



INNOVATION & TECHNOLOGY CONFERENCE 2023

**Innovation Through Advanced Manufacturing
Research & Technologies**

**Sustainability Innovation
Day 2, 27 July**



Sustainability Innovation

Dr Yeo Zhiquan

Deputy Director, R&D

Sustainability & Life Cycle Management (SLCM),
SIMTech



Sustainability Innovation

Equipping for the sustainability journey

Dr. Yeo Zhiquan

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SIMTech, A*STAR

27th July 2023

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Singapore's Sustainability Challenges



- Population = 5.64 million as at June 2022
- Projected to grow to about 6.5 – 6.9 million people by 2030

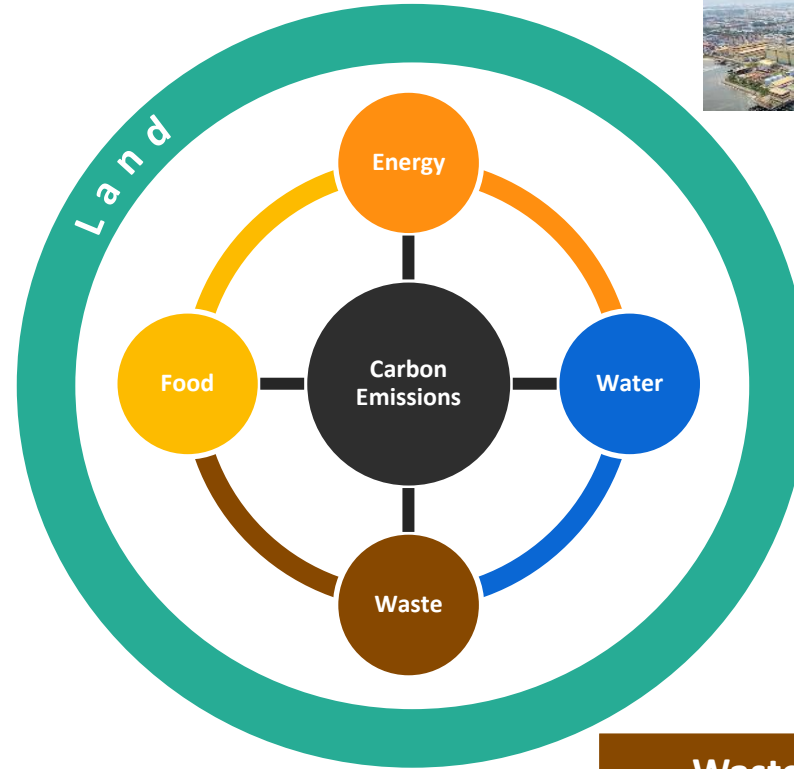


- Limited natural resources
- 734.3 sq km
- 30% at risk of submerging under water as sea level rises due to global warming

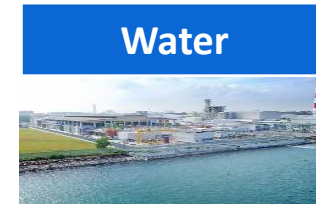
Food



- More than 90% food imported
- Limited land for agriculture



- About 95% natural gas
- Alternative-energy disadvantaged country



- Up to 50% water imported
- Lack of natural surface water sources



- New Waste-to-Energy plant every 7 – 10 years
- Semakau landfill fully filled by 2035

The “Two Zeros”

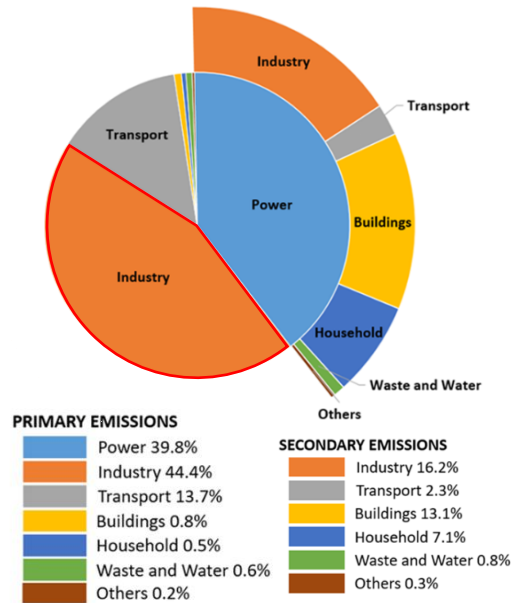


Net Zero

Urgency to Achieve Net Zero → More Ambitious Targets

- Nationally Determined Contribution (NDC): Reduce emissions to around **60 MtCO₂e** in **2030** after **peaking** emissions between **2025 and 2028**
- Long-Term Low-Emissions Development Strategy (LEDS): Achieve **net zero** emissions by **2050**

2020 Emissions: 49.7 MtCO₂e



Progressive Carbon Tax Increase

Currently	\$5 per tonne
2024 & 2025	\$25 per tonne
2026 & 2027	\$45 per tonne
By 2030	\$50 to \$80 per tonne

Developments in energy transition

- Jun 2022: Singapore importing renewable energy from Laos through Thailand and Malaysia
- Oct 2022: Launch of **National Hydrogen Strategy** – hydrogen could supply up to **50%** our power needs by **2050**
- Jan 2023: Singapore announced that 100 MW of electricity will be imported from Malaysia (cross-border energy supply infrastructure)

Zero Waste

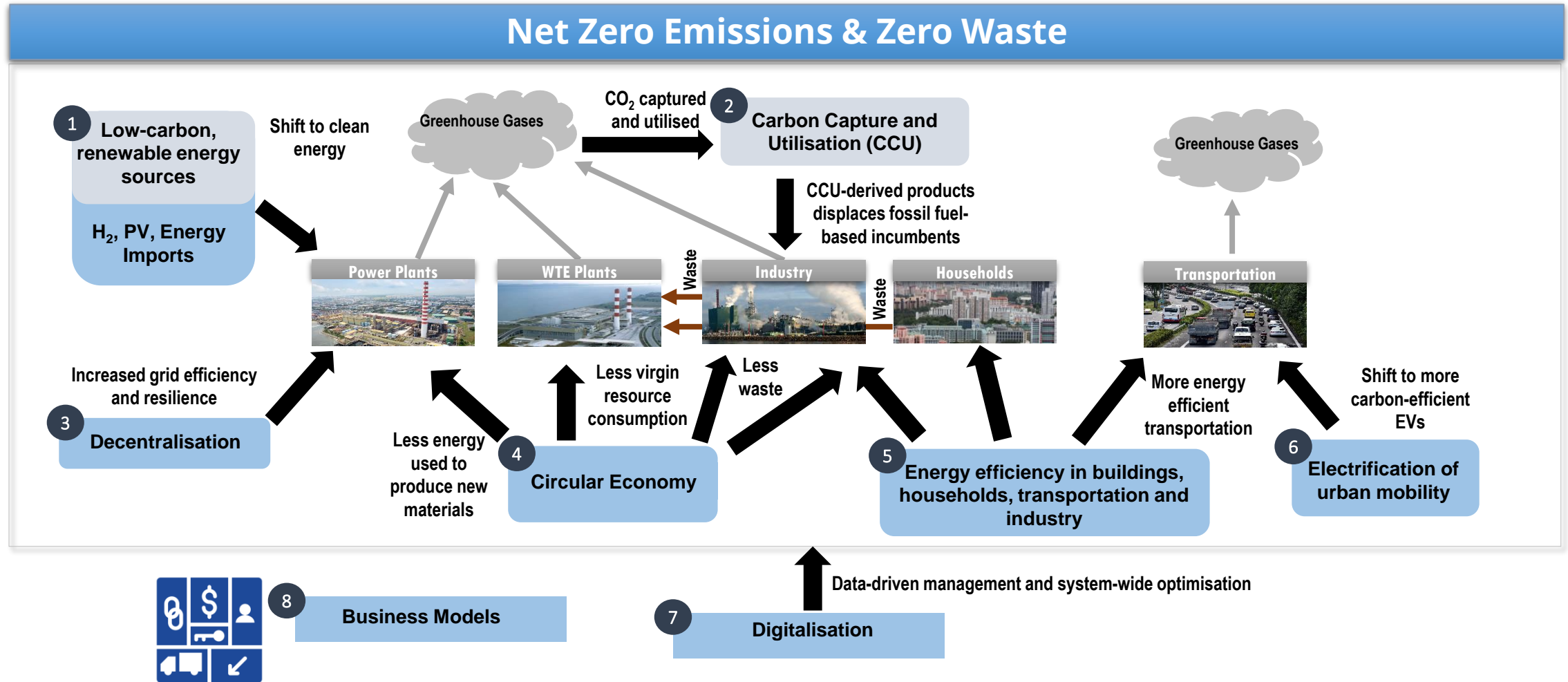


Source: Zero Waste Masterplan

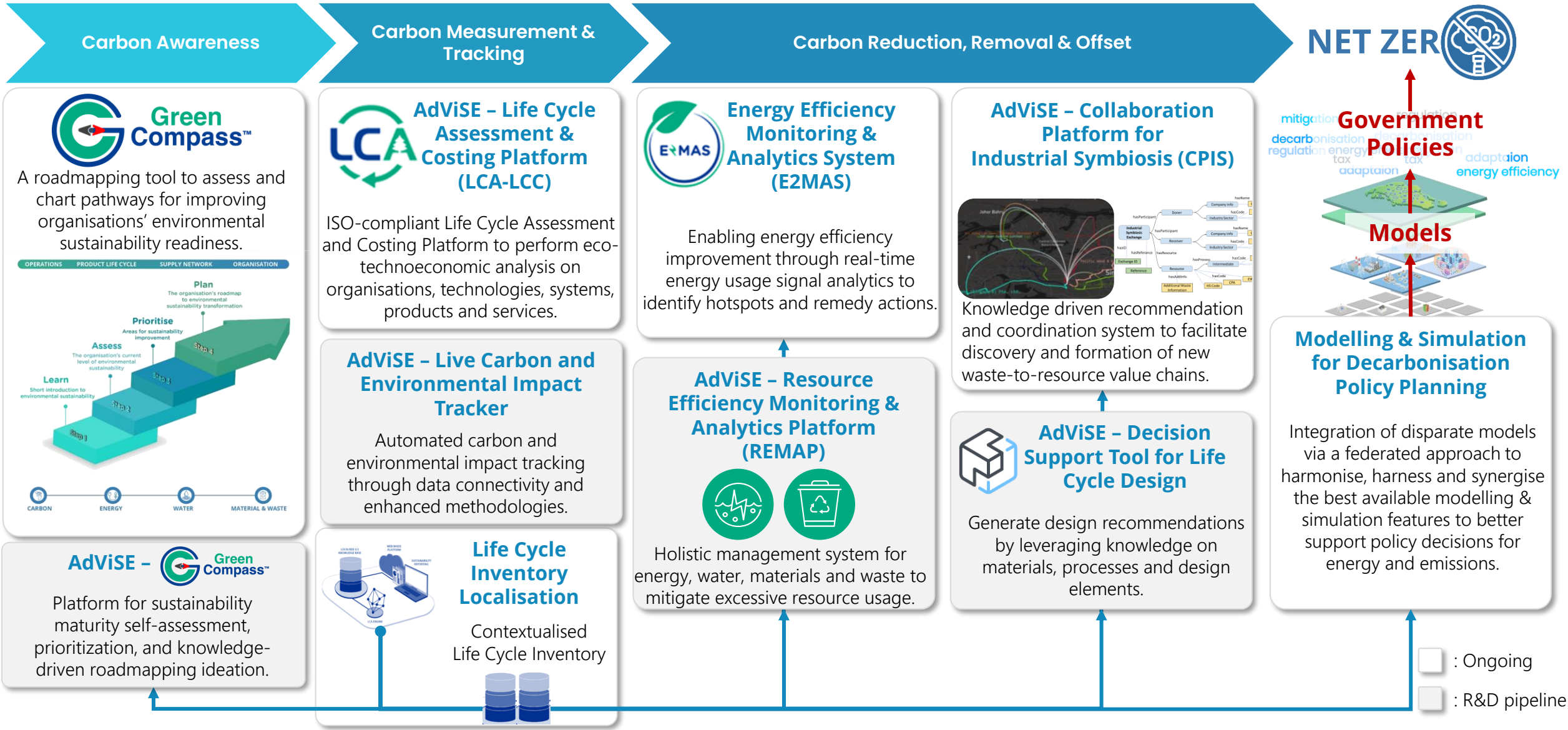
Semakau landfill: Going beyond 2035

- Semakau **landfill** (Singapore’s only landfill) estimated to reach **full capacity** by **2035**
- Reduce waste sent to landfill** per capita per day by **30%** by **2030**.
- Target of **70% overall recycling rate** by **2030**
- Priority waste** streams: **Packaging** waste including **plastic, e-waste** and **food** waste
- Extended Producer Responsibility** progressively introduced from 2021
- New \$80 million **Closing the Resource Loop Funding (CTRL) Initiative**

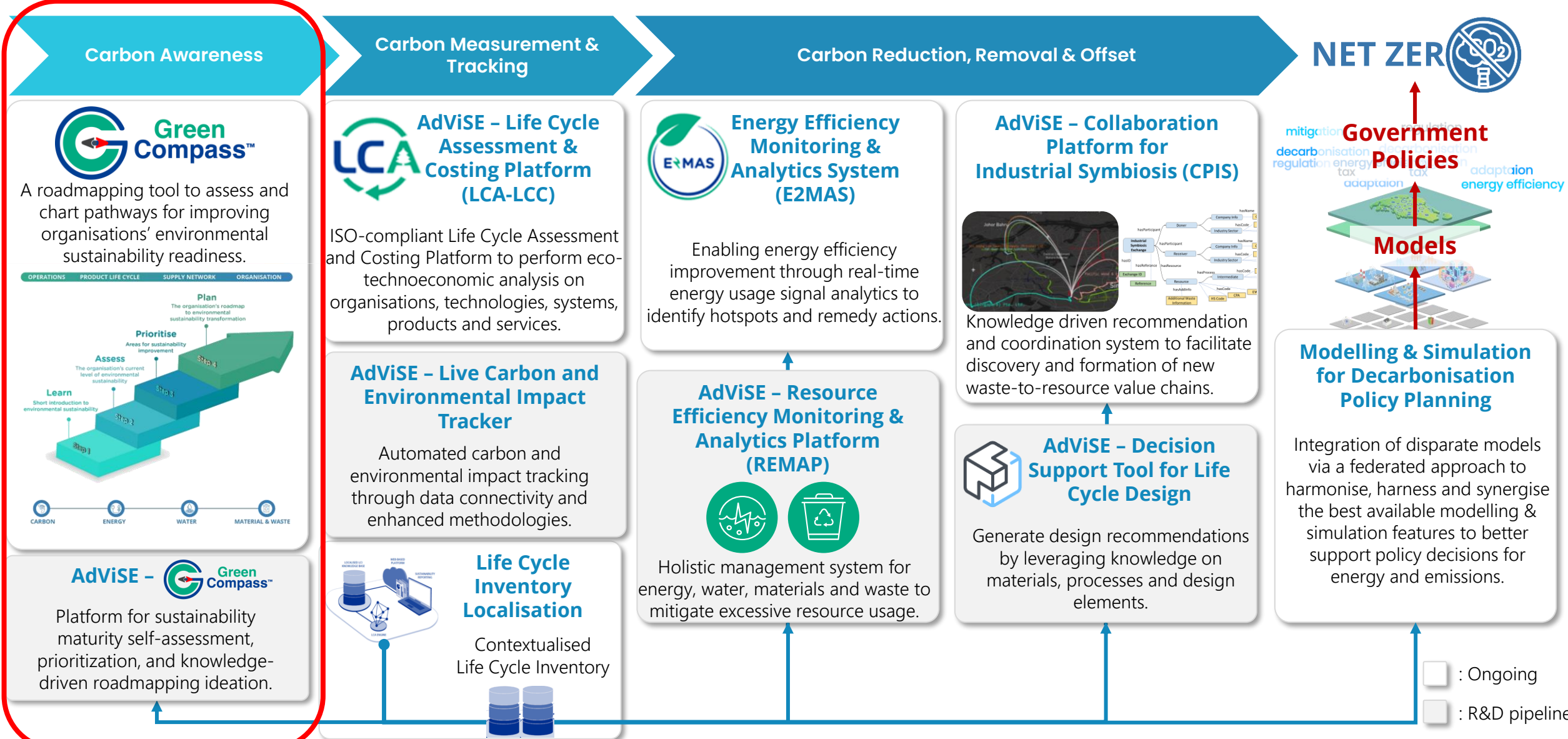
Areas of Innovation for a Sustainable Singapore



Developing End-to-End Capabilities for Net Zero Manufacturing



Developing End-to-End Capabilities for Net Zero Manufacturing

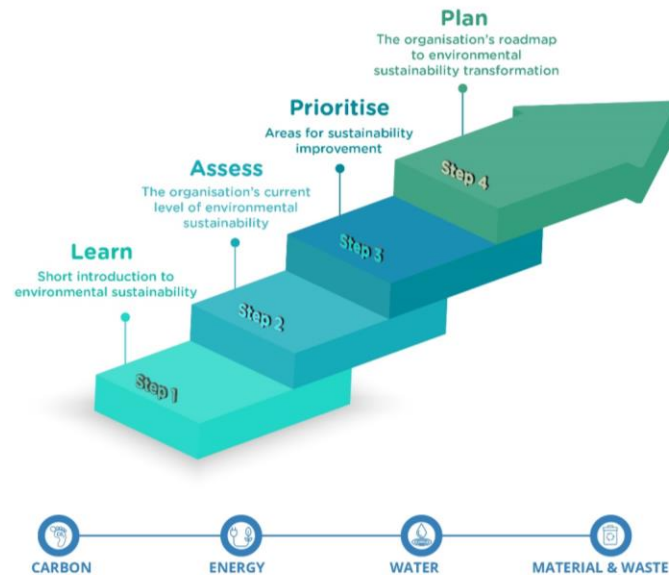


Green Compass™



Green Compass™ is an environmental sustainability assessment and roadmapping tool that enables companies to understand their state of environmental sustainability and develop their sustainability improvement pathways.

OPERATIONS PRODUCT LIFE CYCLE SUPPLY NETWORK ORGANISATION



Key Benefits

- **Reduce Business costs** by learning how to improve resource efficiency
- **Future-ready your business** for sustainability-oriented regulations and industry trends
- **Recommendations** on how to improve the environmental sustainability performance
- **Identification and prioritization** of key improvement areas, considering impact and costs.

- 16-hour workshop, over 4 days
- Launched as a Skillsfuture course in Apr 2022
- *228 pax from 33 companies trained (incl. pilot phase since Oct 2021)

*Data collated as at July 2023

LEARN

Introduction to sustainability trends and methodologies

ASSESS

Which departments/functions have individuals who are required to take environmental sustainability training?

Which job levels are required to take environmental sustainability training?

How frequently is the curriculum for the training programme reviewed?

Environmental sustainability assessment report

PRIORITISE

Select domains to explore your results.

Organisation	Sustainable Business
Select Business	Operations Supply Network Product Life Cycle
Leadership Competency	Carbon Carbon Carbon
Policy & Compliance	Energy Energy Energy
Workforce Learning & Development	Water Water Water
Stakeholder Engagement	Material Material Material

Detailed Results for Operations - Material Management

Prioritised domains based on company strategic value and costs

PLAN

High-level action plan

Developing End-to-End Capabilities for Net Zero Manufacturing

Carbon Awareness

Carbon Measurement & Tracking

Carbon Reduction, Removal & Offset

NET ZERO



Green Compass™

A roadmapping tool to assess and chart pathways for improving organisations' environmental sustainability readiness.

OPERATIONS PRODUCT LIFE CYCLE SUPPLY NETWORK ORGANISATION



Plan
The organisation's roadmap to environmental sustainability transformation

Prioritise
Areas for sustainability improvement

Assess
The organisation's current level of environmental sustainability

Learn
Short introduction to environmental sustainability

CARBON ENERGY WATER MATERIAL & WASTE



AdViSE - Green Compass™

Platform for sustainability maturity self-assessment, prioritization, and knowledge-driven roadmapping ideation.

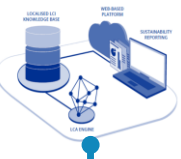


AdViSE - Life Cycle Assessment & Costing Platform (LCA-LCC)

ISO-compliant Life Cycle Assessment and Costing Platform to perform eco-technoeconomic analysis on organisations, technologies, systems, products and services.



AdViSE - Live Carbon and Environmental Impact Tracker

Automated carbon and environmental impact tracking through data connectivity and enhanced methodologies.



Life Cycle Localisation

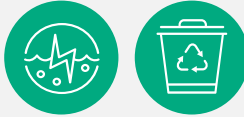
Contextualised Life Cycle Inventory

Energy Efficiency Monitoring & Analytics System (E2MAS)

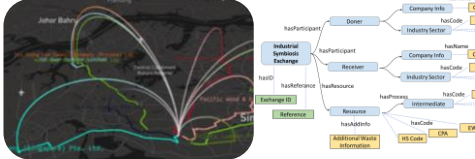
Enabling energy efficiency improvement through real-time energy usage signal analytics to identify hotspots and remedy actions.

AdViSE - Resource Efficiency Monitoring & Analytics Platform (REMAP)



Holistic management system for energy, water, materials and waste to mitigate excessive resource usage.

AdViSE - Collaboration Platform for Industrial Symbiosis (CPIS)

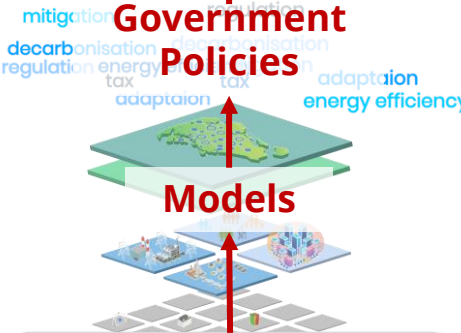


Knowledge driven recommendation and coordination system to facilitate discovery and formation of new waste-to-resource value chains.



AdViSE - Decision Support Tool for Life Cycle Design

Generate design recommendations by leveraging knowledge on materials, processes and design elements.



Government Policies

mitigation, decarbonisation, regulation, tax, adaptation, energy efficiency

Models

Modelling & Simulation for Decarbonisation Policy Planning

Integration of disparate models via a federated approach to harmonise, harness and synergise the best available modelling & simulation features to better support policy decisions for energy and emissions.

: Ongoing
 : R&D pipeline

Life Cycle Assessment and Costing (LCA-LCC)

LCA-LCC equips companies with a science-based collaborative digital web tool that provides customized and credible reports with localized emission data, that can be used for sustainability planning to help businesses reduce carbon emission, compute carbon tax and provide decision support for carbon pricing.



