Solutions Pte Ltd, designed a tidal turbine using computational fluid dynamics (CFD) simulations to convert tidal energy into electricity using the difference in vertical height between the incoming high tides and the outgoing low tides.

Bluenergy Solutions has licensed this innovative tidal turbine design from A*STAR and conducted a demonstration trial on the Sentosa boardwalk in 2019. In March 2023, Maritime and Port Authority of Singapore (MPA) and Bluenergy Solutions launched a Proof of Value (POV) project to harness hydrokinetic energy off the island of Pulau Satumu, Singapore, as an alternative to the transport of diesel to generate power for facilities supporting Raffles Lighthouse.

Tidal turbine

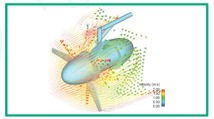
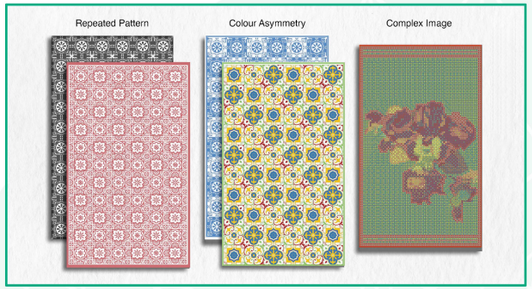


Diagram showing ocean flow across the bi-directional tidal turbine

Funded by A*STAR

Hotspot Free Peranakan PV Modules

To achieve a balance between aesthetics and efficiency of PV panels, the Solar Energy Research Institute of Singapore (SERIS) had developed a peranakan PV design inspired by traditional peranakan tiles and motifs. Its visually stunning appearance eschews the uneven shading of the solar cells underneath. The repeated patterns and smart design concepts ensure homogenous light transmission to the solar cells and prevent hotspot formation. This avoids module damage and early cell degradation, while maintaining optimum performance.



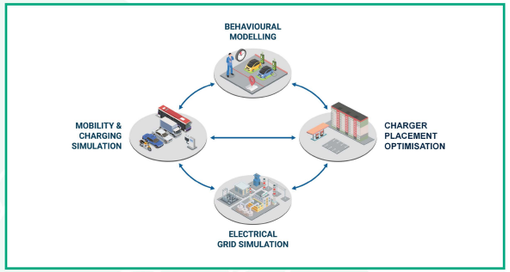
Evolution of Peranakan PV

Scan for more information

Modelling and Simulation

Singapore Integrated Transport Energy Model (SITEM)

A*STAR's Institute of High Performance Computing (IHPC) and the Technical University of Munich at the Singapore Campus for Research Excellence and Technological Enterprise (TUMCREATE) collaborated on SITEM to model future electric vehicle (EV) charging patterns and energy demand. These findings will help to shape policies relating to Singapore's transition to EVs nationwide.

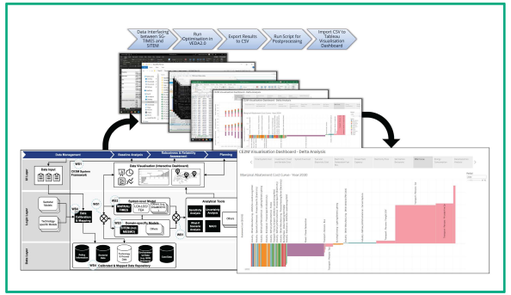


Overview of the SITEM project modelling and simulation framework.

Funded by Public Sector Science & Technology Policy and Plans Office (S&TPPO)

Centre for Energy and Emissions Modelling

A*STAR, with the support of National Climate Change Secretariat (NCCS) and Public Sector Science & Technology Policy and Plans Office (S&TPPO), has developed a federated system with SITEM and SG-TIMES (the energy systems model developed by the Energy Studies Institute at the National University of Singapore) as the first use-case. The federated system can model and simulate the interplay between disparate models, generating insights that help to shape policies on cost-effective decarbonisation pathways and electrification implementation plans.