Validate 'eco-friendliness' of processes, products and services over entire life cycle



Benchmark environmental and economic performance of systems



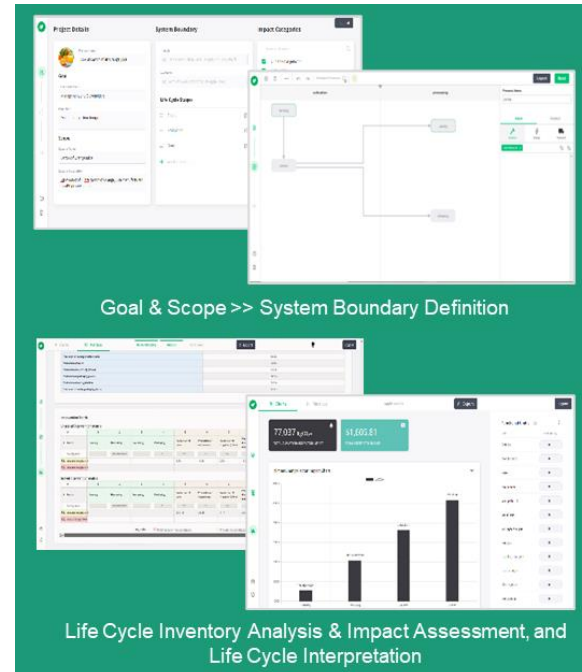
Identify sustainability hotspots and set science-based targets



Support eco-design



Support systematic and strategic planning to maximise financial ROI of sustainability initiatives

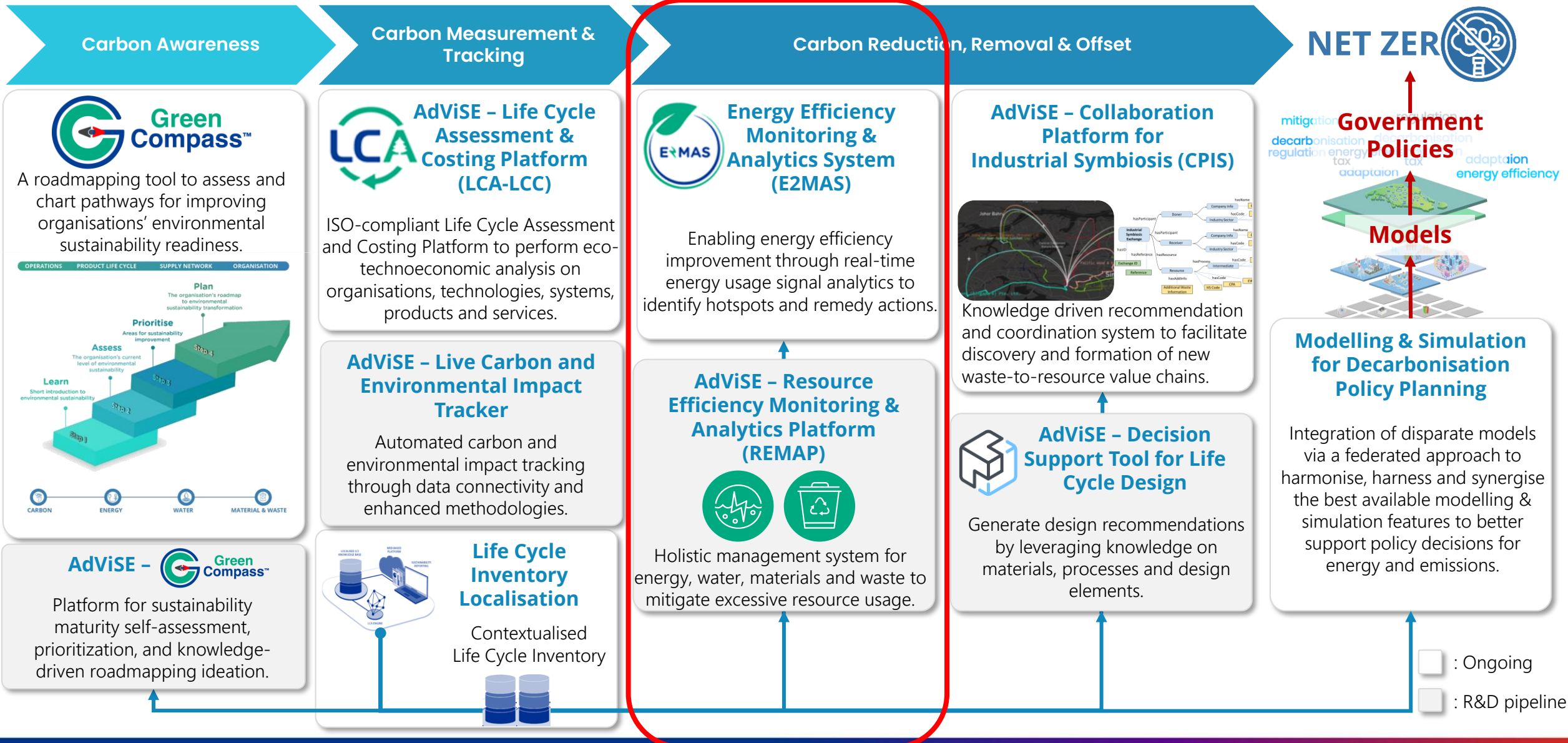


Key Benefits

- To **increase the efficiency** by computing the carbon footprint and other environmental impacts across supply chain
- To **reduce company's carbon emission**, compute carbon tax and provide decision support for carbon pricing
- To maximize financial ROI of Sustainability Initiatives

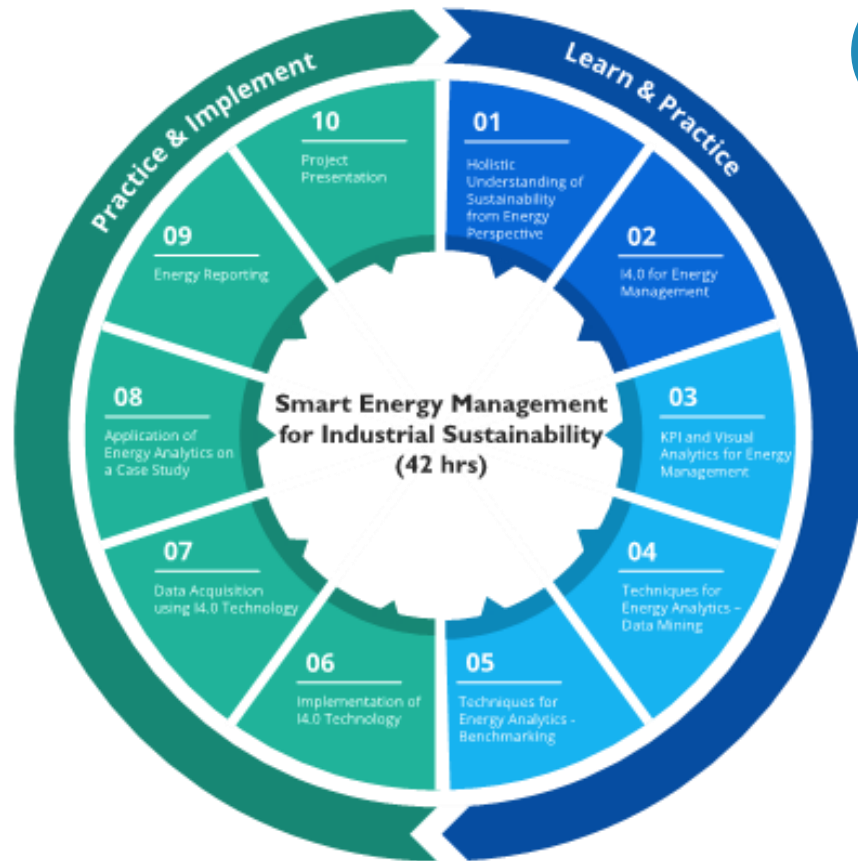


Developing End-to-End Capabilities for Net Zero Manufacturing



Smart Energy Management for Sustainability

Smart Energy Management for Sustainability is designed for participants to understand energy management (ISO50001:2018) with introduction to I4.0 technologies and data analytics for energy efficiency improvement.



 **42 hours** workshop,
over 3 months



Key Benefits

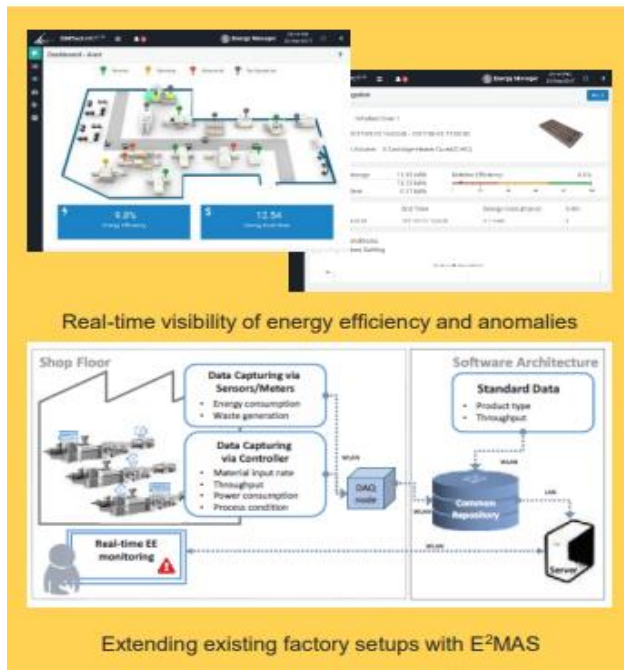
- Experience having metering solutions to practice **data-driven approaches** for energy management
- **Increased visibility of energy consumption** with selected case study on-site
- **Perform energy analytics** by conducting baseline study and identifying energy hotspots and opportunities for improvement



Energy Efficiency Monitoring and Analytics System (E2MAS)

E2MAS equips companies with a **SMART Energy Management System** to:

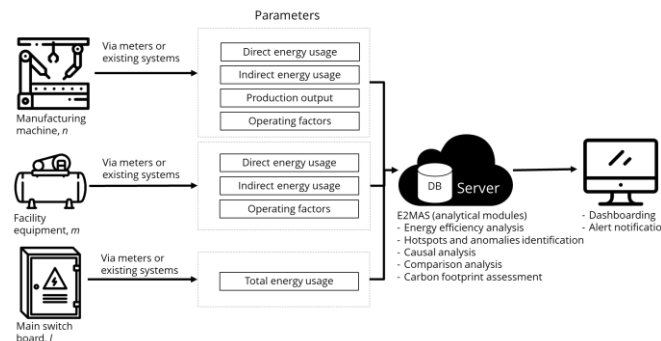
- **Monitor the energy flows** and assess the equipment's energy performance indicators **in real-time**
- **Identify hotspots** and anomalies of excessive energy usage
- **Analyse hotspots** to derive quantifiable energy improvement potentials
- **Estimate carbon footprint** by energy efficiency in real-time
- Export report in one-click



Key Benefits

- To reduce company energy consumption and carbon emission by **>20%**
- To increase equipment efficiency by **>20%**
- To **eliminate 100%** tedious manual task of energy auditing/reporting
- To **identify energy hotspots** and opportunities for energy efficiency improvement

Approach of E2MAS



With E²MAS, LHT can reduce energy consumption by 20 per cent on average

Ms May Yap
Managing Director
LHT Holdings Limited

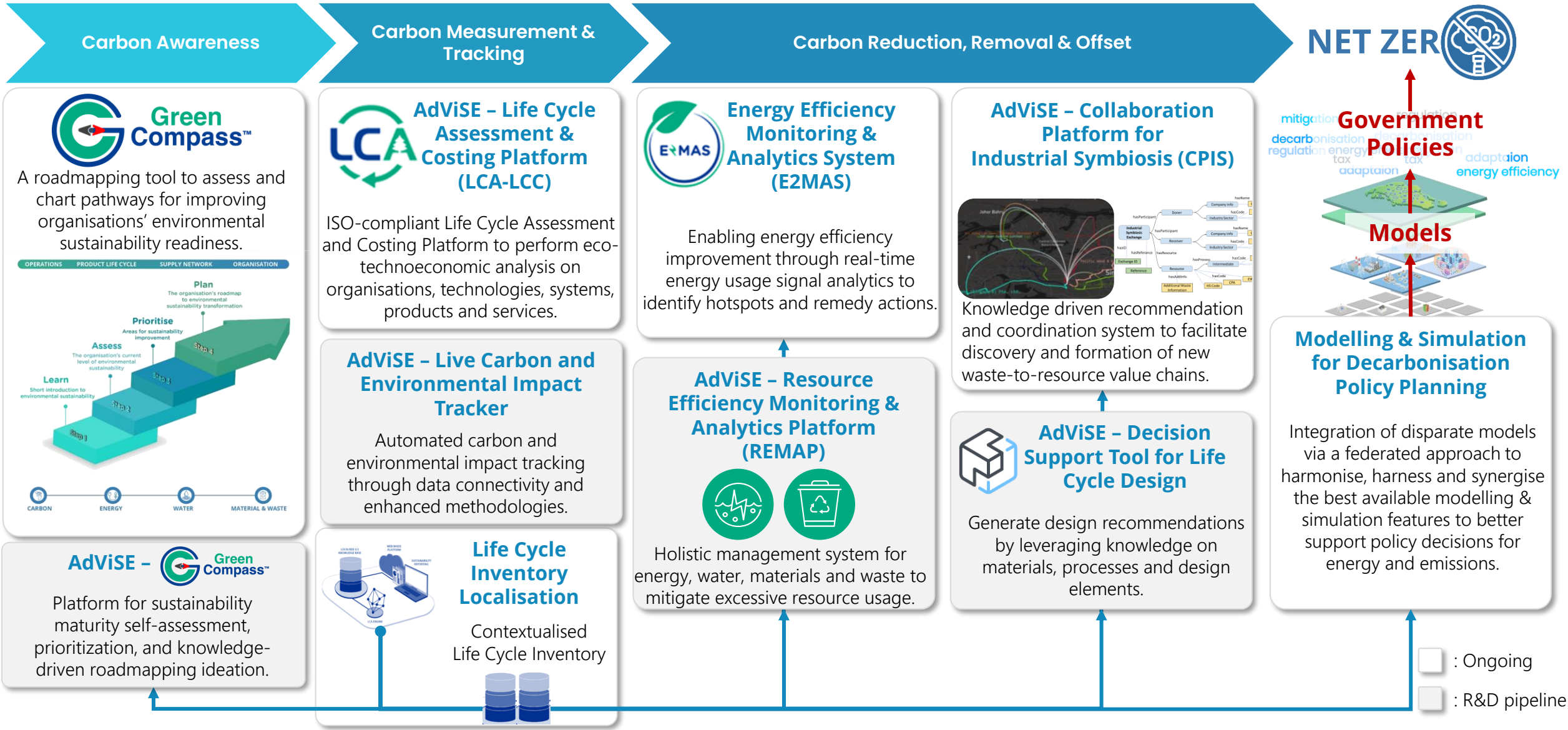


The innovation broadens Singnergy's business applications and is able to position the company with a leading-edge competitive advantage in the waste recycling sector through its high yield and energy-efficient solution

Mr KT Chua
Managing Director
Singnergy Corporation Pte Ltd



Developing End-to-End Capabilities for Net Zero Manufacturing





CREATING GROWTH, ENHANCING LIVES



THANK YOU

www.a-star.edu.sg

Keynote for Sustainability Handling Wet Organic Wastes in Megacities

Prof Tong Yen Wah
Associate Professor
National University of Singapore





Waste to Resources

TONG, Yen Wah (chetyw@nus.edu.sg)

Dept of Chemical and Biomolecular Engineering
NUS Environment Research Institute (NERI)
National University of Singapore

2023



Acknowledgement

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NATIONAL RESEARCH FOUNDATION
PRIME MINISTER'S OFFICE
SINGAPORE



- **E2S2-CREATE:**
 - **Shanghai Jiaotong University:** Prof Peng Yinghong, Prof Dai Yanjun, Prof Liu Xiao, Prof He Yiliang, Prof Wang Ruzhu, Prof Zhai Xiaoqiang, Prof Ge Tianshu and many more
 - **National University of Singapore:** Prof Wang Chi-Hwa, Prof Loh Kai-Chee, Prof Neoh Koon Gee, Prof Wang Xiaonan, Prof Karina Gin, Prof Adam Ng, Prof Michel Cardin and many more
 - **E2S2 Researchers and Students:** Dr Zhang Jingxin, Dr Lim Jun Wei, Dr Tian Hailin, Dr Jonathan Lee, Dr Zhang Le, Dr Tong Huanhuan, Dr Li Wangliang, Dr Li Xian, Dr You Siming, Dr Zhen Xu, Dr Dong Pengwei, Dr Yan Wei-Cheng, Ms Zhang Jingru, Dr Mao Liwei, Dr Kan Xiang, Dr Shen Ye, Dr Lin Jie, Mr Yao Zhiyi, Ms Guo Yalei, etc.





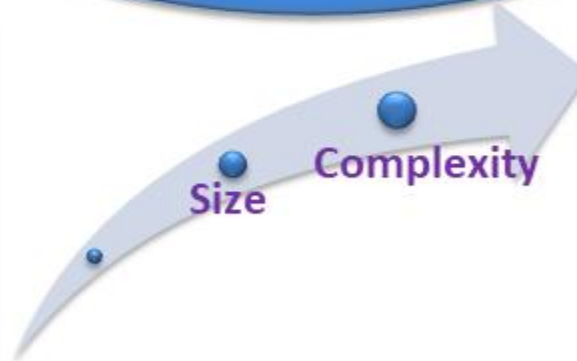
SJTU –NUS CREATE: Coupled Challenges and Solutions for Stressed Megacities



*Joint NUS-Government
Agencies Collaboration*

*Joint SJTU-Government
Agencies Collaboration*

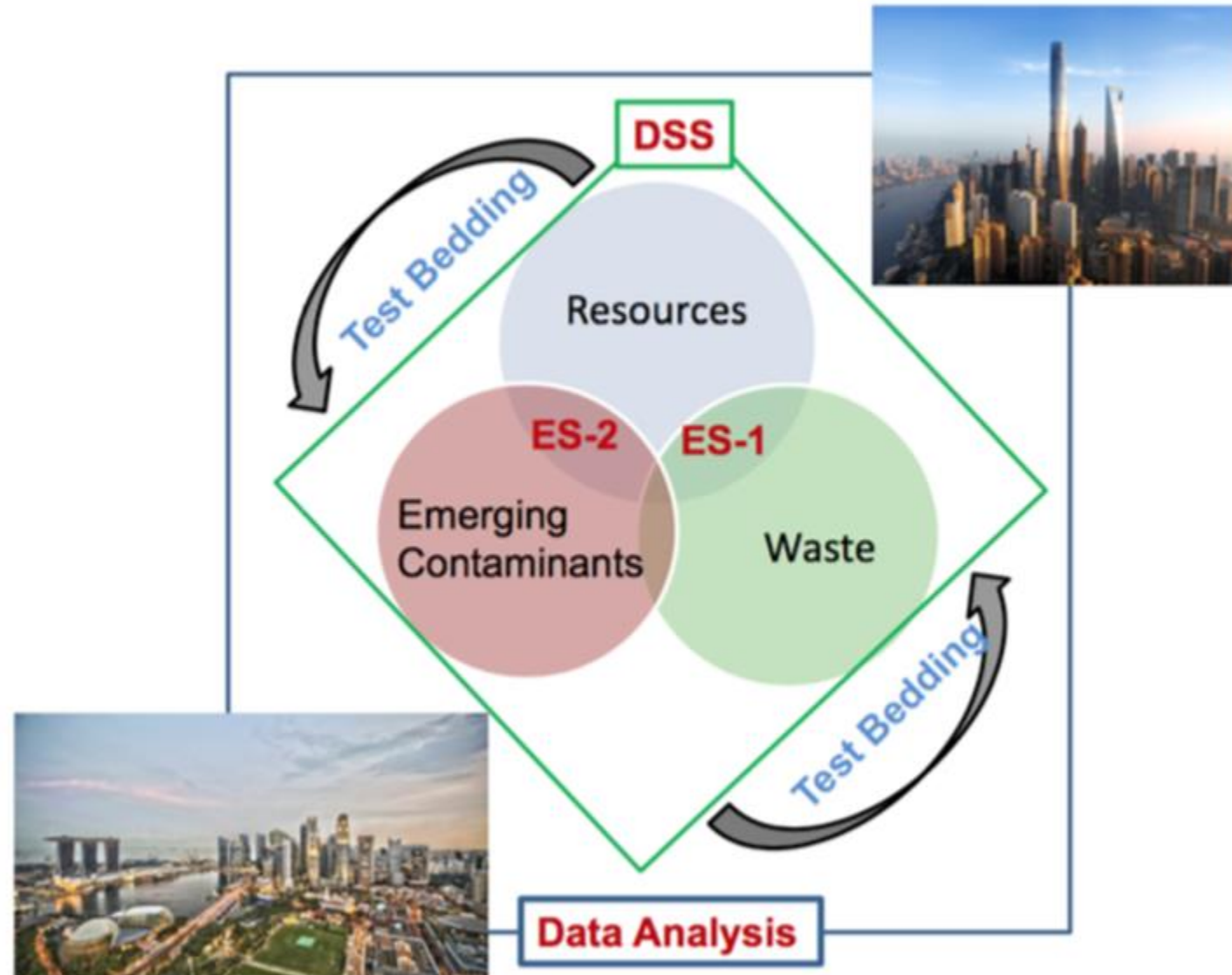
- Test-bedding Solutions:**
- Marina Reservoir
 - Punggol-Serangoon Catchment and Reservoir
 - Ulu Pandan Canal (Aquatic Science Center)
 - NUS Campus



- Test-bedding Solutions:**
- Qingcaosha Reservoir
 - Maqiao City, Minhang District
 - SJTU Campus

***Test-bedding Solutions with State-of-the-Art Technologies
within a Systems Framework***

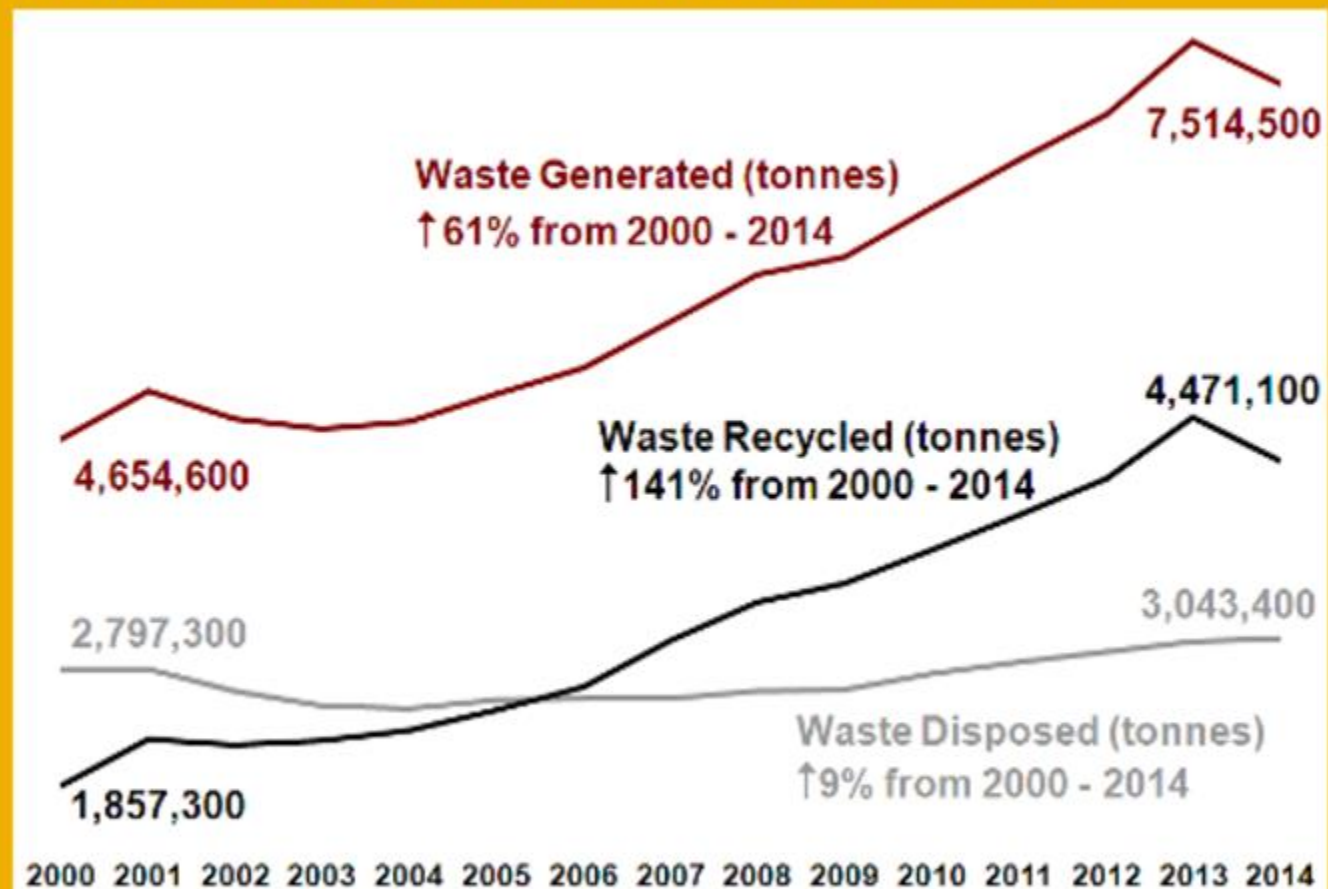
Phase 2 – 2018 to 2023





Municipal solid wastes (MSW) are generated in huge quantities, including food wastes, sewage wastes, paper, plastics, leaves, plant trimmings and etc. A *sustainable* waste management and resource recovery system is needed for megacities.

Waste Statistics from 2000 to 2014

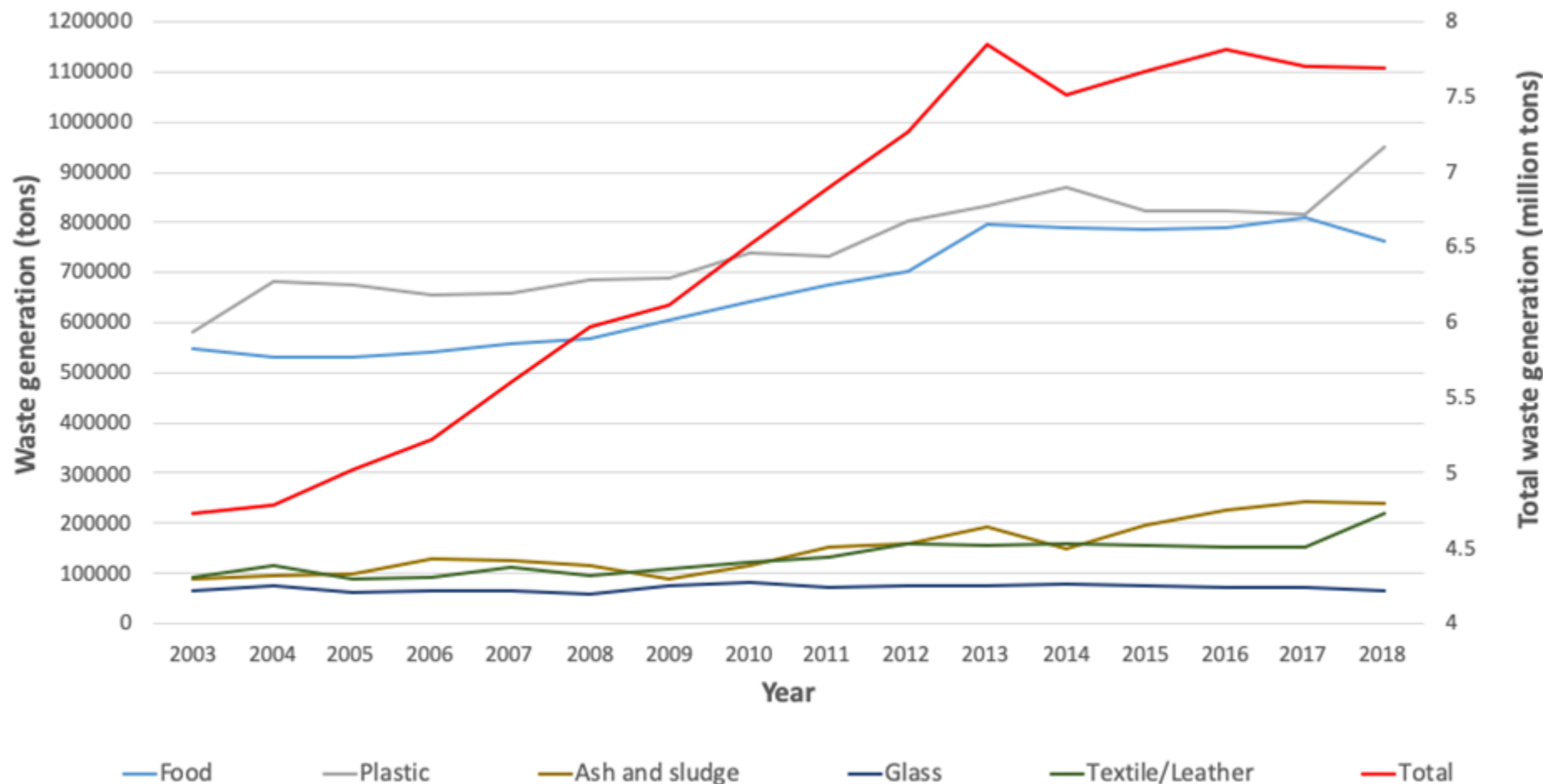




Municipal Solid Wastes in Singapore



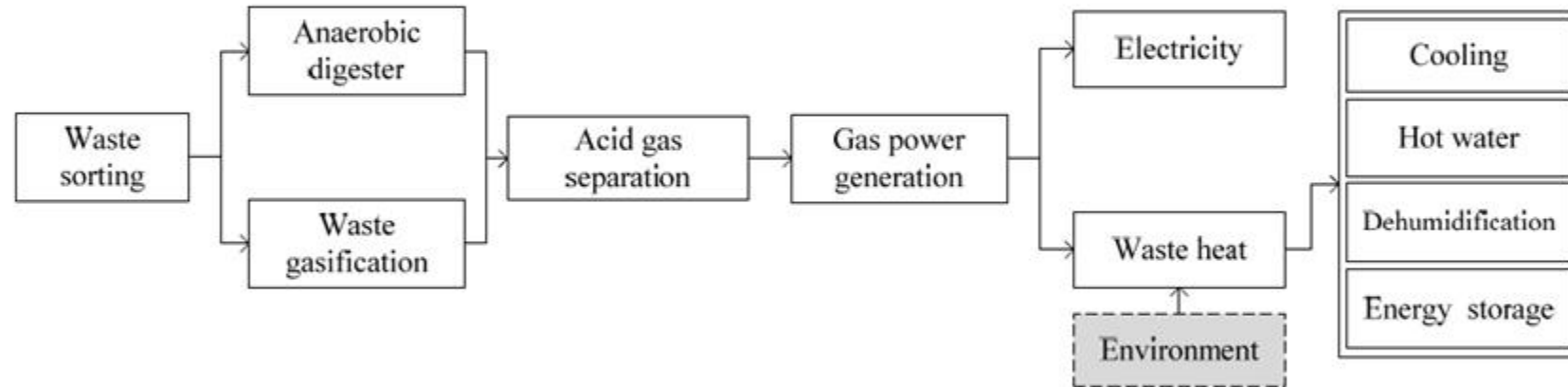
Waste generation statistics of waste that has a low recycling rate (<50%)



*NEA (2014). National Environment Agency.

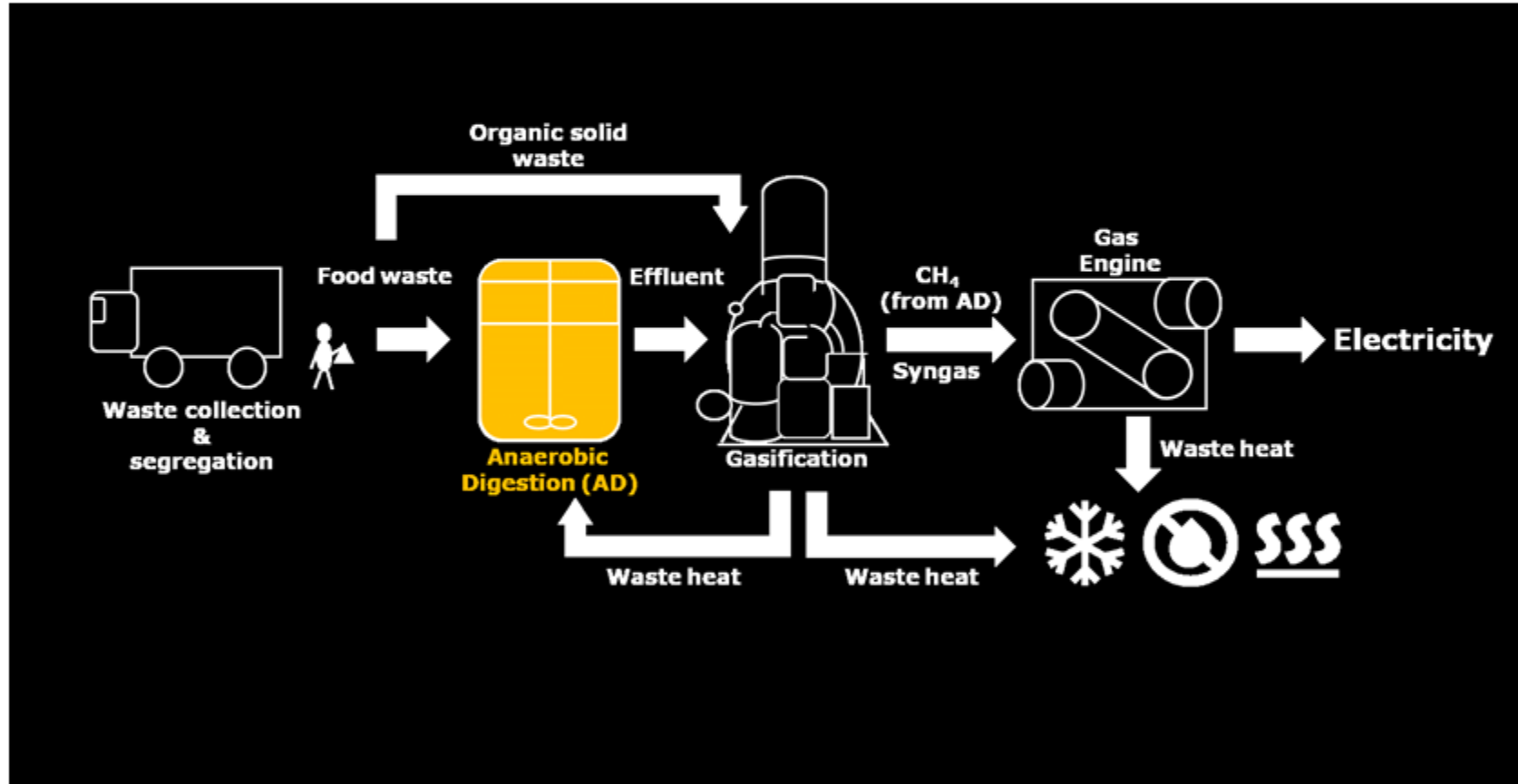
Waste Type	Total Generated ('000 tonnes)	Total Recycled ('000 tonnes)	Recycling Rate	Total Disposed ('000 tonnes)
Ferrous metal	1,338	1,331	99%	7
Paper/Cardboard	1,064	394	37%	671
Construction & Demolition	1,424	1,419	99%	5
Plastics	1,001	57	6%	944
Food	813	146	18%	667
Horticultural	221	188	85%	32
Wood	419	298	71%	121
Ash & sludge	241	27	11%	213
Textile/Leather	254	5	2%	249
Used slag	169	166	99%	2
Non-ferrous metal	92	91	98%	2
Glass	73	11	14%	63
Scrap tyres	26	25	95%	1
Others (stones, ceramics, etc.)	249	30	N.A. ¹	219
Overall	7,385	4,188	57%	3,197





- Emissions, environmental/human effects
- Space for facilities and landfill
- Management of by-products



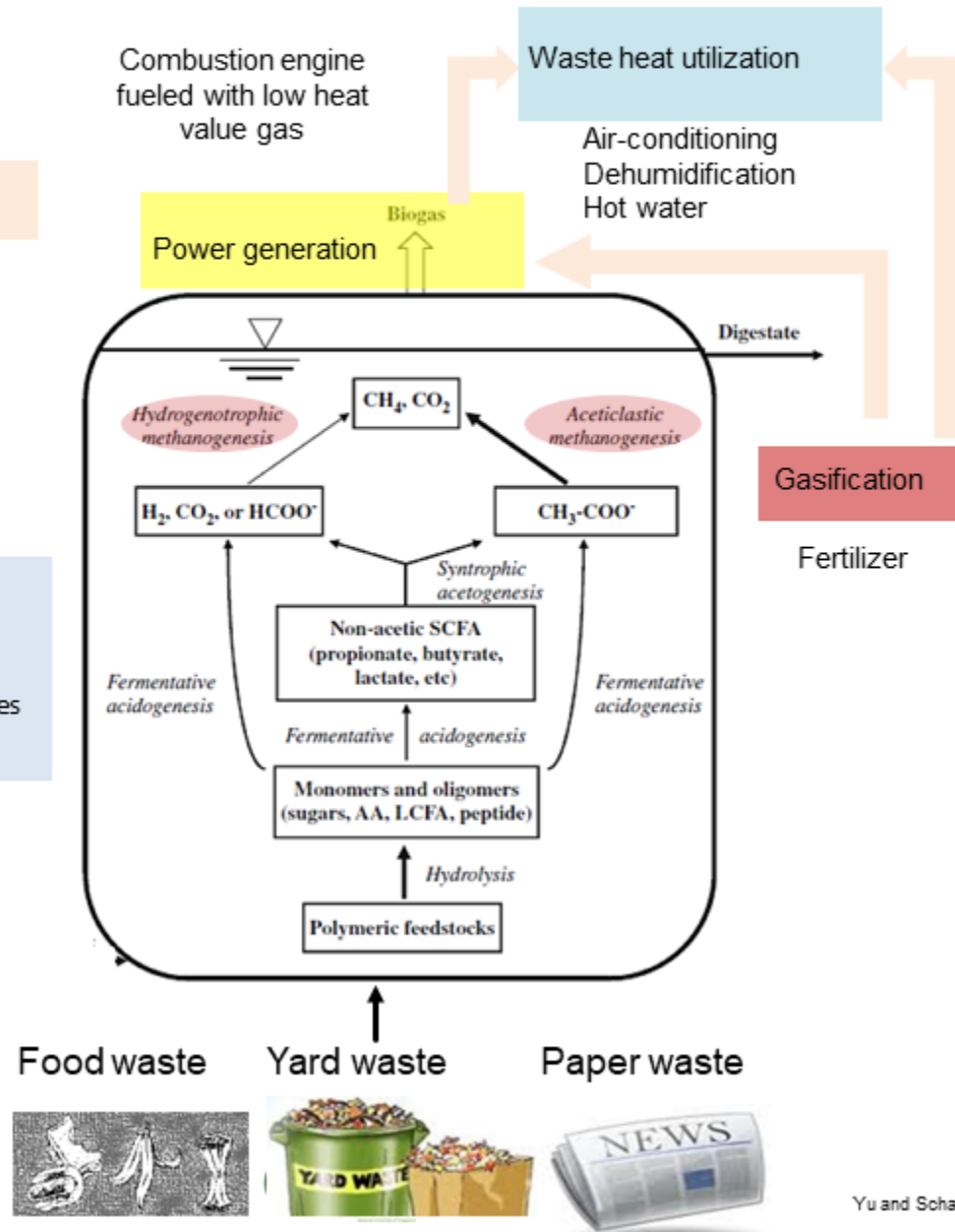


Anaerobic Digestion (AD)

Modularization

Selection and
characterization of
microbial communities

Characterization
of the organic
feedstock



- In Singapore, 10% of total waste generated
- 813000 tonnes generated, 18% recycled (2022)
- All currently incinerated
 - Solutions? Minimization, redistribution, recycling
 - Energy recovery
- Challenges of AD for energy recovery:
 - Slow rate of hydrolysis
 - Slow start-up and product inhibition (VFA, ammonia)
 - Sensitivity to environmental changes
 - Large bioreactors

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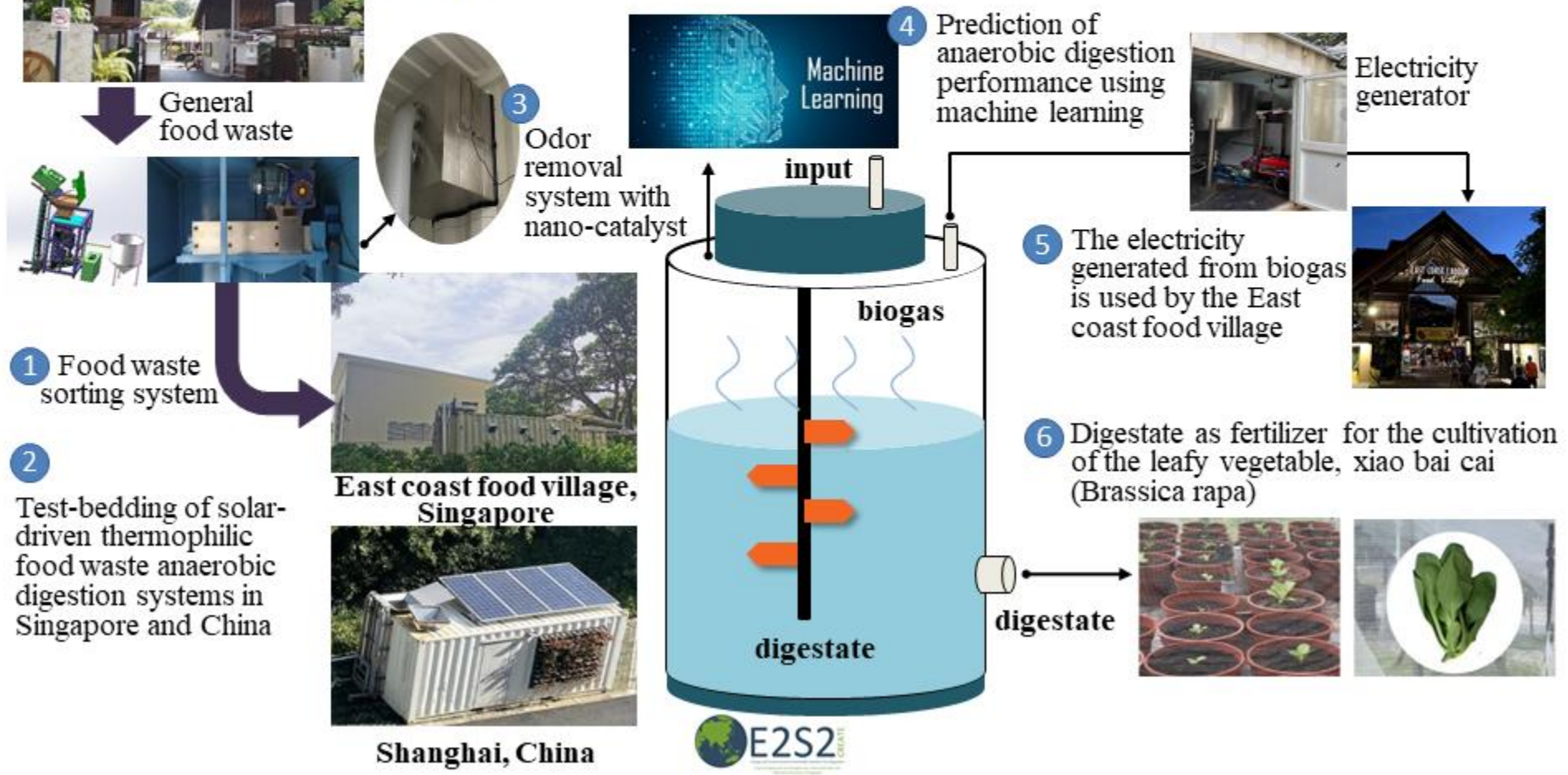


Mixed wastes in AD



Translating E2S2-CREATE Research to ECLFV

Closing The Food Waste Loop Through Onsite Anaerobic Digestion Eco-System

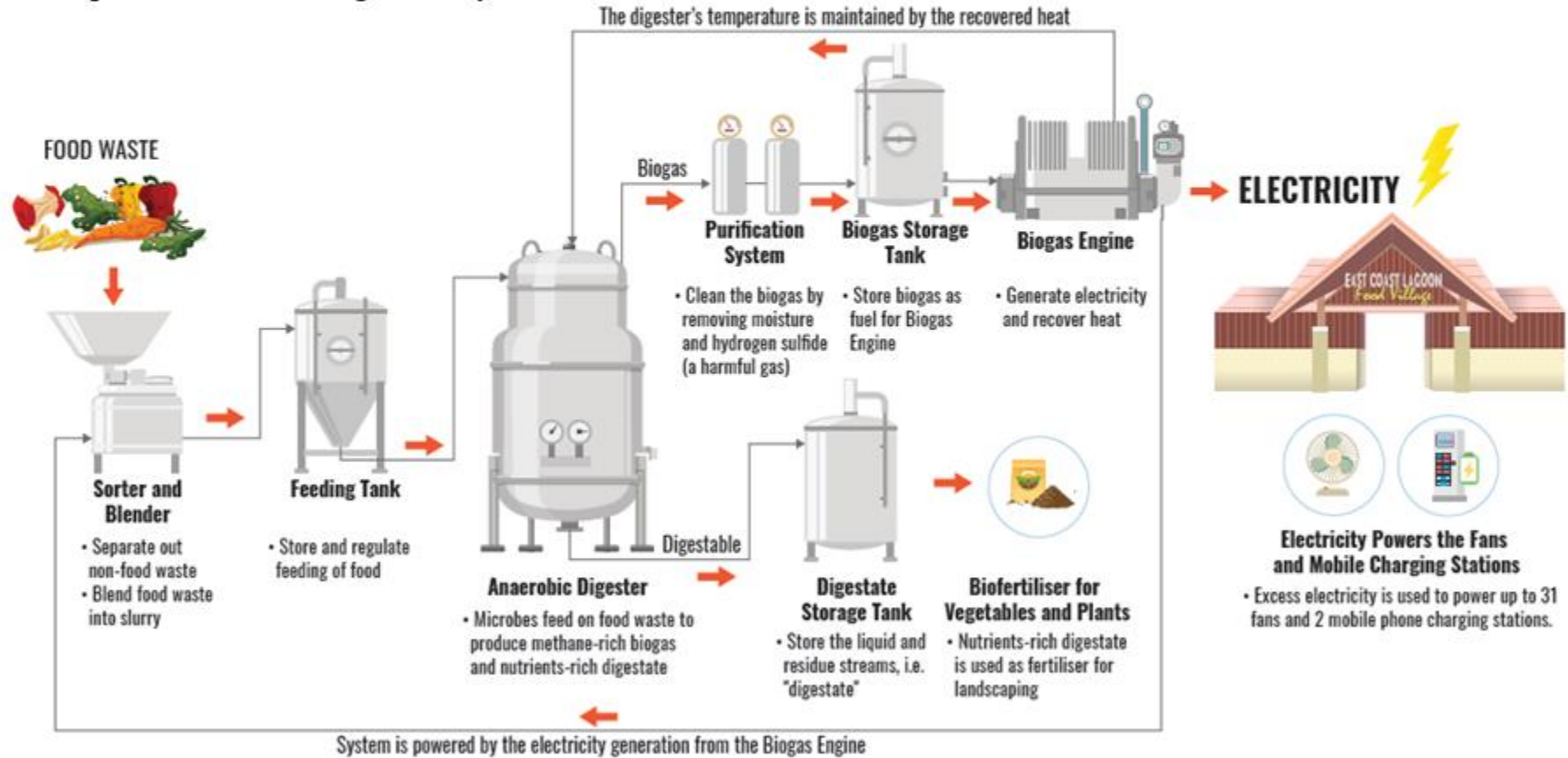


- Food waste generated at ECLFV: Range from 150kg/day on weekdays, and up to 300kg/day on weekends



ECLFV AD System Process Flow

➤ Proposed anaerobic digestion system



FOOD WASTE TO ENERGY AND RESOURCES



Properties needed

Clean	Odor-free	Automated
Distributed	Compact	Safe
Hot water	Electricity	Heat
ROI: 3-5 years	5-yr service warranty	Low maintenance

Annual savings for 1 ton of food wastes per day: \$35,405!
Generate 73 MWh of electricity worth \$17,615!

- Design of a high-tech distributed food wastes handling system
- On-site food waste treatment that is clean, compact, odour-friendly, and generate electricity/heat from wastes
- Suitable for urban areas and city centres, outdoor or indoor
- Separate and sort plastics/paper/inorganics from food wastes for recycling or disposal
- Reduces transportation and waste disposal costs, currently at **S\$97/t**
- Can produce about **200 kWh** of electricity per ton of food wastes, equivalent to **\$48.26** (at 24.13 cents/kWh)

Conclusions

- Municipal solid wastes forms a very complex substrate for treatment
- Hybrid, or mixed, technologies combined with waste sorting would provide more effective conversion of wastes to energy
- A variety of issues have to be addressed
- Test-bedding should be done in different locations/countries



Thank you!