End-to-end automation of workflow for decarbonisation policy modelling

Funded by A*STAR, NCCS and S&TPPO

CLIMATE ADAPTATION

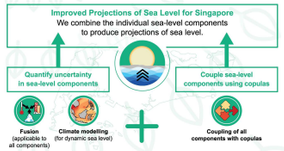
Climate change poses a pressing global challenge with rising temperatures, extreme weather events, and sea-level rise, all of which impacts ecosystems and communities. Adaptation measures are essential to safeguard against these impacts.

Understanding Sea-Level (SL) Rise in Singapore and Surrounding Regions

Probabilistic SL Projection Framework

The project aims to develop a better understanding of the physical mechanisms and variability of sea-level rise in this region, resulting in more accurate sea-level projection.

Scan for more information

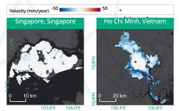


Land Height Change, Coastline Retreat and Coastal Flooding

Global SLs are rising due to the melting of Earth's ice sheets and expansion of warmer sea water. This global phenomenon is further compounded by the sinking of land, known as land subsidence, which can exacerbate the problem. The project aims to monitor and forecast changes in both SL and land height.

Scan for more information

1. Using satellite measurements to monitor land sinking in coastal cities in Southeast Asia



Satellite observations of relative local land subsidence in selected coastal cities. Blue portions indicate sinking, while red portions indicate uplift.

Source: Tay, Cheryl, et al. 2022. "Sea-Level Rise from Land Subsidence in Major Coastal Cities." Nature Sustainability 5 (12): 1049–57.

2. Develop an accurate map of land heights and use it with our estimates of land-height change and sea-surface change to forecast which areas will be flooded.

3. Find new ways to use satellite data to monitor changes in coastlines and map areas of coastal flooding due to sea-level rise.

Source: Noel Ivan Ulina (2023)

Coastline preliminary results (Mekong Delta, Vietnam) overlayed on Planet Labs optical images from 2022, using a method called Automatic Coastline Detection Code

Funded under National Sea Level Programme

Development of Xbloc Modular Coastal Protection System for Singapore's Coastal Adaptation

Delta Marine Consultants was one of four winners of PUB's Global Innovation Challenge 2021 in the category that sought innovative solutions for coastal protection. The proposed solution is a further-developed version of XblocPlus, a single-layer-concrete-armour unit placed in a regular pattern along the shoreline to provide long-term and reliable protection.

XblocPlus' advantage lies in its flexible and scalable design, which minimises land take, as well as its potential for integration into urban developments or natural habitats. It offers resilience to climate change and can be adapted to promote the development of marine life within the system.

First developed in 2002, DMC's modular system has been successfully applied in more than 40 project locations across 30 countries globally, including in the Asia-Pacific region.

Artist's impression of DMC's proposed XBlocPlus solution for the Singapore coastline
(Photo: Delta Marine Consultants)

Scan for more information

Incorporating Environmental Modelling Holistically for Urban Planning & Design

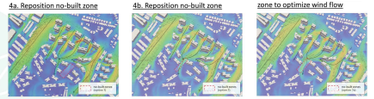
Environmental modelling, such as wind flow and shadow analyses, can help Architects and Engineers optimise building design and site development for outdoor thermal comfort and building performance. However, the potential to improve environmental performance at the building and site level would be limited if planning parameters were not optimised for environmental performance at the upstream stages (e.g. parcellation, urban design guidelines, etc).

To better optimise our built environment for sustainability, URA has incorporated environmental modelling holistically in the entire planning process. This approach enables evidence-based planning and design, ensuring that environmental performance is considered from the earliest stages of development. Moving forward, URA will be deploying sensors to study the effectiveness of the urban strategies (e.g. implementation of wind corridors) in districts (e.g. Lentor Hills Estate, Jurong Lake District) where environmental modelling was used to refine the urban design guidelines.