Climate Change Mitigation Planning

Mr Daren Tan

Group Manager

Sustainability Informatics & Strategy

SIMTech



Climate Change Mitigation Planning

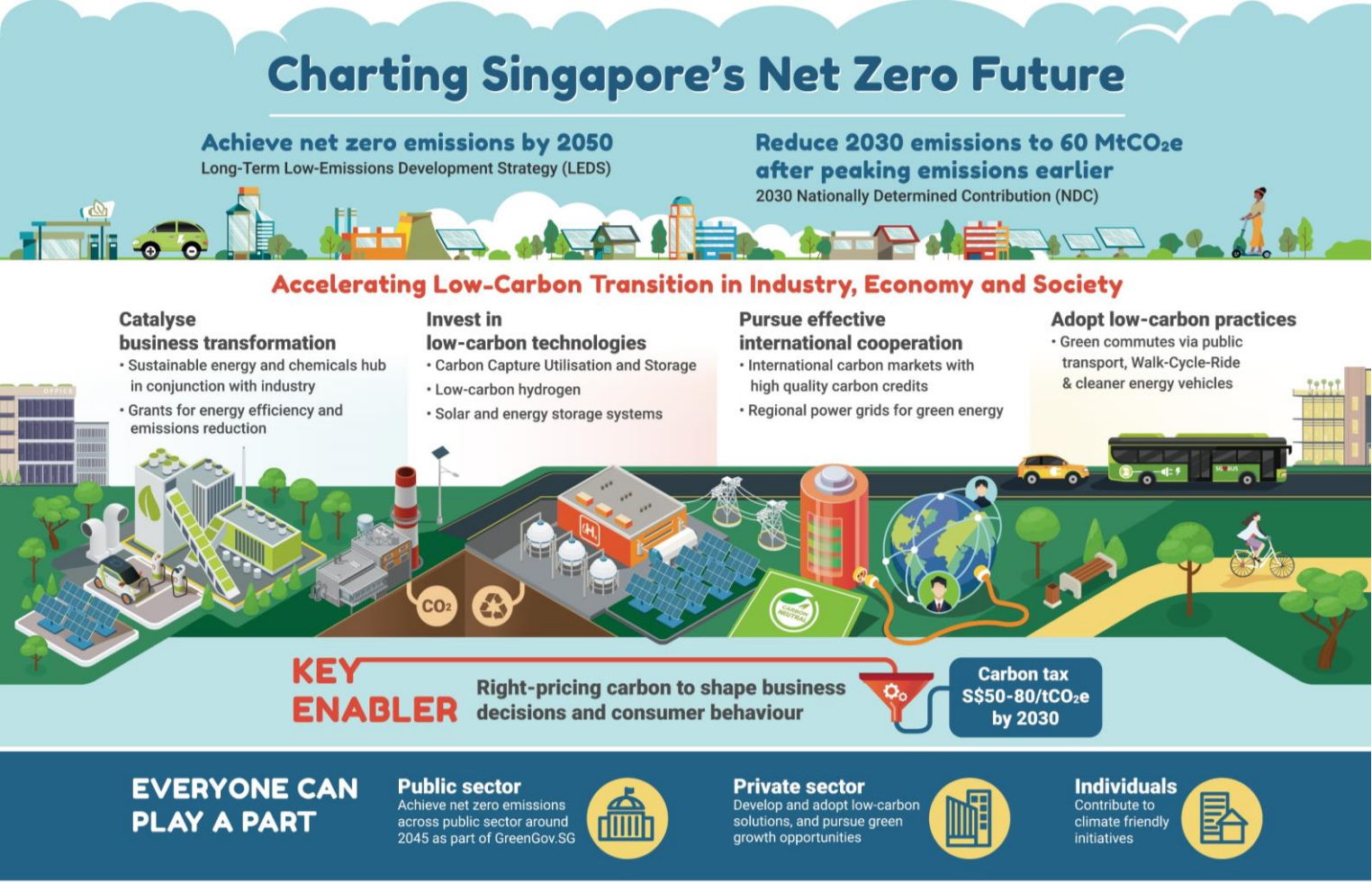
Daren Tan Z. L.

Ag Group Manager

A*STAR SIMTech

Jul 2023

Singapore's Net Zero Goal



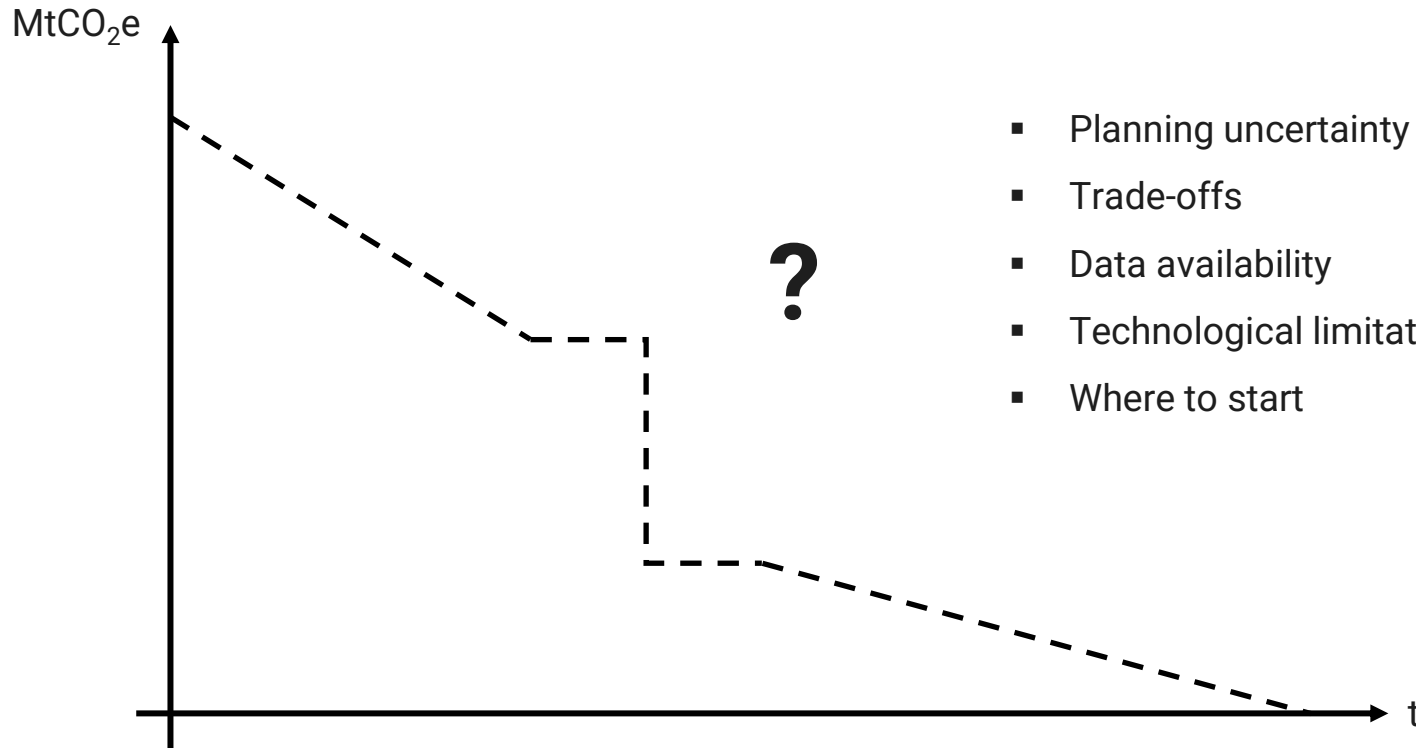
Source: [Joint press release by NCCS and MSE \(25th Oct 22\)](#)



Climate Change Mitigation Planning



Climate Change Mitigation refers to efforts to reduce or prevent emission of greenhouse gases

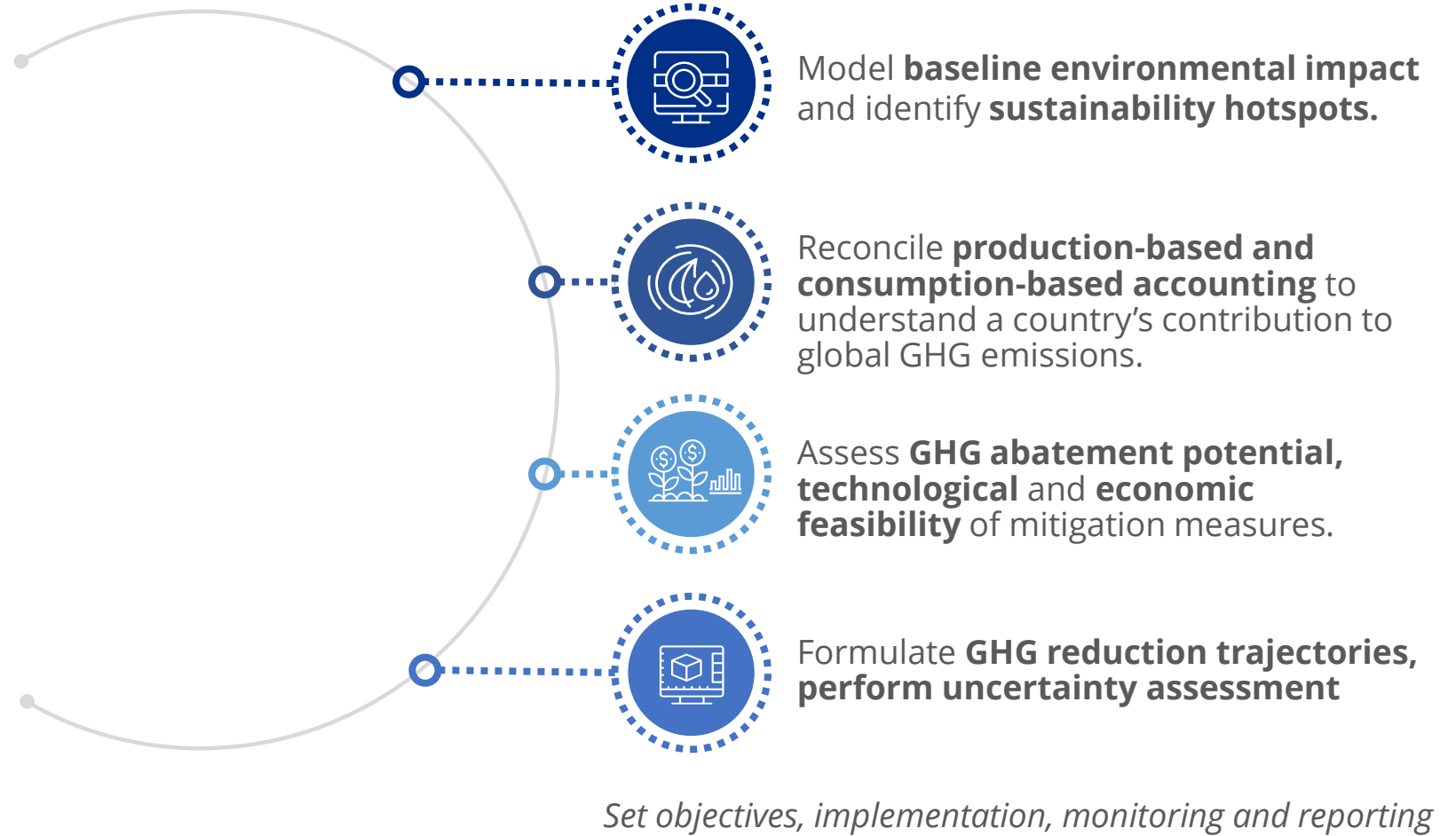


- Planning uncertainty
- Trade-offs
- Data availability
- Technological limitations
- Where to start



Mitigation can mean using new technologies and renewable energies, making older equipment more energy efficient, or changing management practices or consumer behaviours.

Climate Change Mitigation Planning



Climate Change Mitigation Planning

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OPERATIONS PRODUCT LIFE CYCLE SUPPLY NETWORK ORGANISATION

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The organisation's roadmap to environmental sustainability transformation.

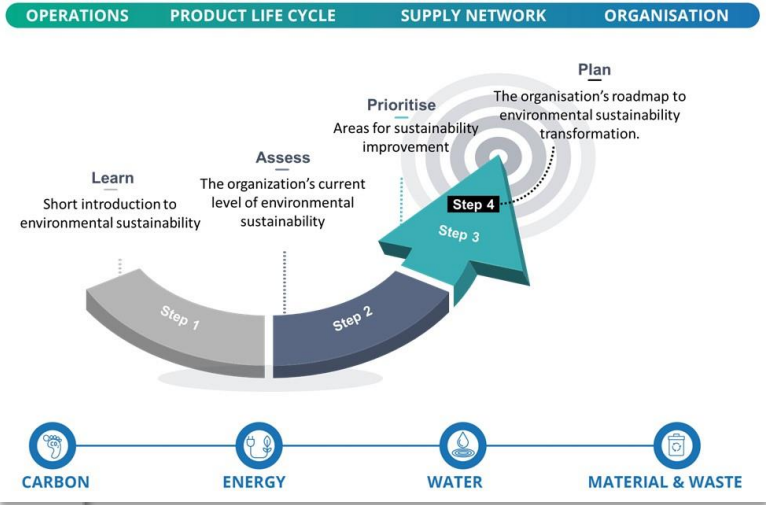
Prioritise
Areas for sustainability improvement.

Assess
The organization's current level of environmental sustainability.

Learn
Short introduction to environmental sustainability.

Step 1 Step 2 Step 3 Step 4

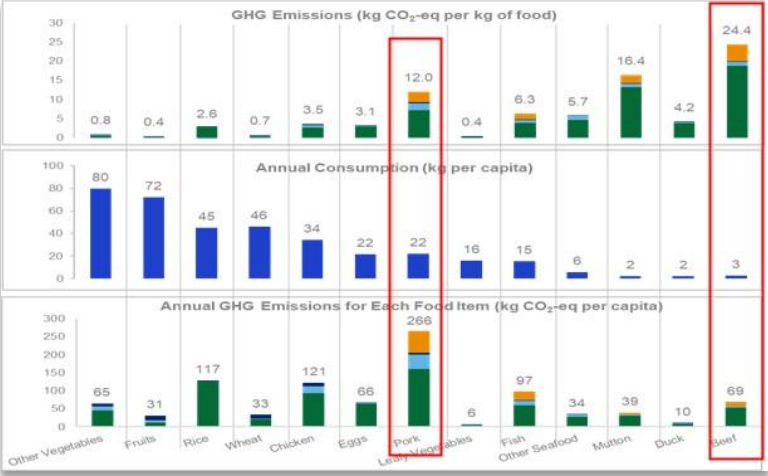
CARBON ENERGY WATER MATERIAL & WASTE



Model **baseline environmental impact** and identify **sustainability hotspots**.

Life Cycle Assessment & Costing Platform (LCA-LCC)

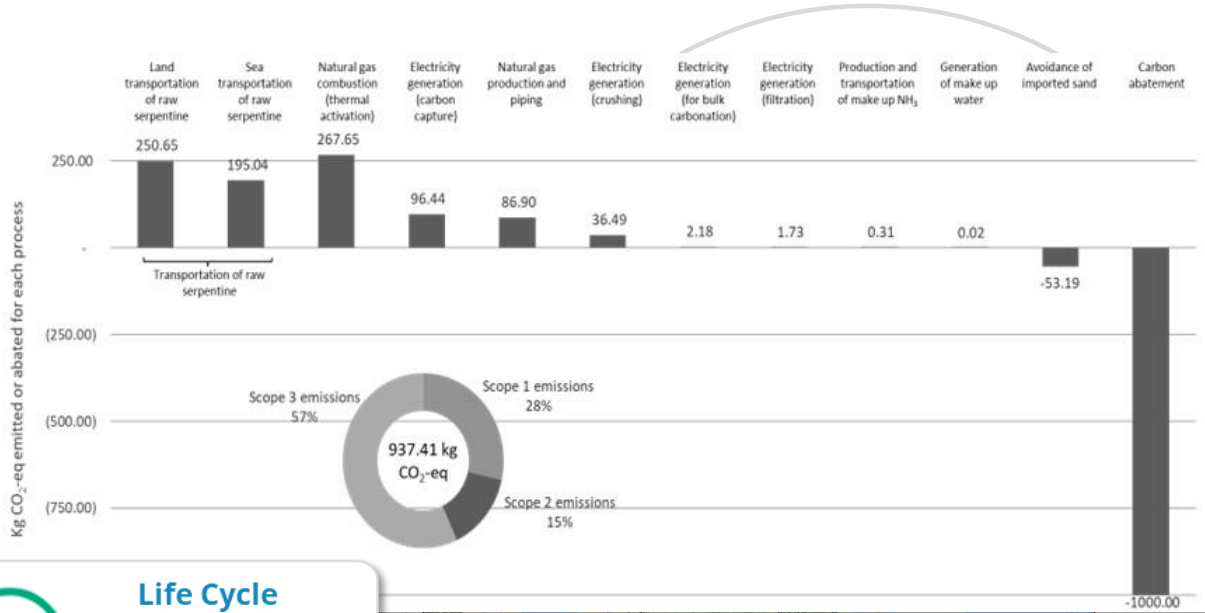
ISO-compliant Life Cycle Assessment and Costing Platform to perform eco-technoeconomic analysis on organisations, technologies, systems, products and services.



Life Cycle Inventory Localisation

Contextualised Life Cycle Inventory

Climate Change Mitigation Planning



Model **baseline environmental impact** and identify **sustainability hotspots**.



Reconcile **production-based and consumption-based accounting** to understand a country's contribution to global GHG emissions.

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Climate Change Mitigation Planning



Decision Support Tool for Life Cycle Design

Generate design recommendations by leveraging knowledge on materials, processes and design elements.



Life Cycle Assessment & Costing Platform (LCA-LCC)

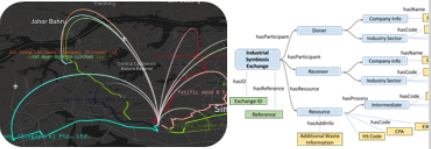
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Energy Efficiency Monitoring & Analytics System (E2MAS)

Enabling energy efficiency improvement through real-time energy usage signal analytics to identify hotspots and remedy actions.

Collaboration Platform for Industrial Symbiosis (CPIS)



Knowledge driven recommendation and coordination system to facilitate discovery and formation of new waste-to-resource value chains.



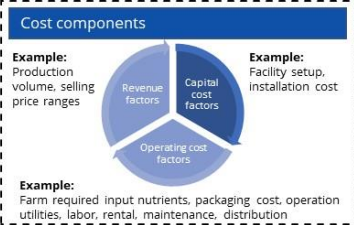
Model **baseline environmental impact** and identify **sustainability hotspots**.



Reconcile **production-based and consumption-based accounting** to understand a country's contribution to global GHG emissions.



Assess **GHG abatement potential, technological and economic feasibility** of mitigation measures.



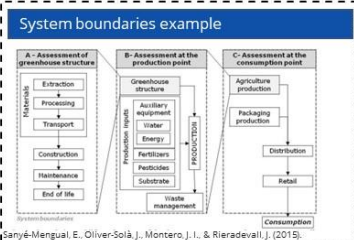
Computation of economic parameters

Parameters for cost evaluation	Value
Cost of Capital / Discount Rate*	7.00%
Number of Years for Evaluation	10
Initial Cost of Project	\$ 5,830,000
Annual Cash Inflow	\$ 150,000,000
Annual Cash Outflow	\$ 14,320,000

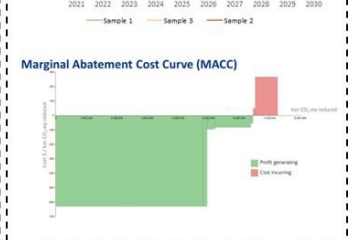
For comparison of different feasible study projection scenarios

Profitability optimization for different use cases such as:

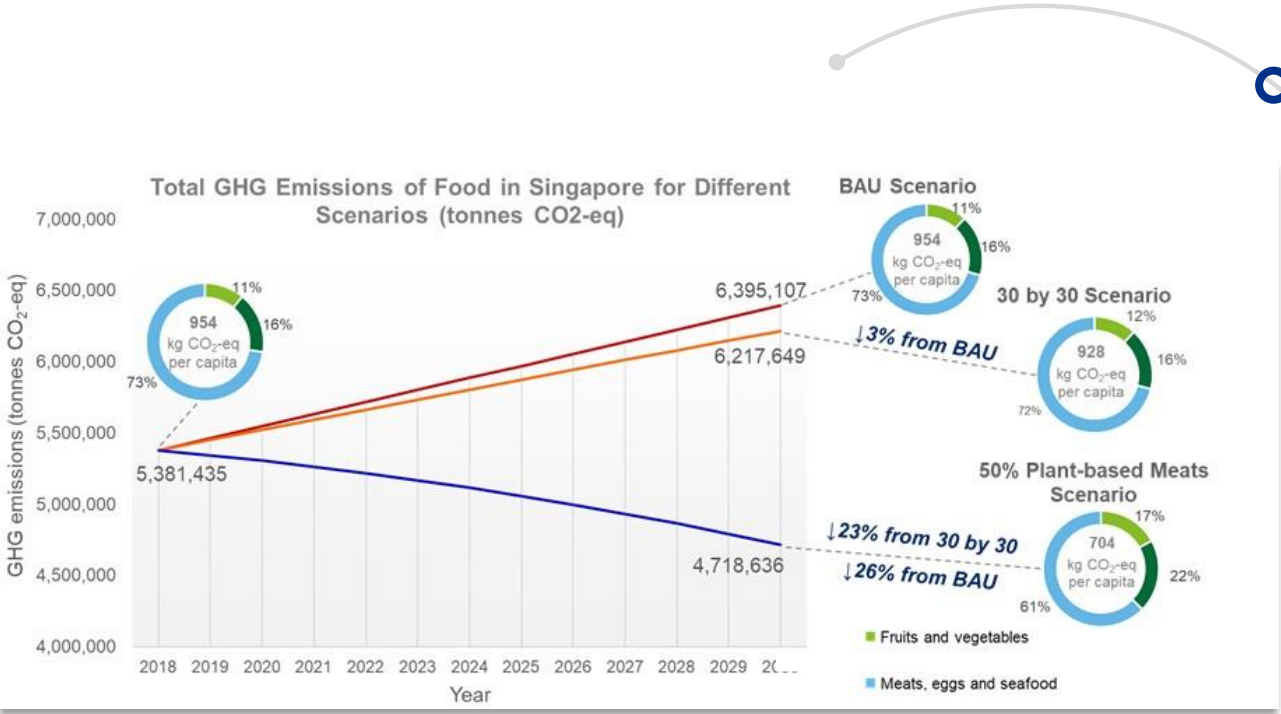
- crop production yield,
- production system cost estimates,
- introduction of automation and new technologies



Results	2.00%	7.00%	7.00%
Cost of Capital / Discount Rate*	2.00%	7.00%	7.00%
Number of Years for Evaluation	10	10	10
Initial Cost of Project	\$ 5,830,000	\$ 12,000,000	\$ 12,330,000
Annual Cash Inflow	\$ 150,000,000	\$ 150,000,000	\$ 150,000,000
Annual Cash Outflow	\$ 14,320,000	\$ 8,450,000	\$ 2,640,000
Net Present Value (NPV)	\$ 951,543,692	\$ 986,753,295	\$ 1,026,479,125
Internal Rate of Return (IRR)	2426.60%	1183.50%	1200.00%
ROI over 4 years	893.93%	1389.83%	3326.32%
Annualized ROI	25.84%	31.01%	42.39%
Number of years to break even	0.04	0.09	0.09
Number of months to break even	0.53046654	1.083544304	1.09



Climate Change Mitigation Planning



Model **baseline environmental impact** and identify **sustainability hotspots**.



Reconcile **production-based and consumption-based accounting** to understand a country's contribution to global GHG emissions.



Assess **GHG abatement potential, technological and economic feasibility** of mitigation measures.



Formulate **GHG reduction trajectories, perform uncertainty assessment**

Set objectives, implementation, monitoring and reporting

Source: Ecosperity Environmental Impact of Key Food Items in Singapore

Climate Change Mitigation Planning

Challenges

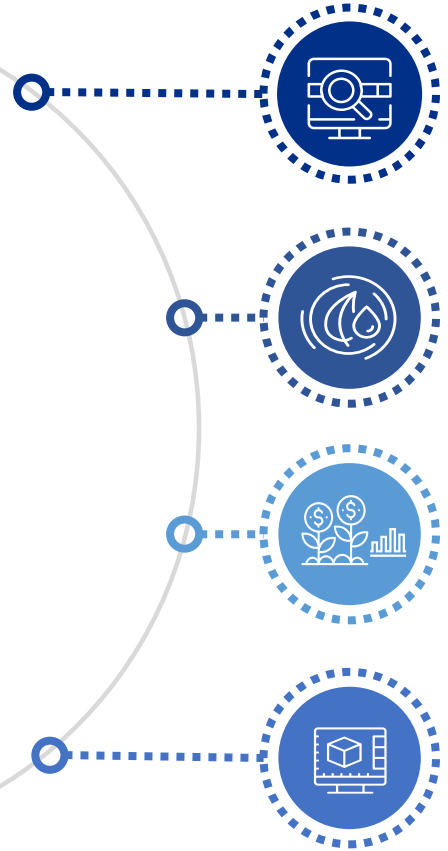
Modelling uncertainty
Technological limitations
Data quality, availability

Opportunities

Technological innovation and advancement
Business growth and transformation
Internationalisation

Not a one-time exercise

It is a dynamic process that requires clear, quantifiable objectives, consistent monitoring and timely iteration



Model **baseline environmental impact** and identify **sustainability hotspots**.

Reconcile **production-based and consumption-based accounting** to understand a country's contribution to global GHG emissions.

Assess **GHG abatement potential, technological and economic feasibility** of mitigation measures.

Formulate **GHG reduction trajectories, perform uncertainty assessment**

Set objectives, implementation, monitoring and reporting



THANK YOU

www.a-star.edu.sg

Moving Towards Green Pallet for Green Packaging

Ms May Yap
Managing Director
LHT Holdings



***MOVING
TOWARDS
GREEN
PALLET FOR
GREEN
PACKAGING***

Ms May Yap

Chairwoman, CEO & MD



“We are always conscious of our role in the conservation of natural resources. Recycling is one of many efforts that reflect our commitment towards mitigating climate change and deforestation”

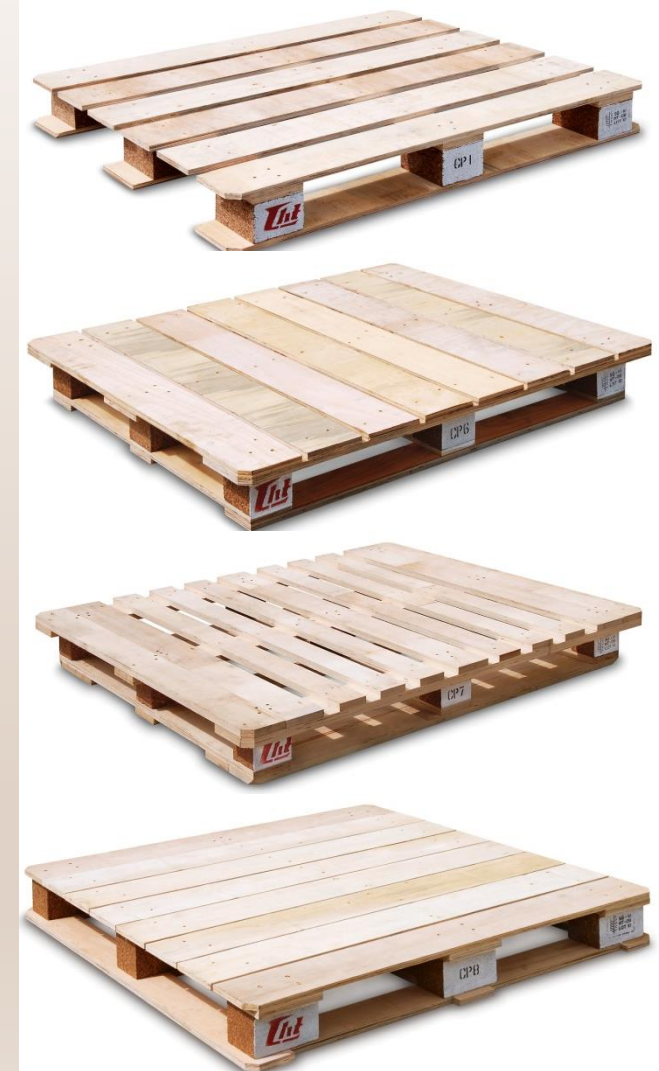


WHAT IS PALLET?

“A pallet (also called a skid) is a flat transport structure, which supports goods in a stable fashion while being lifted by a forklift, a pallet jack, a front loader, a jacking device, or an erect crane. A pallet is the structural foundation of a unit load, which allows handling and storage efficiencies. Goods in shipping containers are often placed on a pallet secured with strapping, stretch wrap or shrink wrap and shipped. Since its invention in the twentieth century, its use has dramatically supplanted older forms of crating like the wooden box and the wooden barrel, as it works well with modern packaging like corrugated boxes and intermodal containers commonly used for bulk shipping. In addition, pallet collars can be used to support and protect items shipped and stored on pallets.

While most pallets are wooden, pallets can also be made of plastic, metal, paper, and recycled materials.”

Source from [Wikipedia](#)





Green Pallet For Green Packaging

An Environment Friendly and Sustainable Logistics Support For You



Tel: 62697890 (18 lines)

Website: www.lht.com.sg

MANDATE ON HEAT-TREATED PALLET

Regulation of wood packaging material in international trade

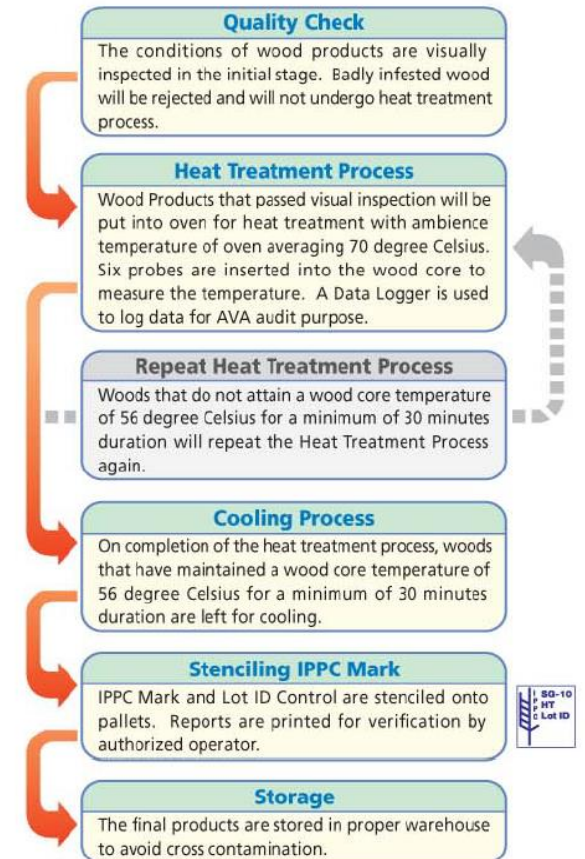
International Standards For Phytosanitary Measures No. 15 (ISPM 15) is an International Phytosanitary Measure developed by the International Plant Protection Convention (IPPC) that directly addresses the need to treat wood materials of a thickness greater than 6mm, used to ship products between countries. Its main purpose is to prevent the international transport and spread of disease and insects that could negatively affect plants or ecosystems. ISPM 15 affects all wood packaging material (pallets, crates, dunnages, etc.) and requires that they be debarked and then heat treated or fumigated with methyl bromide, and stamped or branded with a mark of compliance. This mark of compliance is colloquially known as the "wheat stamp". Products exempt from the ISPM 15 are made from an alternative material, like paper, plastic or wood panel products (i.e. OSB, hardboard, and plywood).

https://en.wikipedia.org/wiki/ISPM_15

LHT Heat Treatment
Process Flowchart

Process Flowchart

Wood Packaging Materials that require heat treatment include Wooden Pallets, Wooden Boxes, Wood Dunnages and Support Wood etc.



EXEMPTIONS FROM ISPM 15

Not all packaging material must be treated to qualify to be used as shipping or packaging material. Here is a list of materials which are not required to be treated and are exempt from ISPM 15 laws and regulations.

- Plastic Pallets - these are most often made from either polypropylene or polyethylene plastic resin.
- Corrugated Pallets (paper pallet) - these are produced using wood pulp, glue and high heat.
- Presswood Pallets - these are made under high temperature and pressure using glue and solely (recovered) wood chips or sawdust.
- Composite wooden pallet blocks - these are made under high temperature and pressure using glue and solely (recovered) wood chips.
- Plywood or Processed Wood - wood packaging made of processed wood material. These include particle board, veneer that has been created using glue, heat or pressure.



Source : https://en.wikipedia.org/wiki/ISPM_15



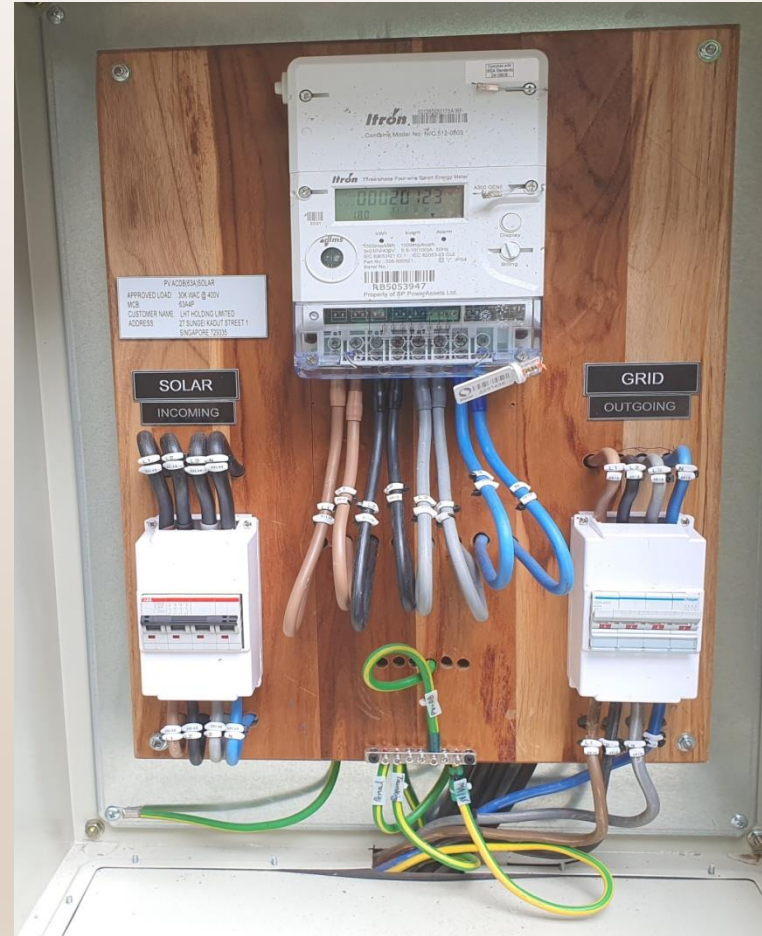
GREEN ENERGY FOR HEAT TREATED PALLET

February 2022, LHT collaborated with NUS on Solar PV System to be installed on the roof top of heat treatment room.



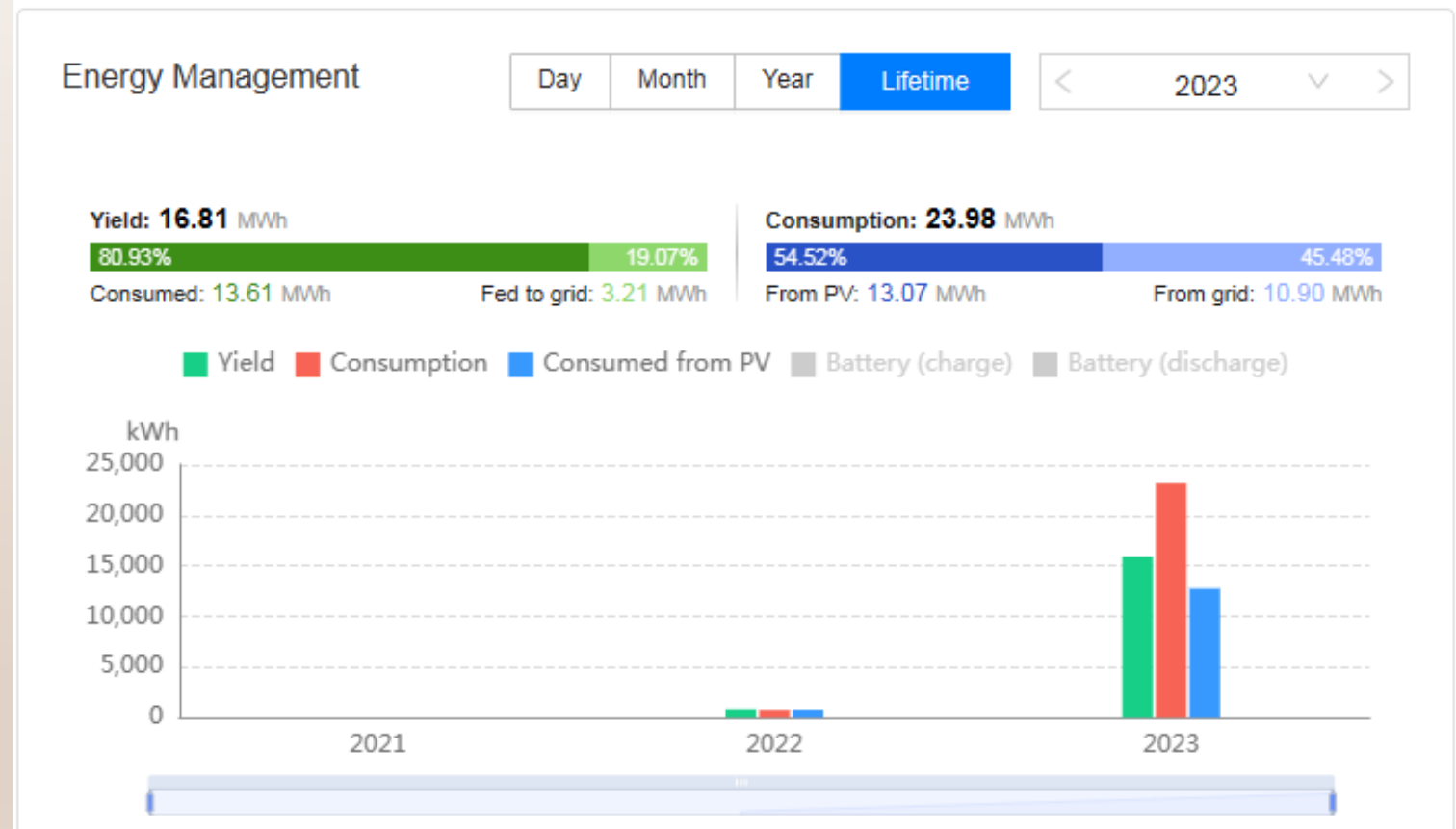
GREEN ENERGY FOR HEAT TREATED PALLET

PV Solar System Layout

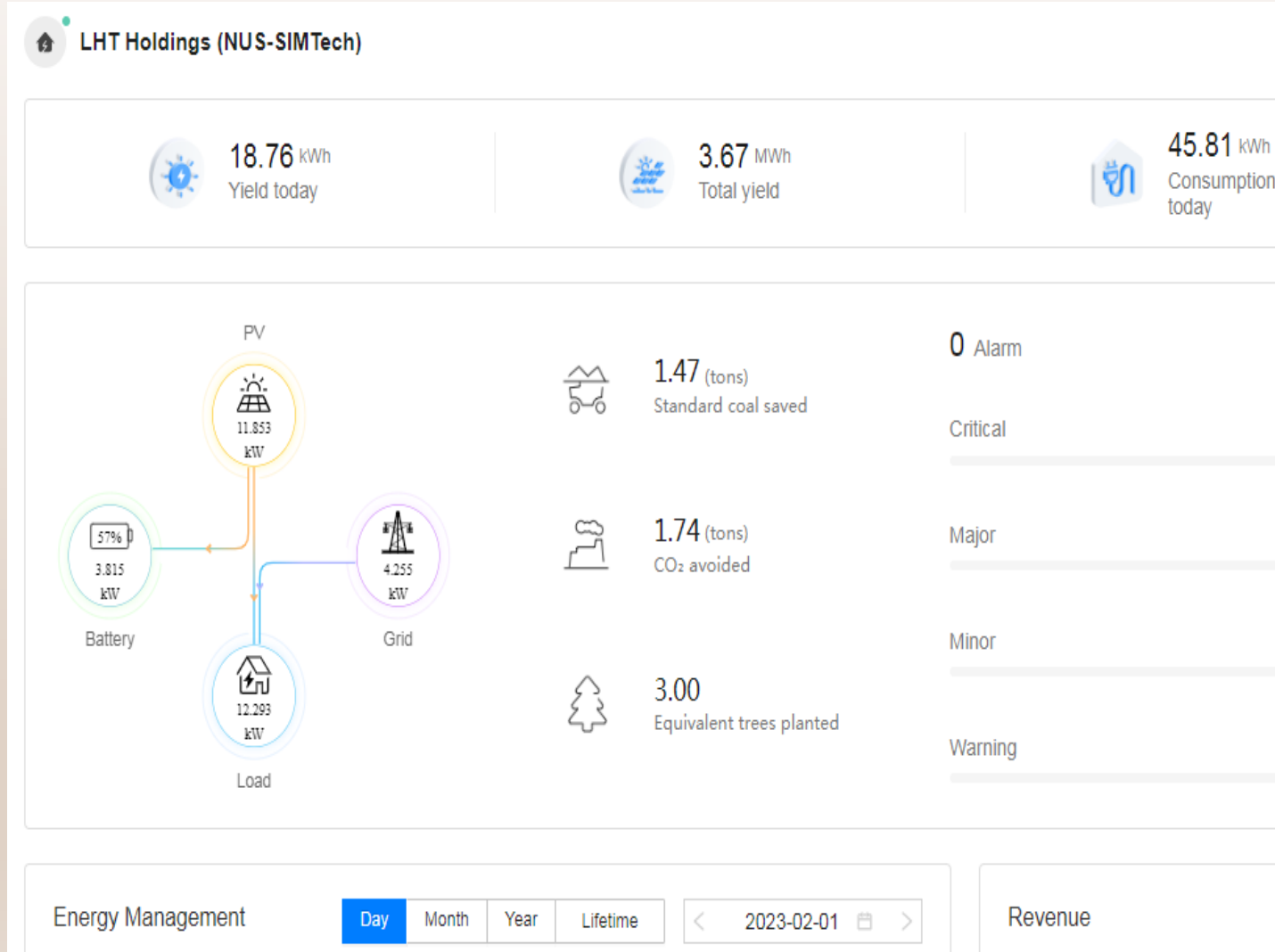


GREEN ENERGY FOR HEAT TREATED PALLET

- Develop dynamic resource planning algorithm for LHT recycling production and waste collection site
- Use solar energy to drive the kiln drying room for pallets' heat treatment



GREEN ENERGY FOR HEAT TREATED PALLET



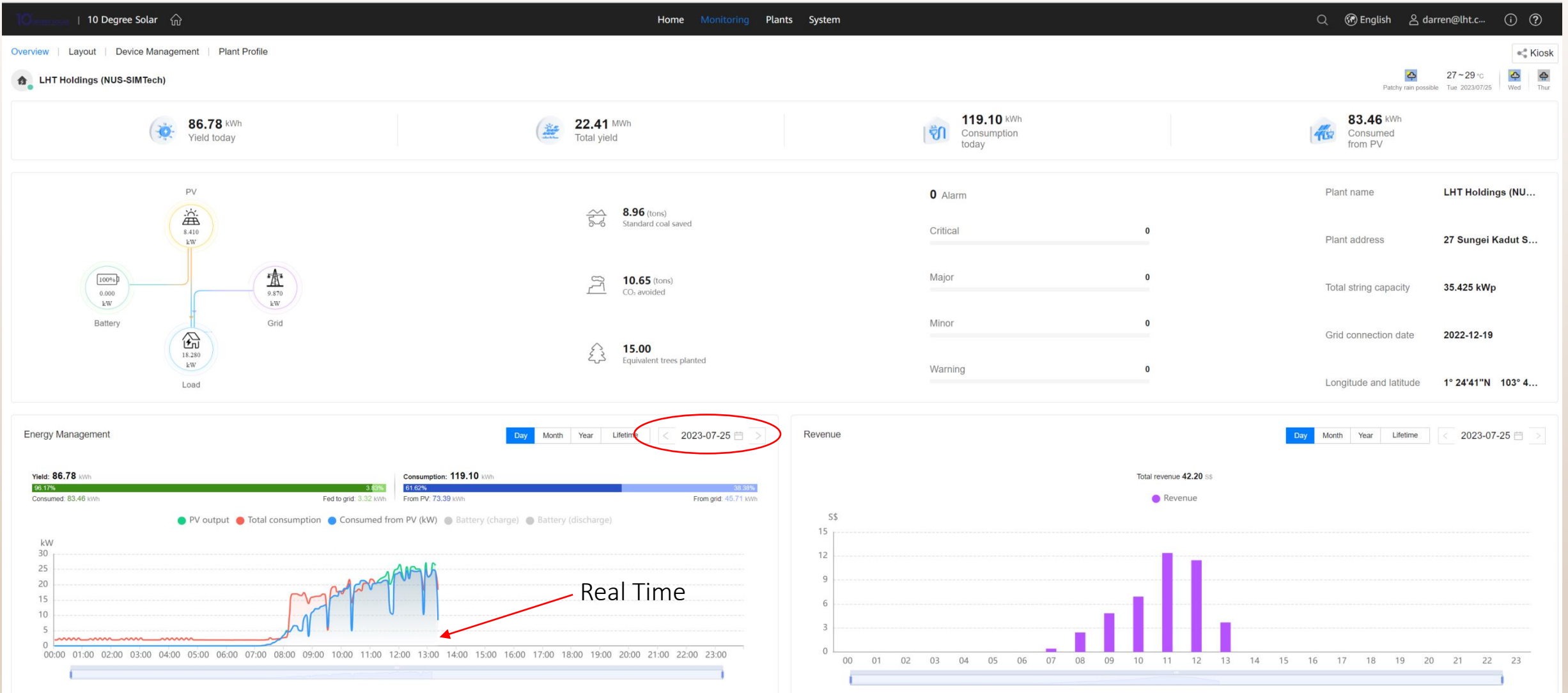
Electricity costs (S\$)	Electricity rate/KWH	
Cost – previous rate (until 31 May 2022)	S\$	\$0.1104
Cost – current rate (wef 01 June 2022)	S\$	\$0.3259

Total Solar Energy 3.67 MWH x 0.3259
 Revenue = \$1196 from Dec22 to Jan 23

*screen shot on 01-Jan-2023



ONLINE ENERGY MANAGEMENT MONITORING



LHT's Sustainability Journey Partnering with A*STAR

S/N	Project title	Scope	Duration
1	RFID enabled pallet leasing and tracking system (PLTS)	Design and develop pallet leasing and tracking system based on selected Gen 2 RFID readers and pallet tags with EPCIS capability	Nov 2008 – Apr 2010
2	Event-Driven Business Process Management (EDBPM) system for pallet manufacturing operations	Reengineer pallet manufacturing processes, design and develop end-to-end business process management system to eliminate paper-based transactions	Sep 2011 – Dec 2012
3	Carbon Management Programme for LHT Holdings Ltd	Comparative life cycle assessment analysis for natural wood pallet and IPPC pallet	Sep 2011 – Dec 2012
4	Development of a Pallets and Crate (PnC) design system for Productivity and Sustainability	Design and develop a 3D Pallet and Crate design system based on SolidWorks with product knowledge capturing and reuse modules.	Jan 2014 – Jan 2016
5	Raw material management system and business activity monitoring tools	Design and develop raw material management system based on pallet design, develop business intelligence report for LHT management	Mar 2014 – Apr 2015