Case Study: Lentor Hills Estate

1. Business as usual scenario
2. With no-built zones
3. With Updated Proposal

4a. Reposition no-built zone
4b. Reposition no-built zone
4c. Refining the width of no-built zone to optimize wind flow



Iterative approach to determine wind corridors' placement, alignment and width to improve the outdoor thermal comfort for Lentor Hills estate. The wind corridors requirements are then implemented as part of the Technical Conditions of Tender for the Government Land Sales sites.

Supported by URA and Urban Planning & Design Technology Centre of Excellence (URBEX)
For queries, please contact Kelvin Li (URA)
<Kelvin_LI@ura.gov.sg>

Integrated Environmental Modeller (IEM)

HDB and A*STAR have developed the Integrated Environmental Modeller (IEM), an innovative modelling tool that uses high-resolution 3D city models to simulate the interaction of urban micro-climatic conditions, such as wind flow, temperature fluctuations, and solar irradiance with one another, as well as their combined effects on the surrounding urban landscape. The IEM has enabled HDB planners and architects to better understand how environmental conditions affect the layout and design of the town, to derive configurations that will create a comfortable living environment for residents.

Funded under Cities of Tomorrow R&D Programme

RESOURCE CIRCULARITY

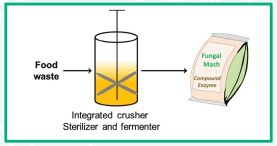
Singapore has established itself as a significant petrochemical hub and embraces a vibrant food culture. Recycling of industrial waste and food waste conserves resources, but also support the city-state's green transition efforts.

Eco-Stomach: Converting Food Waste into Bio-Fertilisers

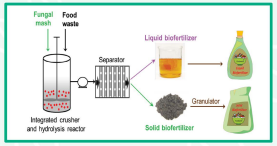
Pilot with treatment capacity of 100 kg/day

Nanyang Technological University had developed a containerised system called "Eco-Stomach" that could convert mixed food waste into bio-fertilisers within eight hours through ultrafast enzymatic conversion processes. This is faster than most commercial food waste composting machines which would usually take 24 hours or longer. Technology has been licensed to a local company and the prototype system has been transferred for further R&D and test-bedding.

Fugal mash production



Biofertilizer production



Fungal mash rich in various hydrolytic enzymes was first produced from food waste. The fungal mash is subsequently used to hydrolyse food waste.

Funded under Closing the Waste Loop

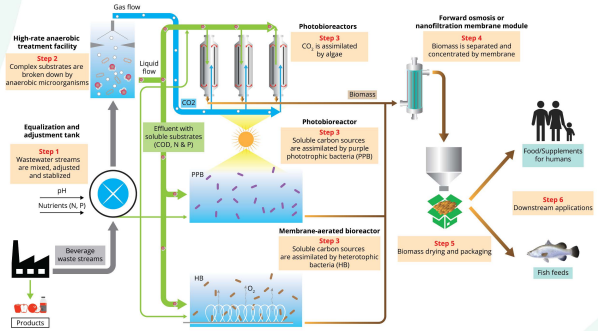
Project information

A Sustainable Bio-platform for High Quality Microbial Protein Production

Nanyang Technological University and Yeo Hiap Seng (YHS) has collaborated to develop a bio-platform to incorporate clean organic waste stream (e.g. F&B processing wastewater) as feedstock into systems with microalgae and bacteria, where the biomass production then led to high-quality products such as single cell protein (SCP).

This integrated system provides cost-effective process via food waste valorization, as well as contributes to improving food self-sufficiency where waste-derived SCP products can be used as animal feed and/or human supplements.

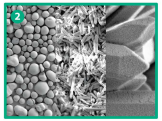
The practice of food waste valorisation within a circular economy framework not only minimises waste but also maximises resource efficiency, ultimately bolstering food security by ensuring that resources are utilised effectively to meet the nutritional needs of the growing population.