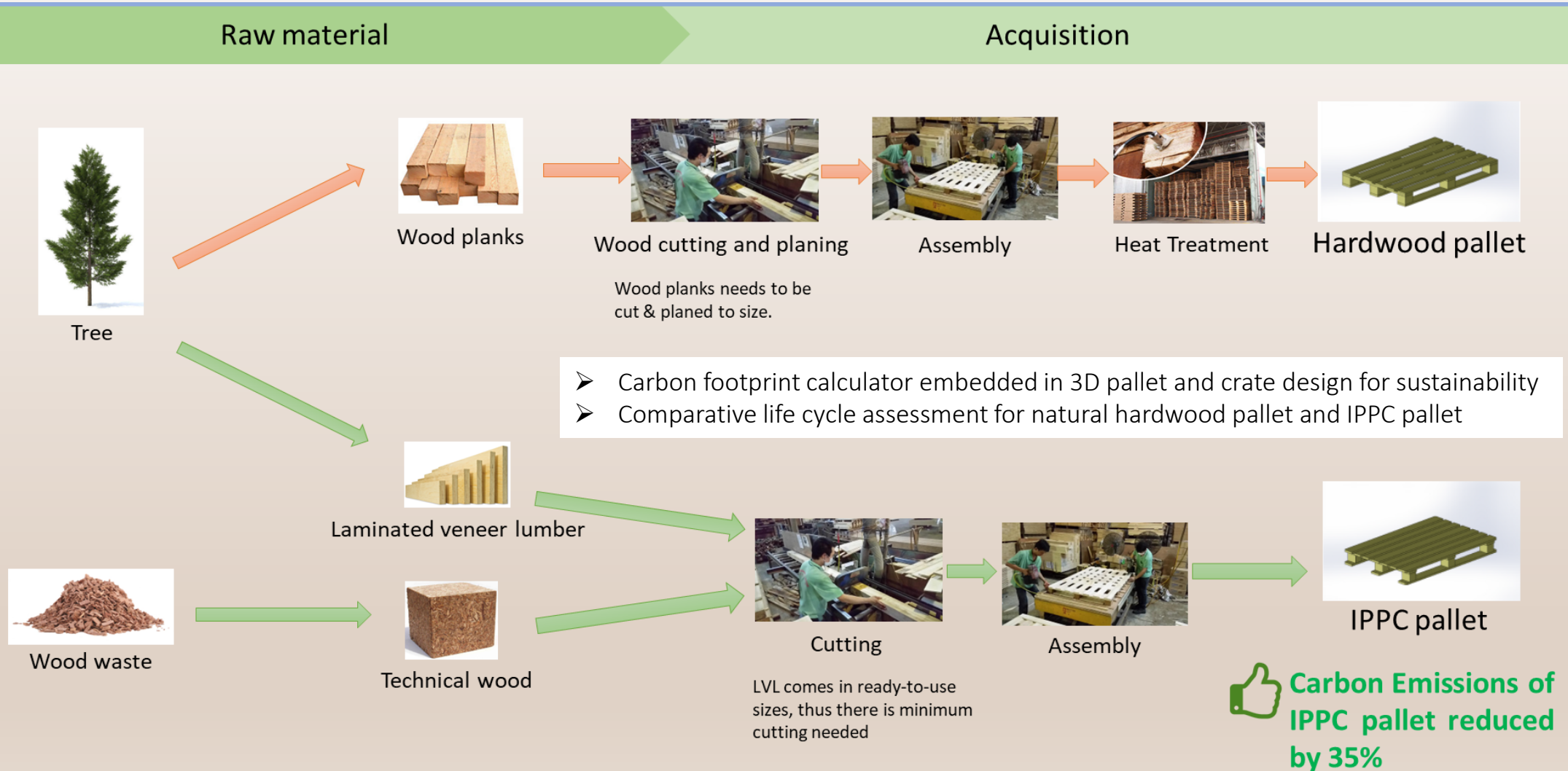


LHT's Sustainability Journey Partnering with A*STAR

S/N	Project title	Scope	Duration
6	Development of Wood fibre Plastic Composites (WPC) for packing applications	Develop Wood fibre Recycled Plastic Composite (WPC) and manufacturing process for forming pallet components.	Dec 2016 – Jul 2018
7	Energy efficiency monitoring and analysis (E2MAS) in manufacturing shop floor (pilot testing site)	Test piloted E2MAS to assess LHT's equipment's energy efficiency in real-time and identify hot spots of excessive energy usage	Apr 2016 – Sep 2017
8	Development of a Sustainable and Smart Production Management System for Automated Pallet Assembly Lines in LHT	Enhance LHT pallet manufacturing operations by connecting shop floor to enterprise system and supply chain, improving shop floor visibility and implementing energy efficiency practices	Sep 2017 – Oct 2019
9	Integrated Dynamic Resource Planning System (IAF-PP)	LHT is the industry collaborator for test bedding of solution from CPPS WP2.5 Dynamic Resource Planning	Apr 2020 – Dec 2022
10	Development of Sustainable and Smart Factory Solutions Enabled by AI and Robotic Pallet Assembly Line in LHT ENVIROHUB	Develop and deploy sustainable and smart factory solutions in LHT manufacturing premise, implementing resource efficiency practices	Sep 2021 – Oct 2025



PALLETS AND CRATE DESIGN SYSTEM FOR PRODUCTIVITY AND SUSTAINABILITY (2014)



DEVELOPMENT OF A SUSTAINABLE AND SMART PRODUCTION MANAGEMENT SYSTEM FOR AUTOMATED PALLET ASSEMBLY LINES IN LHT (2019)



- Automated raw material loading for pallet assembly line for resource optimization
- Compressed air system (CAS) assessment and suggest energy conservation measures
- Production environment monitoring and control

CAS Energy Conservation

Energy Conservation Measures Calculation

<input type="checkbox"/>	Measures	Current Situation	Annual Energy Wastage(kwh)	Potential Energy Savings(kwh)	Potential Dollar Savings(\$\$)
<input checked="" type="checkbox"/>	Reduce Air Leaks	37.79% leakage	58,658.83	27,612.41	5,798.61
<input checked="" type="checkbox"/>	Reduce System Air Pressure	1 bar higher than demand	4,720.63	4,720.63	991.33
<input checked="" type="checkbox"/>	Add Storage Volume / Pressure-Flow Control	Receiver not Enough	7,761.61	7,761.61	1,629.94
<input type="checkbox"/>	Use Load / Unload Control	No Control	13,272.13	13,272.13	2,787.15
Summary		need to take action	84,413.20	53,366.77	11,207.02
			Annual Energy Consumption(kwh): 155,232.13	Annual Energy Bill(\$\$): 32,598.75	

Source: SIMTech project report 2019



INNOVATIVE PROCESSED PRODUCT CONVERSION SERIES

LHT innovative processed product conversion (IPPC) used 50% to 100% technical woods / block as components, which are made from its waste wood recycling plant that produce the “*World First Pest Free*” pallet. The Pest-Free pallets have lower carbon footprint and exempted for heat treatment process, hassle free entry to all countries’ quarantine that enforcing ISPM 15 implementation.



PEST FREE
PALLET



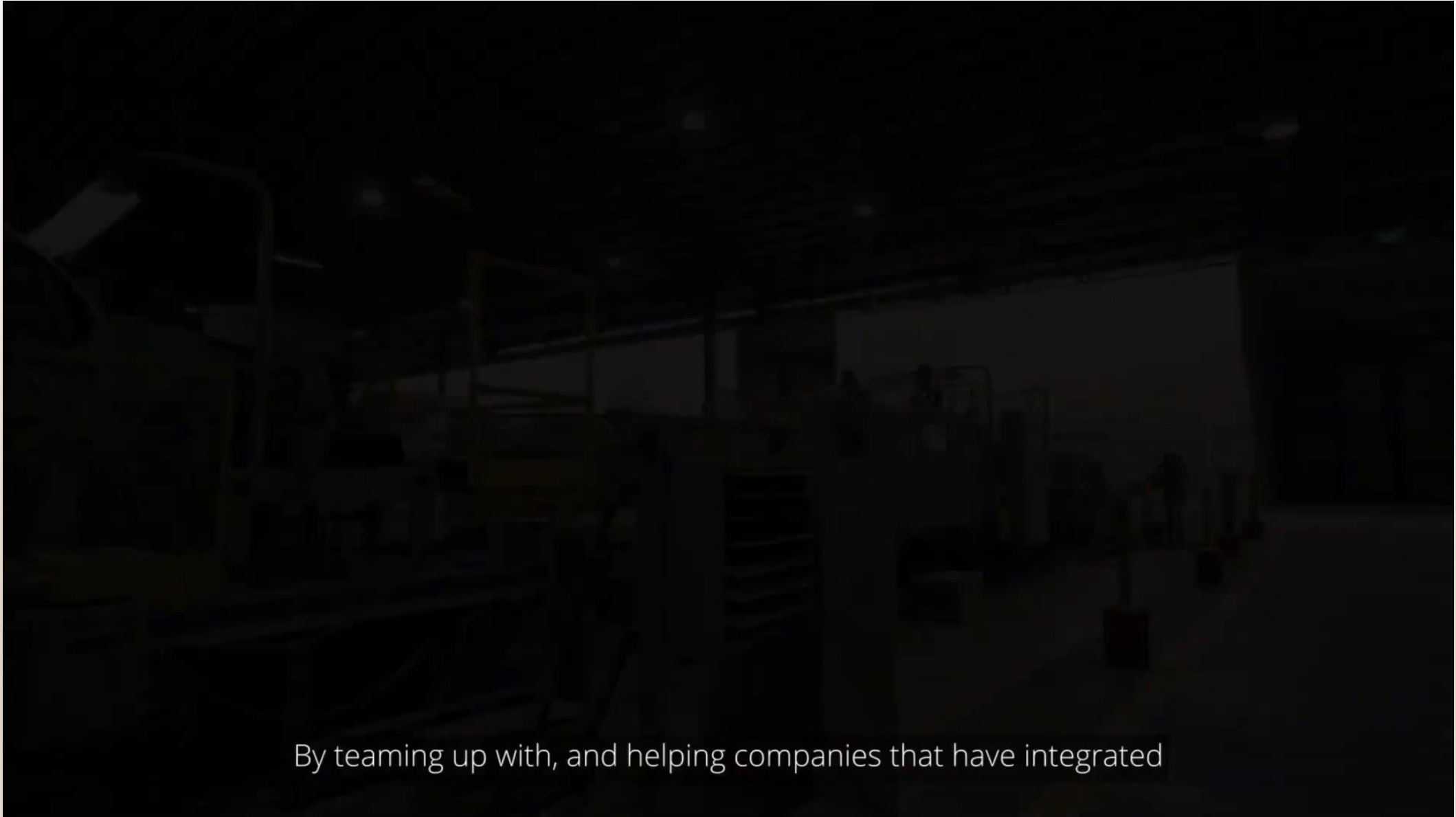
035 001
Made From
Recycled Materials



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LHT LHT Holdings Limited
green pallet for green packaging

TOWARDS NET ZERO MANUFACTURING (1 MINUTE)



By teaming up with, and helping companies that have integrated



MOVING TOWARDS GREEN PALLET FOR GREEN PACKAGING

*Sustainability is everybody journey mitigating
Global Warming in Climate Change*

- global warming
- climate change
- extreme weather
- melting glacier
- sea levels rising

Source: Image from the internet



Helping SMEs Win at Sustainability

Mr Allan Lim
Founder
Alpha Biofuels



Alpha Biodiesel

Sustainable Fuels From Waste Cooking Oil

About Alpha Biofuels Pte Ltd

Established in 2008

- Only biodiesel company manufacturing and supplying Biodiesel in Singapore
- All feedstock are made from waste cooking oil

Sectors at we serve

- Land Transport
- Marine Biodiesel
- Marine application

Our biodiesel is manufactured to EN14214 standard

- Compliance for use with all Euro engine (including Euro 6)

Certified sustainable by ISCC.EU- since 2017

Currently the only locally made biodiesel provider in Singapore



energy from waste

Our Humble Beginning



<https://www.youtube.com/watch?v=3gHgLBzfS6E>

<https://www.youtube.com/watch?v=jlv9fXdv-vo>

<https://www.youtube.com/watch?v=i2iKPCoiKxU>



ALPHA BioDiesel will soon allow

by the hotel's shuttle bus and fuel

who wishes to convert waste cooking

biofuel's work in some of its jobs,

Alpha Biodiesel in Marine Bunker



16/04/2021, 21:07

Big bulk carrier sails from Singapore to South Africa on fuel partly converted from used cooking oil | The Straits Times

THE STRAITS TIMES

Big bulk carrier sails from Singapore to South Africa on fuel partly converted from used cooking oil



Alpha Biofuels supplies biodiesel, converted from cooking oil collected from food manufacturers, food and beverage businesses and households around the island, to the Singapore-registered bunkering vessel *Merlin Tiga*, before it goes to the receiving vessel *Frontier Jacaranda*. PHOTO: ALPHA BIOFUELS



Chemical View

PUBLISHED 9 JUL 2021, 5:57 PM SGT

SINGAPORE - A bulk carrier has successfully sailed from Singapore to South Africa while using biodiesel converted from used cooking oil.

This reduced the vessel's carbon dioxide emissions by 5 per cent, raising the prospect of such alternative fuels powering large ships.

The *Frontier Jacaranda* - a vessel that is too large to transit through the Suez or Panama canals - made the journey with a mix of 7 per cent biofuel and 93 per cent regular fuel.

Alpha Biofuels, a Singapore company, blended the biofuel at their plant in Tuas, converting it from cooking oil collected from food manufacturers, food and beverage businesses and households around the island.

The successful first-of-its-kind trial paves the way for the use of higher percentage blends in future trials, which could further reduce the carbon output of a voyage.

Alpha Biofuels on Friday (July 9) noted the significance of the maiden trial carried out in Singapore, the world's largest maritime fuel market.

A company statement said: "The operation was instrumental in verifying the stability of the biofuel in storage and its performance as a fuel."

Alpha Biodiesel in Formula ONE



THE STRAITS TIMES

More green initiatives at Singapore Grand Prix to reduce carbon footprint of F1 race



The Formula One Singapore Airlines Singapore Grand Prix returns to the Marina Bay circuit from Sept 30 to Oct 2, 2022. © PHOTO: AGGREGO/ALC



Wallace Wong

UPDATED: 28 SEPTEMBER 2022, 11:39 AM SGT

SINGAPORE - When the [Formula One Singapore Airlines Singapore Grand Prix](#) returns to the Marina Bay circuit from Sept 30 to Oct 2, the pit building will be fully powered by carbon-neutral sources of energy.

Besides the pit building, the grandstands, most of the hospitality suites, as well as the food and beverage and activity areas in Zone 1 on the circuit will be powered by clean energy through the purchase of renewable energy certificates.

The certificates, from power companies Geneco and Flo Energy, represent units of electricity generated from renewable energy generation facilities.

This is just one of a series of initiatives introduced this year to reduce the carbon footprint of the race.

On the other side of the circuit at Zone 4, where the Padang is located, 48 per cent of the sector will be powered by generators using B7 biodiesel provided by local fuel distributor PS Energy Group.

B7 biodiesel is a mix of regular diesel and up to 7 per cent of bio-based diesel, which is made from plant or animal sources.

What is Biodiesel?

- Biodiesel is a renewable, biodegradable fuel manufactured domestically from vegetable oils, animal fats, or recycled restaurant grease. It is a cleaner-burning replacement for petroleum diesel fuel.
- Biodiesel, which is most often used as a blend with regular diesel fuel, can be used in many diesel vehicles without any engine modification.
- Biodiesel improves fuel lubricity and raises the cetane number of the fuel. One advantage of biodiesel is that it can impart satisfactory lubricity to diesel fuels at blend levels as low as 1%.
- Biodiesel made from waste cooking oil is better than biodiesel from palm oil because it reduces waste and greenhouse gas emissions, while palm oil production may cause deforestation and habitat destruction.

Source : U.S Department of Energy – Alternative Energy Data Center

<http://www.afdc.energy.gov/vehicles/diesel.html>



ALPHA
biofuels

energy from waste

Cooking Oil to Biodiesel

Alpha Biofuels is the **first and only** biodiesel company in Singapore that recycles waste cooking oil into biodiesel - currently, we even have the fastest biodiesel system in the world!

Our work relies on a key technological breakthrough - our proprietary Alpha BX technology.

STEP 1

The process begins with a feedstock of waste vegetable oil, animal fats, or non food-base oils.



STEP 3

At the **trans-esterification** phase, a proprietary EDM pulse causes the reaction of biodiesel in a continuous flow, reducing reaction time by 20x and ensuring a high yield of 80% feedstock by volume.

Catalyst added

STEP 2

At the **pre-treatment** phase, the feedstock is de-watered, solids and separated out, and levels of free fatty acids (FFA) are reduced.

STEP 4

At the **glycerin separation** phase, a proprietary membrane technology is used to quickly remove glycerin from the biodiesel mix.

GLYCERIN

STEP 5

At the **methanol removal** phase, methanol is recovered from the biodiesel mix and re-used in the previous trans-esterification phase.

METHANOL

END

Throughout the biodiesel production process, Alpha BX technology has been carefully calibrated to reduce water consumption, energy cost, and reaction time - **reducing the environmental costs** of fuel production.

Our end product is a truly green product, fuelled by **truly green technology**.

STEP 6

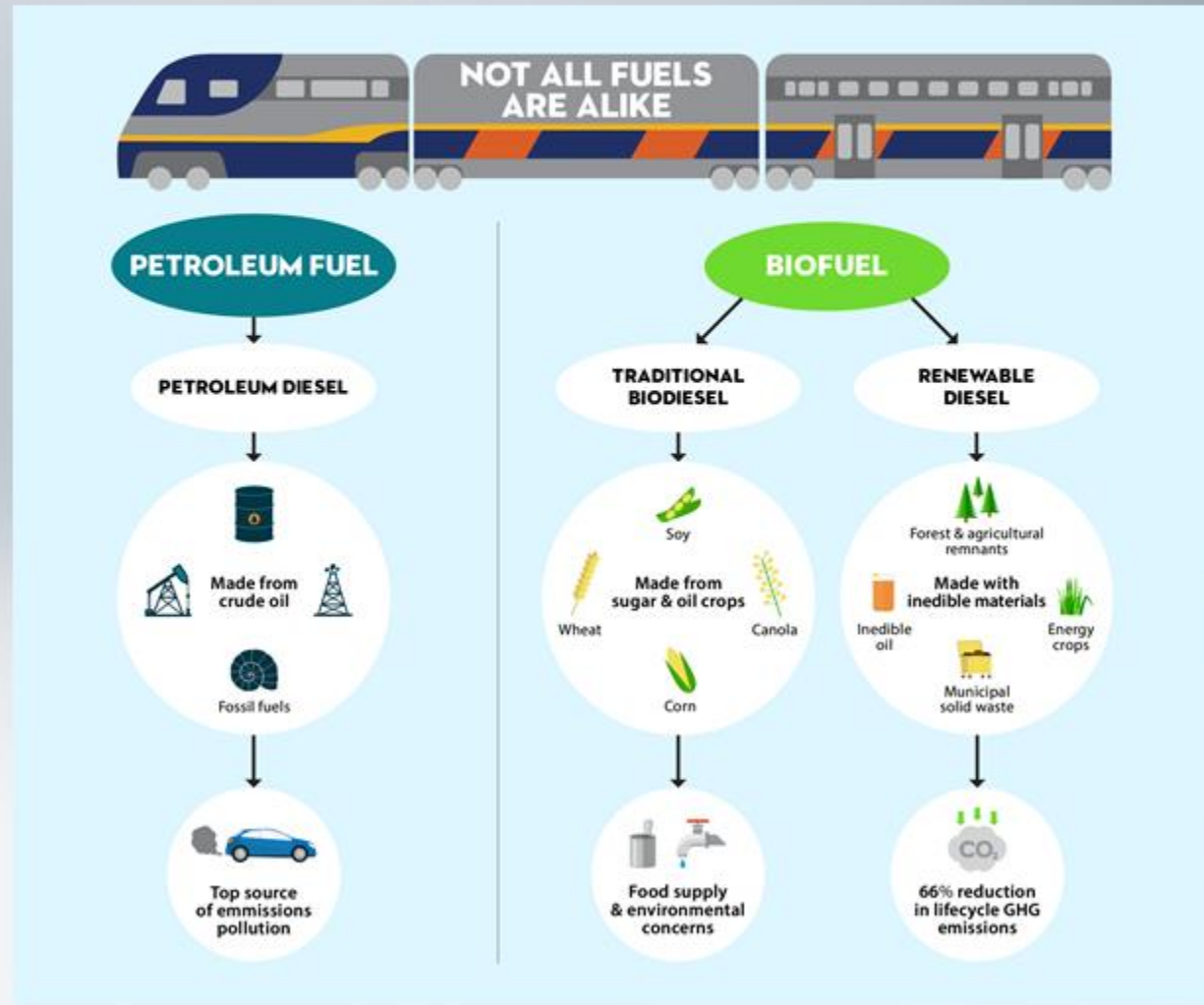
At the **biodiesel purification** phase, the biodiesel is carefully cleansed of impurities to ensure maximum performance and smooth engine function.

BIODIESEL



Life Cycle Emission of Biodiesel

- Lifecycle greenhouse emissions refer to the total amount of greenhouse gases emitted during the production, use, and disposal of a product or service.



Life Cycle Emission of Different Type of Diesel/Biodiesel



Fuel Type	Life Cycle GHG Emissions (g CO ₂ e/MJ)
UCOME (Used Cooking Oil Biodiesel)	27.3
PME (Palm Oil Biodiesel)	62.0
Fossil Diesel	94.6

Note: UCOME refers to Used Cooking Oil Methyl Ester and PME refers to Palm Oil Methyl Ester.

These values are approximate and may vary depending on various factors such as feedstock sources, production methods, and transportation.

Biodiesel Quality



- Biodiesel is tested to En14214 standard
- Blend with EN950 compliant fossil diesel from B1 to B99 (B1 = Biodiesel 1%, Fossil Diesel = 99%)
- All sustainable biofuels must comply with ISCC.EU in order to be considered for carbon offset
- <https://www.iscc-system.org/certificates/all-certificates/>



Tailpipe emissions test of engine using Alpha Biodiesel

Tailpipe emissions (kg/km)	Diesel	Biodiesel	Percentage (%) change
SO ₂	1.90E-04	3.22E-05	-83.02
NO _x	1.98E-03	2.04E-03	3.02
CO ₂	5.61E-01	5.77E-01	2.94
CO	2.99E-03	2.38E-03	-20.36
Total PM _{2.5} and PM ₁₀	2.04E-04	1.06E-05	-94.80
NMVOC	1.60E-03	7.53E-04	-52.93
CH ₄	7.90E-04	7.86E-04	-0.52



Singapore Institute
of Manufacturing
Technology

SIMTech



energy from waste

Net life cycle emission of Alpha Biodiesel

Net life cycle emissions (kg/km)	Diesel	Biodiesel	Percentage change
Net life cycle SO ₂	5.01E-01	3.43E-05	-99.99
Net life cycle NO _x	7.99E-02	1.64E-03	-97.95
Net life cycle N ₂ O	9.02E-06	3.53E-07	-96.08
Net life cycle fossil fuel CO ₂	9.41E-01	4.31E-02	-95.42
Net life cycle CO	2.02E-02	1.91E-03	-90.54
Total PM _{2.5} and PM ₁₀	1.42E-01	1.35E-05	-99.99
Net life cycle NMVOC	7.23E-03	6.13E-04	-91.52
Net life cycle CH ₄	4.28E-03	7.58E-04	-82.28



Singapore Institute
of Manufacturing
Technology

SIMTech



ALPHA
Biofuels

energy from waste

Key Challenges in Biodiesel for Business



- Carbon is a burden
 - Sustainability transformation is not the same as digital transformation
 - Longer and Bigger investment is necessary without surety of uplift in business
 - No clear winner or business model to follow
 - Some changes are highly disruption and operationally difficult

Helping Business Win with Sustainability



- CASE Study : (Bollare – Richland Logistics)
 - FMCG company wishes to decarbonize a part of the logistic route as the product transship via Singapore Ports
 - NETT Life Cycle CO2 needs to be presented and attributable to all products carried under this initiative
 - Product haulage is once every 2-3 days using trucks



Helping Business Win with Sustainability



- CASE Study : (Bollare – Richland Logistics)
- Solution
 - Identify Key requirements and objectives of decarbonization (modality, accounting and accreditation)
 - Calculate the LC GHG for each modality
 - COST Vs GHG Reduction



Using Alpha Biodiesel to reduce GHG emissions

Alpha CO2 eq calculations for biodiesel blend

Source : ISCC 2017 default values

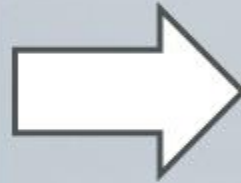
UCOME (Biodiesel made from waste cooking oil)

Specific emission = 14 g CO2 eq / MJ

% Abatement GHG = 83%

Diesel GHG = 82.3 g CO2 eq / MJ

Therefore 1 mj of UCOME will abate 83% of 82.3G CO2eq of GHG
= 68.309 gCO2eq per 1 mj of diesel replaced by biodiesel.



Therefore for 1 liter of B20

20% of diesel is replaced by B100 UCOME

For every litre

UCOME content. = 0.2 litres

Energy capacity of UCOME = 35mj/l

Total MJ replaced = 35 X 0.2 = 7Mj

Total GHG abated = 7 X 68.309g CO2 eq
= 478.163 g CO2 eq per liter of b20 used

*Actual figures for Alpha Biofuels in Accordance to ISCC audits 2022

Helping Business Win with Sustainability



- CASE Study : (Bollare – Richland Logistics)
 - Implementation
 - Low Dose Steady State
 - Cost Efficient Operating model that minimizes down time
 - Tracking and Traceability



ISCC.EU Proof of Sustainability



Proof of Sustainability (PoS) for Biofuels and Bioliquids		V4.8
<p>For biofuels and bioliquids according to the Renewable Energy Directive (RED) and the Fuel Quality Directive (FQD), both amended through Directive (EU) 2015/1513</p>		
<p>Unique Number of Sustainability Declaration: EU-ISCC_CERT-PL214-35780921</p> <p>Date of dispatch: 30-Sep-22</p> <p>Place of dispatch: Singapore</p> <p><input type="checkbox"/> Same as address of supplier</p> <p>Date of Issuance: 30-Sep-22</p>		<p>www.iscc-system.org</p>
Supplier	Recipient	
<p>Name: Alpha Biofuels (S) Pte Ltd</p> <p>Address: 2 Tuas South Ave 2, #02-28, 6637601</p> <p>Certification System: ISCC EU</p> <p>Certificate Number: EU-ISCC_CERT-PL214-35780921</p>	<p>Name: Singapore GP Pte Ltd</p> <p>Address: 50 Cuscaden Road, #02-02 HPL House Singapore 249724</p> <p>Contract Number:</p>	
1. General information		
Type of Product:	Biodiesel	
Type of Raw Material:	Used cooking oil (UCO) entirely of veg. Origin	
Additional Information (voluntary):	Invoice 2648 (3000 Liters)	
Country of Origin (of the raw material):	Singapore	
Quantity:	2.580 mt <input type="checkbox"/> m ³ <input checked="" type="checkbox"/> metric tons	
Energy content (MJ):	95,460 MJ	
2. Sustainability criteria of the biomass according to Article 17 RED:		
The raw material complies with the sustainability criteria according to Art. 17 (3), (4) and (5) RED ¹ <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		
The raw material meets the definition of waste or residue according to the RED, i.e. it was not intentionally produced and not intentionally modified, or contaminated, or discarded, to meet the definition of waste or residue ² <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		
3. Greenhouse Gas (GHG) information		
Total default value according to RED applied <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		
E = Total GHG emissions from supply and use of the fuel (gCO ₂ eq/MJ) 14 gCO ₂ eq/MJ		
<p>GHG emission saving³:</p> <p>83.3% (for biofuels 83.8 gCO₂eq/MJ) 81.8% (for heat production 77 gCO₂eq/MJ)</p> <p>84.8% (for electricity production 91 gCO₂eq/MJ) 83.6% (for cogeneration 85 gCO₂eq/MJ)</p>		
If the GHG emission savings are below 60%:		
The installation where the final biofuel or bioliquid was produced started physical production of biofuels or bioliquids after 5 October 2015 <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		
Voluntary: Date when the final biofuel producer started operation ⁴ 2011		
<p>This form is valid without signature. By issuing this PoS, the Issuing Party guarantees that all information made on this Proof of Sustainability are correct, in compliance with the requirements of ISCC and the RED, and that the biofuel or bioliquid has not already been used to fulfil a national quota obligation.</p>		

Proof of the origins and the traceability of the feedstock

Declare by the certificate holder

Audited annually

Developing Sustainable Industry Spaces for Singapore

Mr Kevin Emanuel Suhartono
Senior Engineer
JTC





Developing Sustainable Industry Spaces for Singapore



Kevin Emanuel Suhartono

Senior Engineer, Sustainability Department, Future of Building and Infrastructure Division

Innovation & Technology Conference 2023

27 July 2023



Introduction to JTC

Master planner, developer, and a valuable partner.

A government agency under the Ministry of Trade and Industry, JTC was founded in 1968 to grow Singapore's manufacturing landscape and support the nation's economic goals.

We build industries and develop clean, green, and smart estates so that Singapore stays innovative, dynamic, and sensitive to global manufacturing trends.

We also foster vibrant ecosystems, bringing businesses and communities together in an environment that nurtures ideas shaping the future.



JTC through the years.

Since the 1970s, our efforts cut across the entire building & infrastructure value chain, from planning & design, to construction and to operations & maintenance.



Our transformation journey over the years

JTC at a glance.

88%

of Singapore's
industrial land owned
by JTC

7,000 ha

of industrial land
developed

**5.32
million
sqm**

of allocated
ready-built facilities

13,000

customers across
various sectors

The choice of Fortune Global 500 companies



Figures are as of June 2021

We wear many hats.

JTC is more than just an industrial landlord. In fact, we play several key roles to catalyse the growth of new industries and transform existing enterprises:



Advocate for manufacturing

We develop infrastructure to support the growth of advanced manufacturing and work with companies to encourage Industry 4.0 transformation.



Receptacle for innovation

Our estates are testbeds where new prototypes or game-changing solutions can be trialed and scaled. To accelerate digitalisation in the Built Environment sector, we are early adopters of technology.



Leader for sustainability

Going green is a collective effort. We work with our partners to roll out initiatives that move the needle on sustainability.



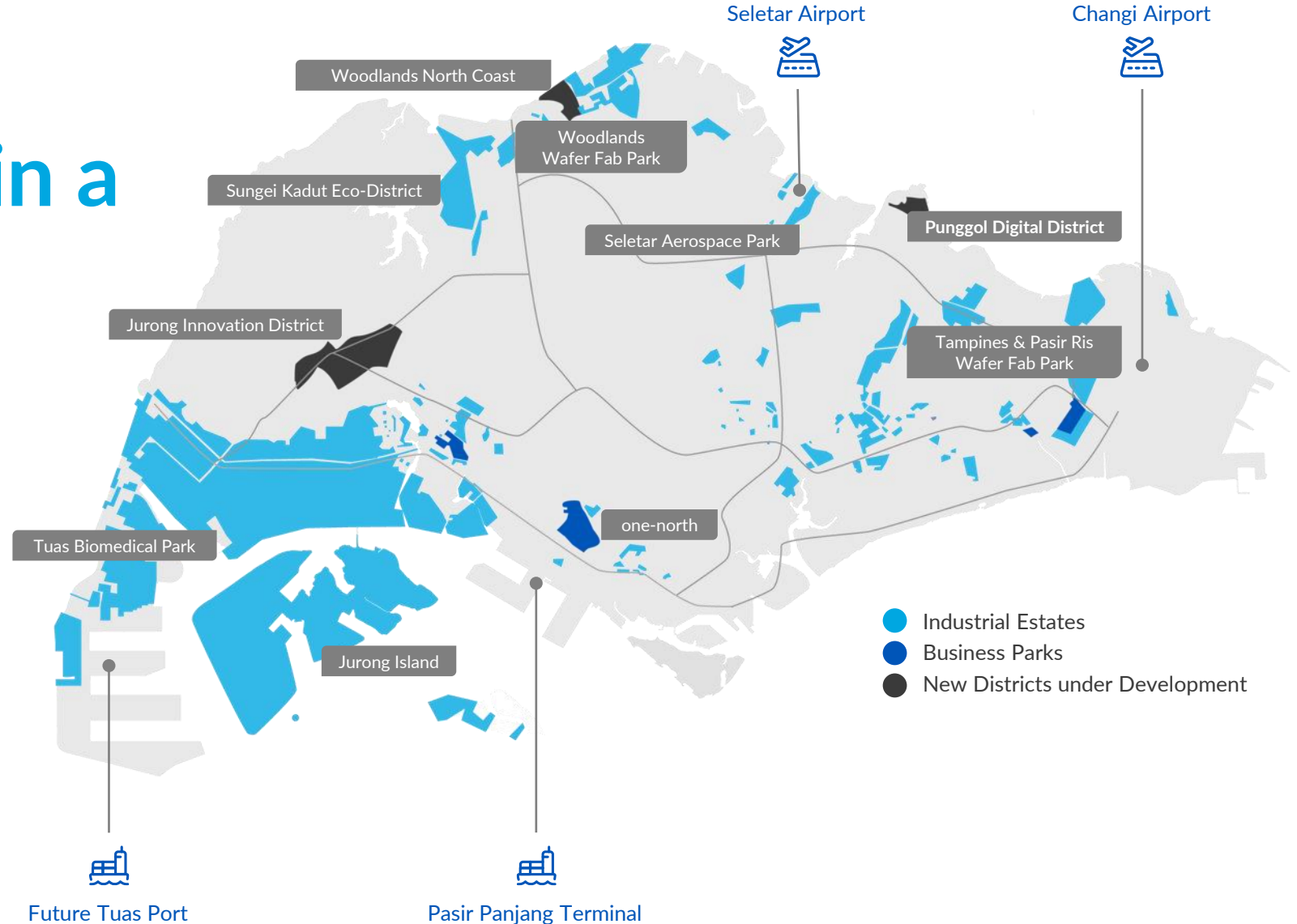
Matchmaker for talent

We facilitate industry-academia collaborations and organise industry days to nurture tomorrow's talent.

We drive the progress of manufacturing in a city-state.

From industrial estates to business parks, our vast network of developments form the backbone of Singapore's thriving manufacturing landscape.

Situated along strategic belts across the island, they are also near key transport nodes, offering connectivity to the rest of Singapore and beyond.



Ideate, innovate, create — re-thinking industrial estates.

Our extensive suite of properties is designed with ever-evolving market demands in mind.

Small and Medium Enterprises (SMEs) can look forward to having their needs met at spaces built for general industrial trades, while specialised industries are supported with infrastructure that boast high specifications. By clustering companies from a sector together, we aim to nurture ecosystems that facilitate collaborations between like-minded partners.



Transforming the industry is a joint effort – we catalyse partnerships.

From aviation to biopharmaceuticals, electronics to info-comm, Singapore's key industries are housed in conducive environments where they can thrive.

Bringing like minded people together is at the heart of what we do. We identify practical synergies in industries to foster business relationships, spark innovation and create value.

One such example is Jurong Island, a world-class destination for refining & chemical manufacturing. It is also a meeting point where its tenants can uncover synergies between their various operations.



Jurong Island



Sustainability & Innovation in JTC

Singapore Green Plan 2030.



Climate change is a global challenge, and Singapore is taking firm actions to do our part to build a sustainable future.

The Singapore Green Plan 2030 is a national sustainability movement with ambitious and concrete targets, which builds on our existing climate mitigation and adaptation measures.

It is a living plan which will evolve as we work with Singaporeans and partners from all sectors to co-create solutions for sustainability.

Our collective action will make a difference. Let's build a greener and more liveable home together.

1. City in Nature

A Green, Liveable and Sustainable Home for Singaporeans

- ✓ Add 1000ha of green spaces and 160km of park connectors
- ✓ Every household will live within a 10-min walk from a park
- ✓ Plant 1 million more trees across Singapore by 2030

2. Sustainable Living

Strengthen Green Efforts in Schools

- ✓ Work towards two-thirds reduction of net carbon emissions from schools sector by 2030
- ✓ At least 20% of schools to be carbon neutral by 2030

Green Commutes

- ✓ 75% of all trips to be on mass public transport by 2030, up from 64% today
- ✓ Triple cycling path network to 1,320km by 2030 from 460km in 2020

Green Citizenry: Less waste and consumption

- ✓ Reduce amount of waste to landfill per capita per day by 20% by 2026, with the goal of reaching 30% by 2030
- ✓ Encourage water conservation and water efficient practices for households and industries

3. Energy Reset

Cleaner-energy Vehicles

- ✓ Require all newly-registered cars to be of cleaner-energy models from 2030
- ✓ Expand network of electric vehicle charging points to 60,000 by 2030

Sustainable Fuels

- ✓ Promote sustainable fuels for international trade and travel

Greener Infrastructure & Buildings

- ✓ Raise sustainability standards of our buildings through the next edition of the Singapore Green Building Masterplan

Sustainable Towns & Districts

- ✓ HDB Green Towns Programme to reduce energy consumption in HDB towns by 15% by 2030

Green Energy

- ✓ Quadruple solar energy deployment by 2025
- ✓ Green Singapore's electricity supply by tapping on cleaner electricity imports

4. Green Economy

Sustainability as New Engine of Jobs and Growth

- ✓ New Enterprise Sustainability Programme to help local enterprises adopt sustainability practices
- ✓ Develop Singapore as a carbon services hub, and as a leading centre for green finance in Asia and globally
- ✓ Develop Jurong Island to be a sustainable energy and chemicals park

New Investments to be Carbon and Energy Efficient

- ✓ Seek out new investments that are among the best-in-class in carbon/energy efficiency

5. Resilient Future

Safeguarding our Coastlines against Rising Sea Levels

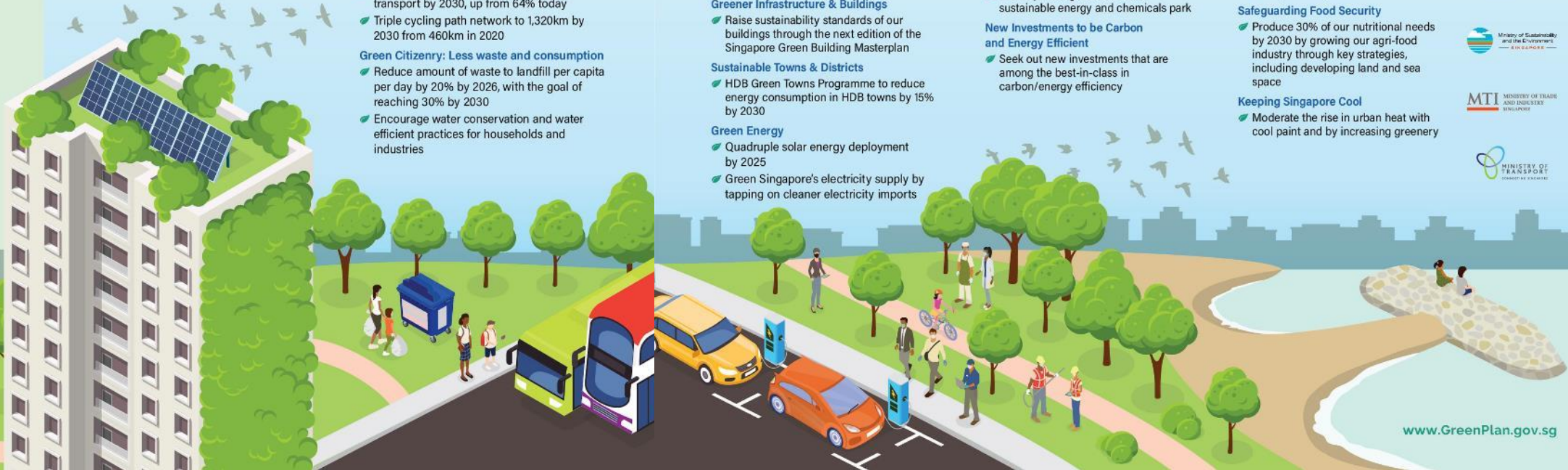
- ✓ S\$5b dedicated to coastal and drainage flood protection measures
- ✓ Complete engineering design & implementation plans for coastal protection measures at East Coast, Lim Chu Kang, Sungei Kadut, & Jurong Island by 2030

Safeguarding Food Security

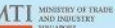
- ✓ Produce 30% of our nutritional needs by 2030 by growing our agri-food industry through key strategies, including developing land and sea space

Keeping Singapore Cool

- ✓ Moderate the rise in urban heat with cool paint and by increasing greenery



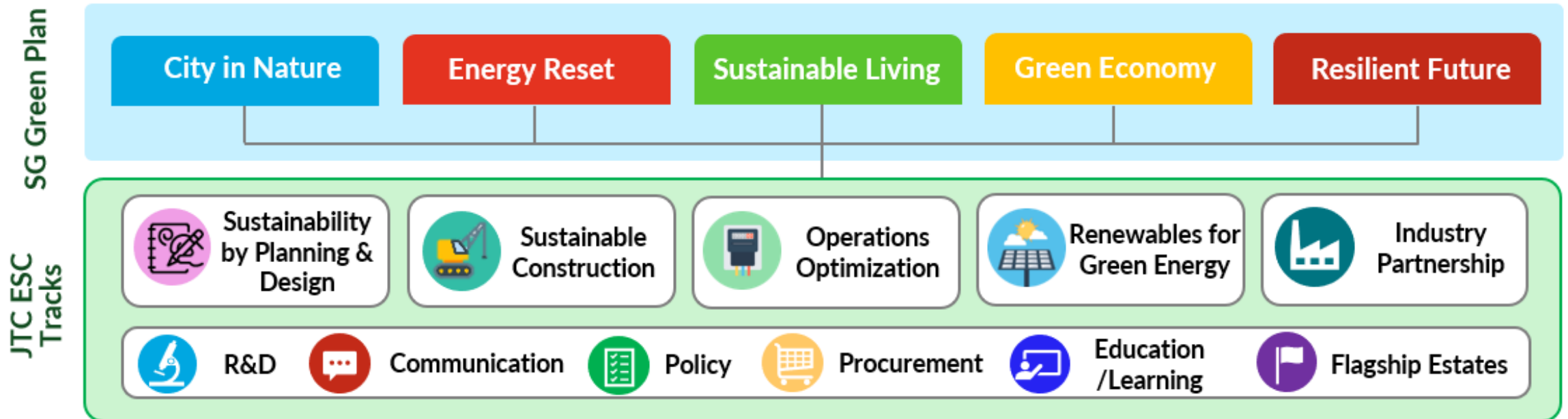
Jointly led by:



www.GreenPlan.gov.sg

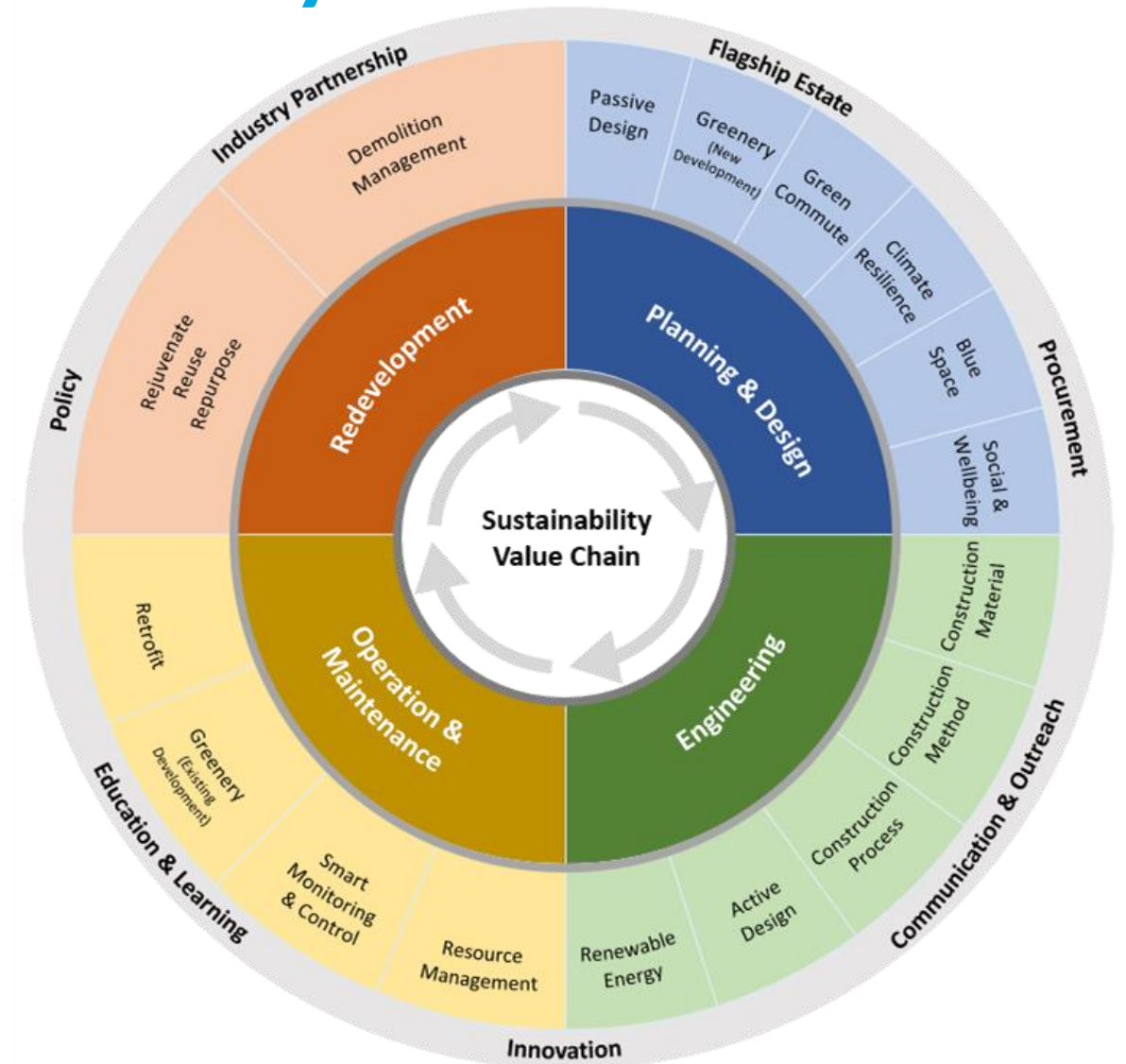
Sustainability at the heart of what we do.

- As a sustainable developer, we strive to adopt environmental sustainability as a core principle, value pillar and strategic differentiator in our industrial estate development and operation and our partnerships with our customers
- Our sustainability efforts cut across the entire building & infrastructure value chain
→ from **planning & design**, to **construction** and to **operations & maintenance**



Our drive towards Sustainability.

- Our sustainability efforts cut across the entire *building & infrastructure value chain*. By taking a **WHOLE-LIFE-CYCLE APPROACH** to sustainability we ensure that this mindset is imbued into the entire spectrum of JTC's work from Planning & Design, Engineering, Operation and Maintenance, to Redevelopment
- JTC's Sustainability Committee (SC) ensures Environmental, Social and Governance (ESG) aspects are calibrated in workstream processes
- This sustainability framework will evolve over time as we roll out more initiatives/projects in future.



Wheel of Sustainability

JTC Green Plan 2030.

Design & Construction

Operations & Maintenance

Customer Engagement



Development Carbon



Operational Carbon



Industry's Carbon



Reduce development carbon of new construction projects compared to their conventional equivalents by 2030



Reduce operational carbon intensity of our buildings by 2030.



Reduce carbon footprint of the industry through customer engagement

Real Estate Life Cycle



Total Carbon



Reduce our organizational carbon footprint by embarking on green initiatives.



Development Carbon

Manufacture, transport and installation of construction materials

Operational Carbon

Building energy consumption

Industry's Carbon

Tenants' and lessees' economic activity

Sustainability in Planning & Design.

Design considerations for climate resilience

Estate

- Through our Urban Design Guidelines (UDG), sustainability is adopted as a key design principle
- One such example is how JTC has incorporated green mobility and car-lite into the planning of our estates.



Woodlands North Coast



Punggol Digital District Campus Boulevard integrate SIT and JTC

JTC wins the Best Car-Lite Advocate Award in the Land Transport Excellence Awards (LTEA) 2022.

Infrastructure

- Our sustainability criteria are enshrined in our Infrastructure Design Requirement (IDR) for a wide spectrum of infrastructure projects
- JTC's work also covers coastal and offshore areas; we actively ensure the preservation of marine biodiversity and ecosystems



Grow-a-Reef Garden Project

(a joint JTC-NParks-Garden City Fund project)

JTC co-developed and built eight ecosystem-enhancing reef structures, which currently house 1,636 coral colonies of various biological classes

Building

- JTC incorporates a green building design approach in our Building Design Requirement (BDR) which includes the use of resource-saving features to improve the sustainability performance of JTC buildings
- We have been certified Eco-office Plus Champion since FY2020



A Certified Eco Office Champion

Flagship Estates carved for Sustainability.