Funded under Singapore Food Story R&D Programme 1.0's Theme 2: Future Foods: Alternative Proteins

Conversion of Spent Fluid Catalytic Cracking Catalyst into Value-added Precipitated Silica

A*STAR developed a lab-scale prototype that converts spent FCC catalysts from oil refinery to produce precipitated solid supports (silica, mullite, alumina) and rare-earth metals salts. Spent FCC would otherwise be disposed of in Semakau Landfill. A*STAR's novel process includes an acid leaching process to recover valuable metals salts (e.g. lanthanum), a base leaching process to recover the silica support via a CO2 mineralisation step, isolation and purification of the various solids.



1. Catalyst and metal-recovery mini-pilot setup:
(1) Acid leaching reactor
(2) Liquid-liquid extractor
(3) Temperature control unit
(4) Alkaline leaching reactor
(5) Drying Oven
Credits: Institute of Sustainability for Chemicals, Energy and Environment, A*STAR (ISCE2, A*STAR).

2. Scanning electron microscopy images of the (a) SFCC solids with spherical morphology of agglomerated particles of 5-100mm sizes and (b) recovered Lanthanum salt NaLa(SO4)2 depicting well-differentiated hexagonal prism particles
Credits: Institute of Sustainability for Chemicals, Energy and Environment, A*STAR (ISCE2, A*STAR).

3. Samples of the spent FCC substrate, acid leachate solution, silica and NaLa(SO4)2 salt, mullite and base leachate solution.
Credits: Institute of Sustainability for Chemicals, Energy and Environment, A*STAR (ISCE2, A*STAR).

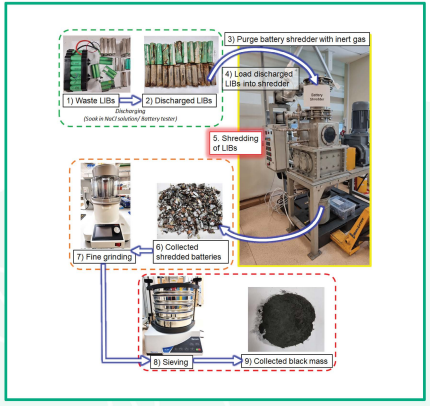
Funded under Closing the Waste Loop

RESOURCE CIRCULARITY

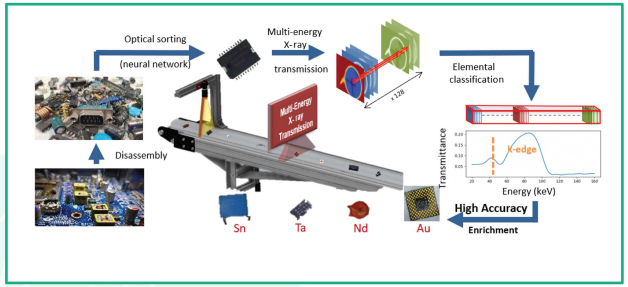
Singapore generates more than 60,000 tonnes of electrical and electronic waste (e-waste) each year, and this is expected to increase. Recycling e-waste helps to conserve our earth's previous natural resources and protects human and environmental health.

NTU Singapore – French Alternative Energies and Atomic Energy Commission (CEA) Alliance for Research in Circular Economy (SCARCE)

The centre develops new environmentally friendly end-to-end processes to sort, extract valuable metals from spent lithium ion batteries, and regenerate them into new materials to manufacture new batteries or other applications. A pilot trial with SE-CURE Waste Management Pte Ltd on the use of orange peel and mixed fruit peel as reagent for metal extraction is ongoing.



SCARCE is working with the industry to develop pilots for dismantling and sorting electronic components from printed circuit boards (PCBs). Precious metals and critical metals present in the sorted electronic components can then be recovered at a higher recovery rate and purity.



Funded under Closing the Waste Loop and Closing the Resource Loop

Check out the TV for more

TOWARDS NET ZERO

These innovative solutions are developed to support the 80% energy efficiency improvement target (over 2005 levels) of the Singapore Green Building MasterPlan (SGBMP) for best-in-class green buildings by 2030.

PlantDetective: Smart Energy Management System to Measure Chiller Plant Power Consumptions using Advanced Data Analysis and Machine Learning

AmpoHub is an ultra-compact, wireless-enabled power meter and IoT gateway that measures power consumption of key equipment and transmits the data to the cloud platform.

Conventional Building Management System (BMS) is costly and implementing a system, especially in older buildings, is time consuming and disruptive. Building owners may hesitate to install a BMS because of the high upfront cost and hence may lose the opportunity to optimize the chiller plant efficiency.

PlantDetective developed by Ampotech Pte Ltd and won ASEAN Energy Awards 2022 for the innovative solution, is a low cost and non-invasive system to monitor the chiller system and estimate the upper bound of chiller efficiency. This system can offer a chiller monitoring function including monitoring its power consumption for individual equipment, water temperature, water pressure and estimating chiller efficiency in kW/RT.

PlantDetective estimates chiller plant power consumptions using advanced data analysis and machine learning without using a flowmeter, thereby lowering the implementation cost and installation time significantly compared to a traditional BMS. It serves as a "light-BMS", intended as a fast and easy method for energy service companies or facility managers to estimate the chiller efficiency. Building operator can base on the results and decide if further upgrade works is needed to optimize chiller performance.

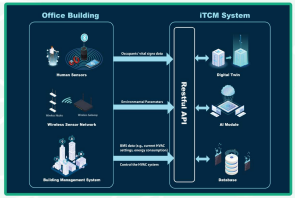
Funded under Green Buildings Innovation Cluster

Greener, Smarter and Healthier Buildings with Learning-Based Thermal Comfort Models

This solution applies the mature wireless in-situ sensing techniques, the emerging wearable devices as well as the cutting-edge Artificial Intelligence (AI) technologies to develop the digital twin for novel Intelligent Thermal Comfort Management (iTCM) System.

Digital twin technology helps to achieve this goal by providing real-time, data-driven insights and simulations, enabling us to make more informed decisions and optimize building performance to its fullest potential. The use of AI and digital twin technologies handles the data such as vital signs, feedback and surrounding environment from IoT-based sensors or wearable devices and optimize the building thermal condition to drive "greener, smarter and healthier" buildings in tropical regions.

The solution was developed by NTU with a start-up company created: Red Dot Analytics Pte Ltd.



By using various deep learning techniques from the thermal comfort modelling, which consists of two research stages, our objective is to bring human beings into the building management loop to drive "greener, smarter and healthier" buildings in the tropics.

In the first stage, we adopt the Deep Neural Network (DNN) to build the thermal comfort model with six PMV parameters, and achieves the improvement of prediction accuracy.

And in the second stage, to improve the prediction accuracy further, we apply the Deep Transfer Learning (DTL) to the thermal comfort modelling built upon the DNN-based approach. We take more thermal comfort parameters into consideration, such as time (i.e. the hour of the day), personal information (i.e. age, gender, weight, height and clothing insulation) and vital signs (i.e. metabolic rate, heart rate and skin temperature).

Funded under Green Buildings Innovation Cluster

TOWARDS NET ZERO

As Singapore ramps up our solar energy deployment, there is a need to address the end-of-life management for solar photovoltaics (PV).

Demonstration of Cost-effective PV Recycling Solutions

Pilot line setup at SP

Singapore Polytechnic (SP) collaborated with Sembcorp Solar to develop and demonstrate Singapore's first semi-automated solar PV recycling pilot line (80 - 100 PV modules per day), recovering more than 90% of the panel weight. This is in line with the ES Industry Transformation Map in improving productivity, as Singapore ramps up its solar energy deployment to at least 2 GWp by 2030.

Funded under Closing the Waste Loop

Project information