Walking to green talk



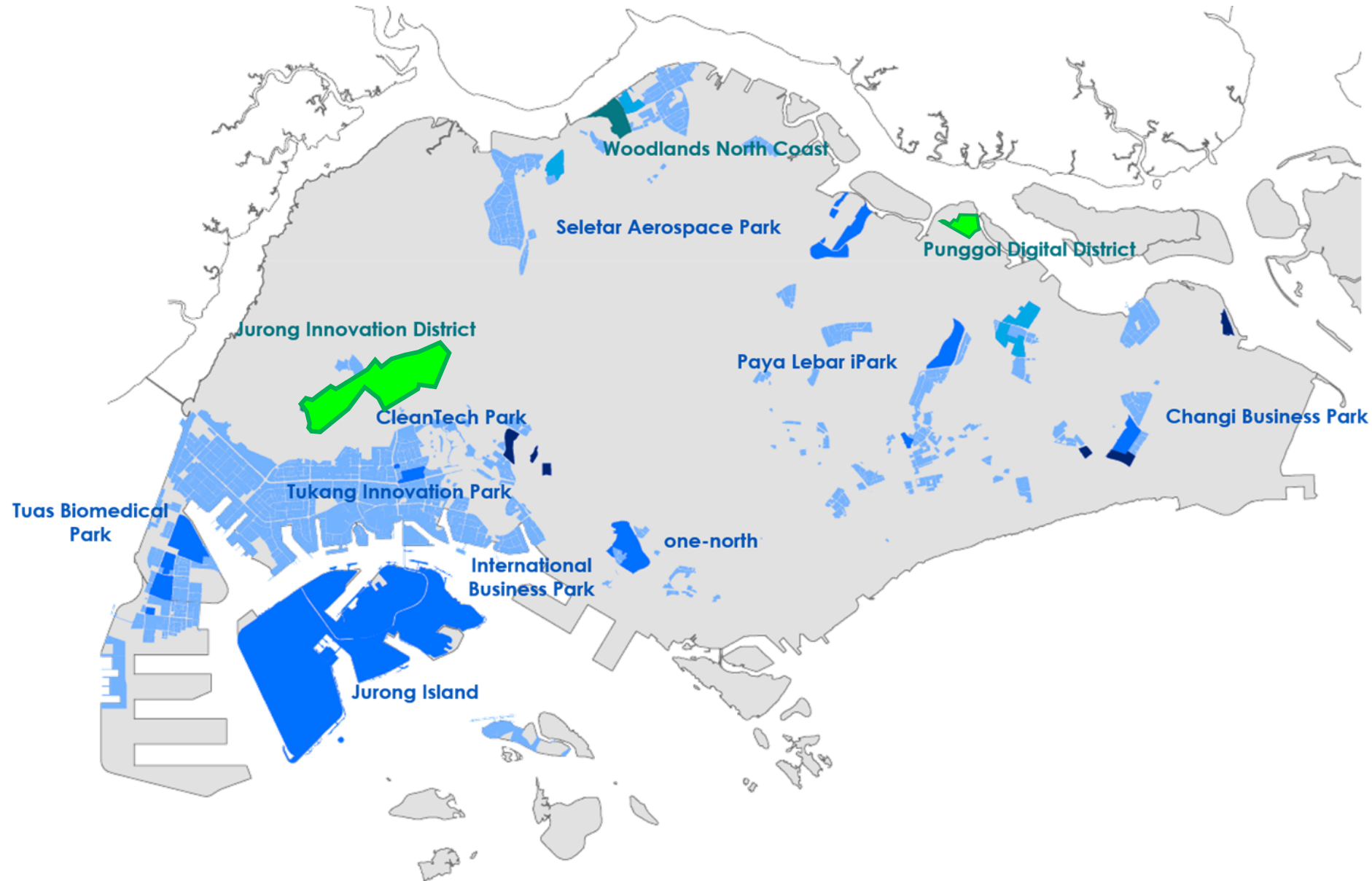
JURONG INNOVATION DISTRICT (JID)

Advanced Manufacturing, 440 ha (excluding NTU)



PUNGGOL DIGITAL DISTRICT (PDD)

Digital & Cyber Security, 50 ha



Sustainability in Engineering.

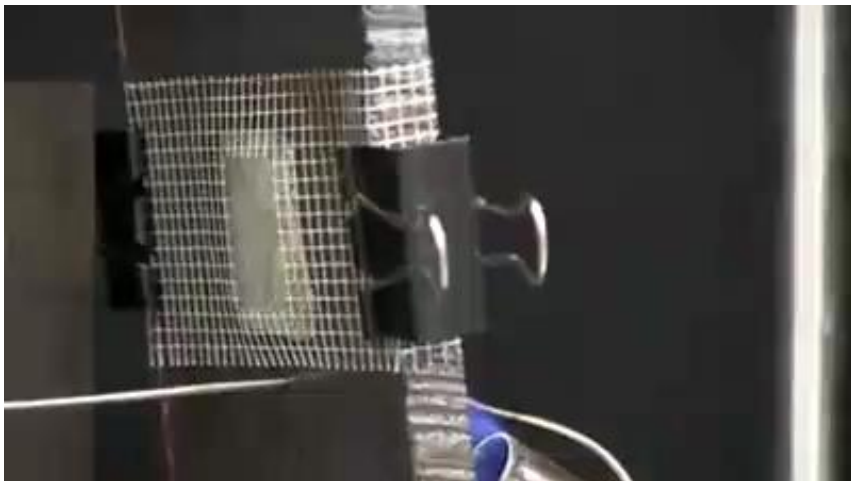
Sustainable Construction

- JTC partners companies and Institutes of Higher Learning on R&D in the area of sustainability e.g. sustainable materials and tools to transform and decarbonise the construction industry

FiroShield: Fire and Corrosion Resistant Coatings for Steel Structures

Key Benefits:

- *At least 50% cheaper than conventional coating*
- *At least 50% less time to apply*
- *Slows the spread of fire for 2 hours to allow building's occupants to escape*
- Only 5 mm thick with excellent adhesion
- No requirement of sand blasting and multi-layered coatings
- Can be spray painted in factory (DfMA)



FasRaP: Fast Wrapping Fibre Reinforced Polymer to Reinforce Structural Elements and Increase Resilience Against Blasts

Key Benefits:

- *Save 50% manpower*
- *Save 30% overall cost*
- Easy application on site, suitable for existing, occupied facilities (increase productivity)
- Factory controlled quality (less reliance on skilled workers)

113



Sustainability in Engineering.

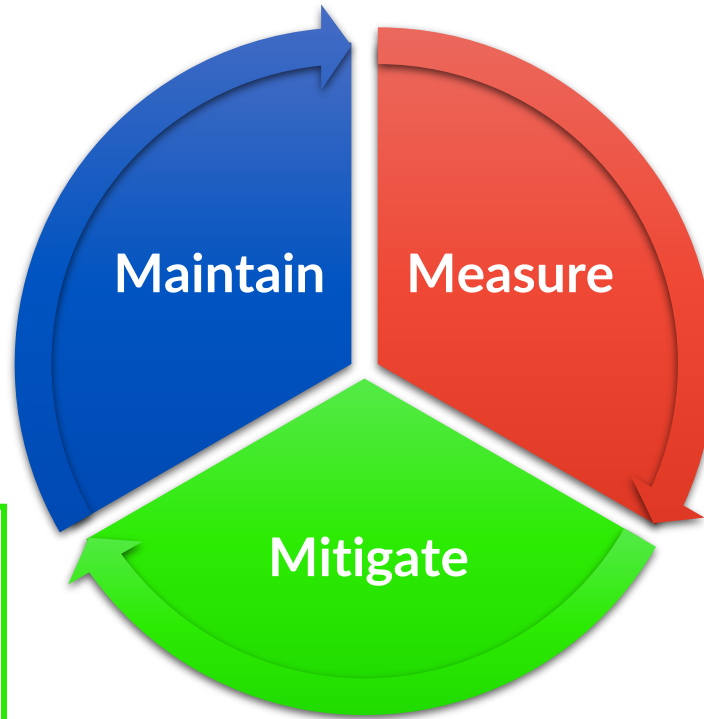
Sustainable Construction

Maintain safety and quality – while striving for sustainability: Focused on reducing upfront embodied carbon emissions through the use of sustainable materials and best construction practices & processes.



JTC SemiconSpace with CarbonCure:

JTC worked with both the main contractor and Pan United to implement the use of CarbonCure concrete as an alternative to conventional concrete at JTC SemiconSpace @ The Tampines Wafer Fab Park, thus reducing the amount of cement use and the concrete's carbon footprint.



BIM-based Embodied Carbon Calculator: To formulate tools to transform and decarbonise the construction industry

Key Benefits:

- *Integrate in BIM modelling based on localised carbon database*
- Formulate embodied carbon accounting standards and raise awareness of carbon impact of building materials



Please scan the QR code to try

Application of Municipal Solid Waste Slag in Construction:

Utilising MSW slag, a byproduct of a new waste processing method to be used as a sand replacement in concrete elements such as footpaths.



Sustainability in Engineering.

Achieving Greater Sustainability through Solar

- JTC's solar initiatives aim to produce and utilise more solar energy in order to reduce Singapore's grid dependency on the burning of fossil fuels
- One such example is the SolarLand programme which has been generating solar energy to the national grid via the installation of solar PV panels on vacant land since May 2019
- Since land is scarce, JTC is exploring offshore floating solar deployments with industrial partners at its waterfront.
- JTC has also embarked on solar-related innovations aimed at improving the solar yield, increasing flexibility of deployment, and maximising the use of limited land and roof space



Please scan the QR code for more information about our solarisation efforts,

Integrated Solar Generation with Farming

Partnering Terrenus Energy to testbed multi-functional use of PV spaces



Automating labour intensive tasks that boost productivity and power generation

Autonomous PV Cleaning Robots

Mobile Substation with Portable Solar Panels

Piloting mobile PV systems to improve deployment speed and versatility



Achieving quick and reliable solar fault detection using drones and smart vision

Solar PV Inspection with Drones & AI

JTC's solar-power innovations

Sustainability in Engineering.

JTC Solar Initiatives - Timeline



In total, more than 100MWp of solar installation capacity has been progressively installed across JTC's land and rooftops



Driving collaborative and practical R&D efforts to build new capabilities for JTC and the industry

Solar Maximization

- Mobile substation for quick deployment of PV
- Smart inspection for reliable solar energy generation

Near term (~3yrs)

Solar Integration

- PV + farming, PV at site office
- Transformation of existing infrastructure to support smart system

Mid term (4-6yrs)

Beyond Solar

- Hydrogen as a fuel, storage, carbon capture and transportation
- Other renewables

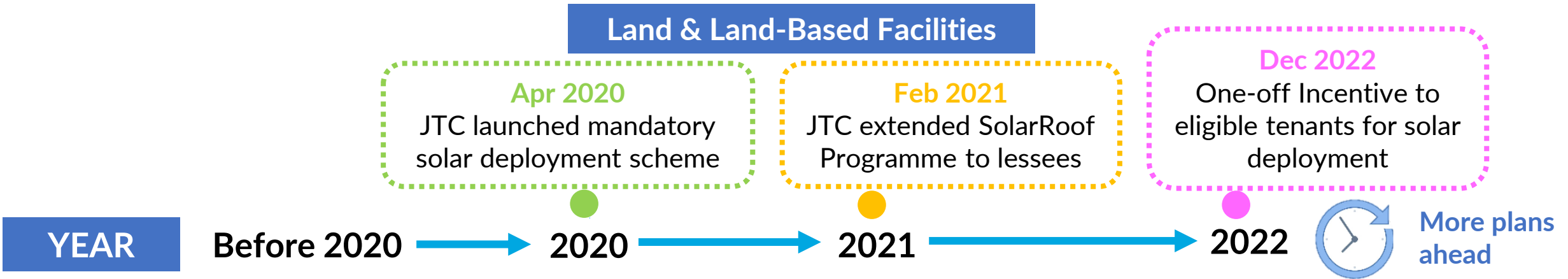
Long term (7yrs~)

Sustainability in Engineering.

JTC'S Solar Initiatives – Broadening our Lessees' Access to Renewable Energy



Land & Land-Based Facilities



Voluntary solar deployment

Solar deployment carried out by JTC lessees on their own initiative. No fee required for the lessees to apply for JTC's consent.

Mandatory solar deployment

Applicable for new lease allocations, lease renewals, launches and tenders at JTC industrial estates which fulfil a set of criteria.

SolarRoof Programme

Extension of JTC SolarRoof Phase 2's demand aggregation scheme to JTC lessees interested in solarising their properties' rooftops & various engagement to promote the programme



As of June 2022, more than 200MWp of solar panels have been installed across JTC's lessees rooftops



Whole-life-cycle Approach

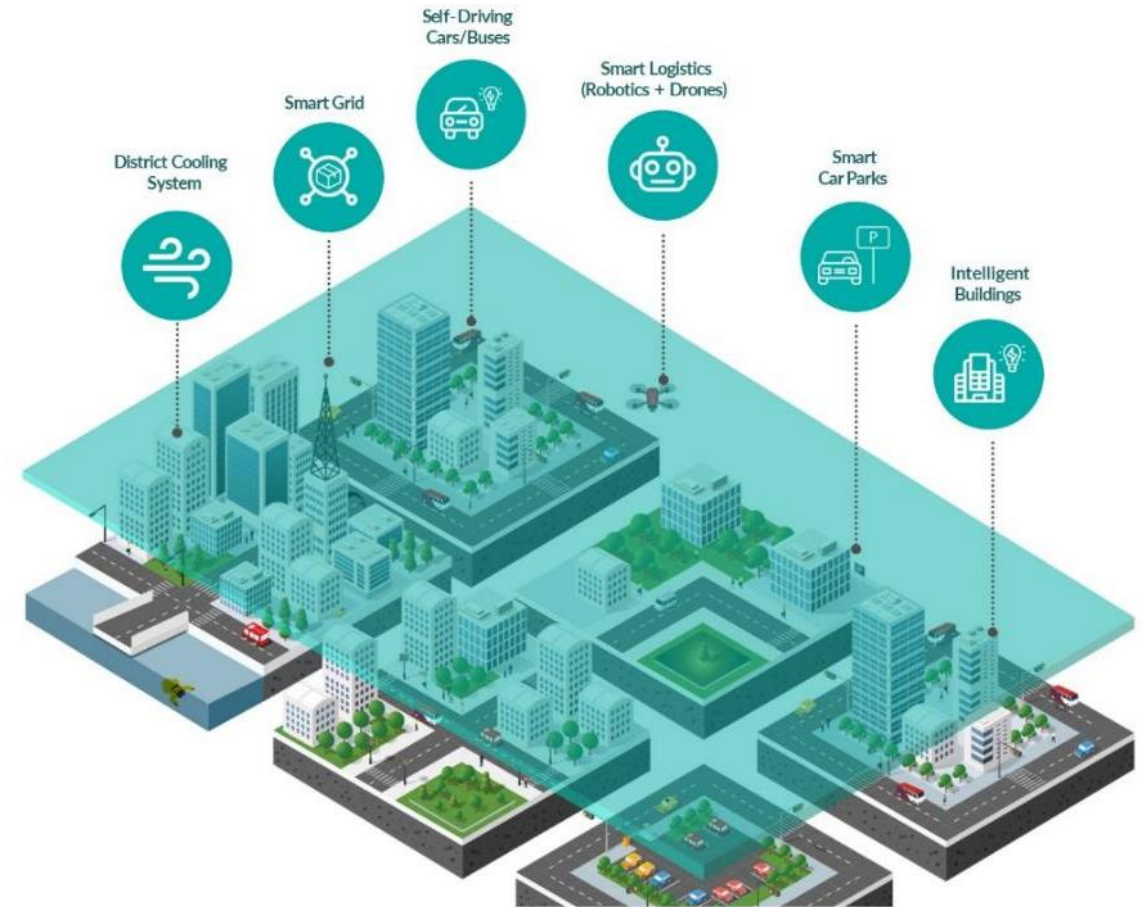


Operations & Maintenance in Practice

Sustainability in Operation & Maintenance.

Operations Optimisation

- JTC adopts a sustainable building operation approach and focuses on managing and reducing energy and water consumption, as well as waste generation in our estates.
- JTC has also developed our own smart estate management systems, such as the Open Digital Platform (ODP), to enable smart services and integrated operations.
- The ODP connects different district management systems on different communications technologies and optimises building operation according to the real-time data.



Key Features of the Open Digital Platform

Sustainability in Operation & Maintenance.

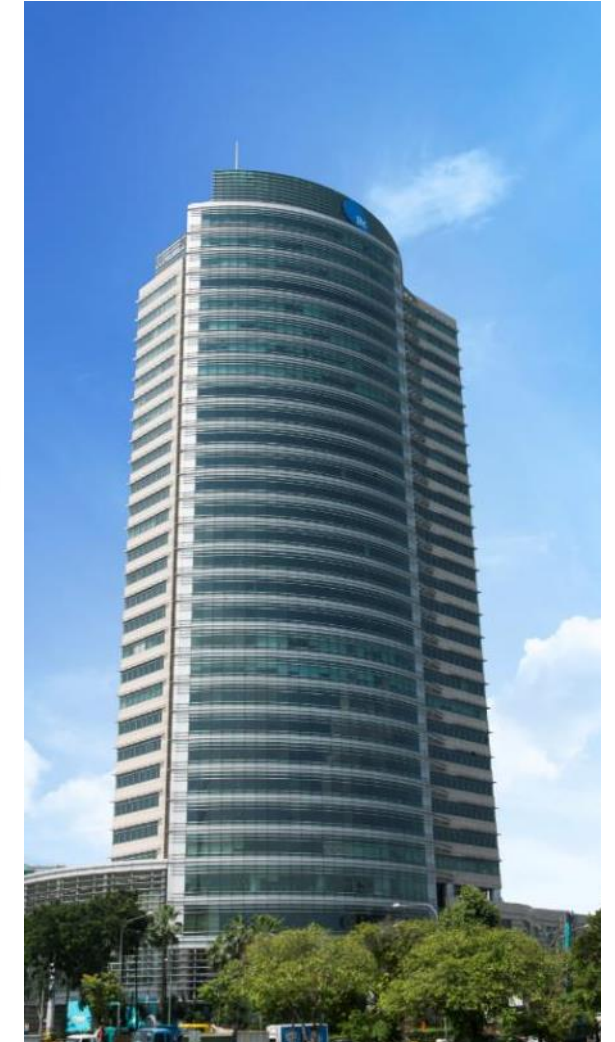
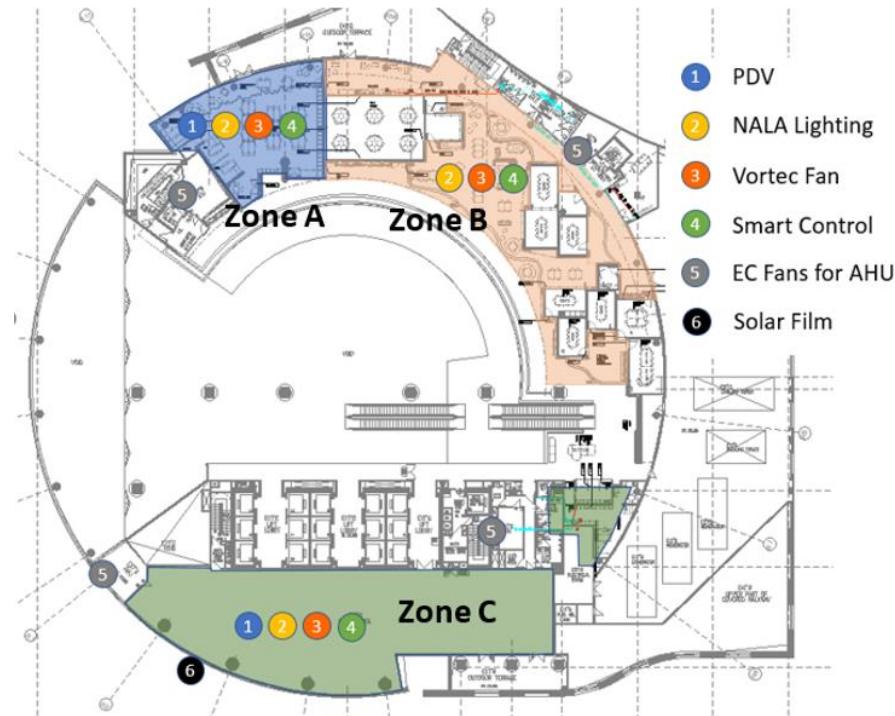
Providing test-bed sites and invests resources in our drive towards sustainability

Super Low Energy Building Demonstration at JTC Summit

Trying new technologies and solutions to achieve 15% improvement over today's best in class

Objectives:

- Demonstrate potential of achieving SLEB for retrofitting
- Demonstrate cost effectiveness for proposed solutions/technologies
- Demonstrate ease of integration to existing building systems
- Scalability and applicability to other office spaces
- Test optimal office configuration for low energy use profile, user comfort/productivity

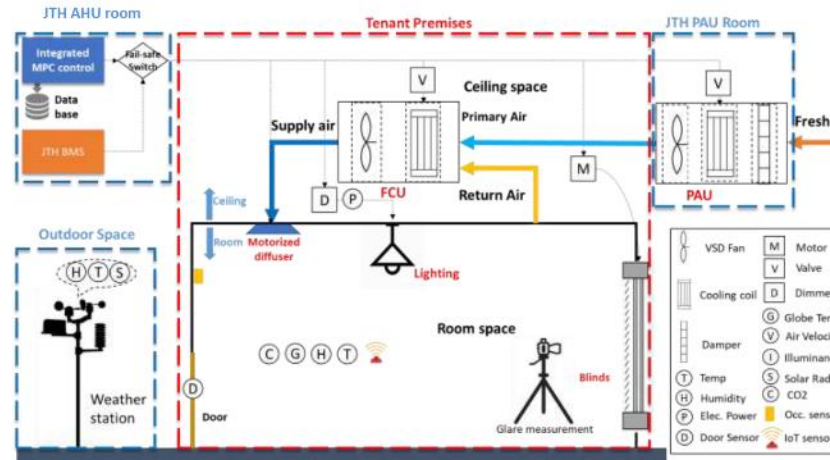


Sustainability in Operation & Maintenance.

Uncovering & exploring innovative cooling solutions

Model Predictive Control (MPC) System for Building Automation and Control (BAC)

The MPC system aims to optimise the building energy consumption and occupants comfort (thermally) through adaptive control with multi-objective functions. The current pilot test at JTH shows promising preliminaries cooling and lighting energy savings.



- Controlled systems:**
- ACMV (FCU, PAU, motorized diffuser)
 - Lighting (dimming)
 - Blinds (blind position)

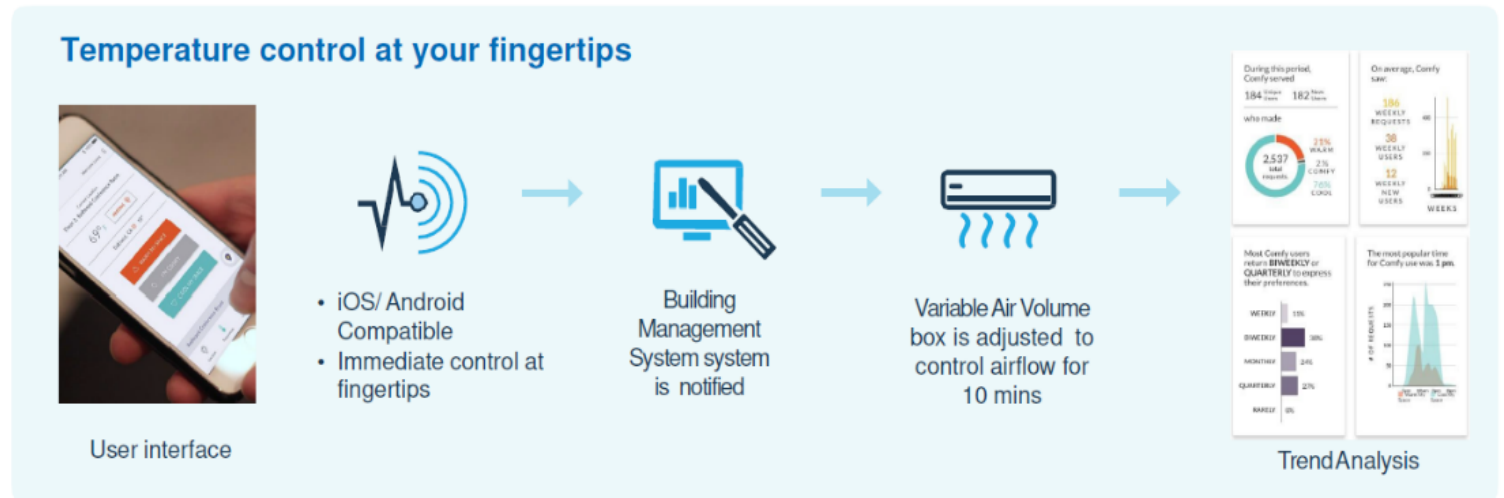


Test site - Civil Service College @ Jurong Town Hall Building (Level 3)

Comfy App

On demand cooling for your comfort

Comfy is an APP which can command the Building Management System to temporary increase the airflow at the user location for 10mins. Example: A person who came back from lunch could use Comfy to help him cool down faster by increasing the airflow at his desk. The Comfy App interface gives the user immediate control of air flow to bring instant cooling on demand.



Sustainability in Operation & Maintenance.

Leveraging technology in maintaining our solar panel systems

Hydropanels & Robotic Cleaner



Hydropanels allows water to be extracted from the air sustainably without the need of constructing water infrastructure. This water is used for the solar panel robotic cleaner.



Robotic Cleaner.

- use of mobile cleaning robot to clean the solar panels regularly,
- less workers are needed to clean large area of solar panels and the time required will be significantly shortened.

Solar Analytics with Drones

- Using drones to scan solar farm in RGB and thermal imaging to highlight defects and potential defects
- Save manpower costs and time in identifying defects in large solar installations
- Mitigate risks of work-at-height for solar rooftop installations
- Identify defects to enable JTC to improve plant yield and safety of operation and maintenance





Whole-life-cycle Approach

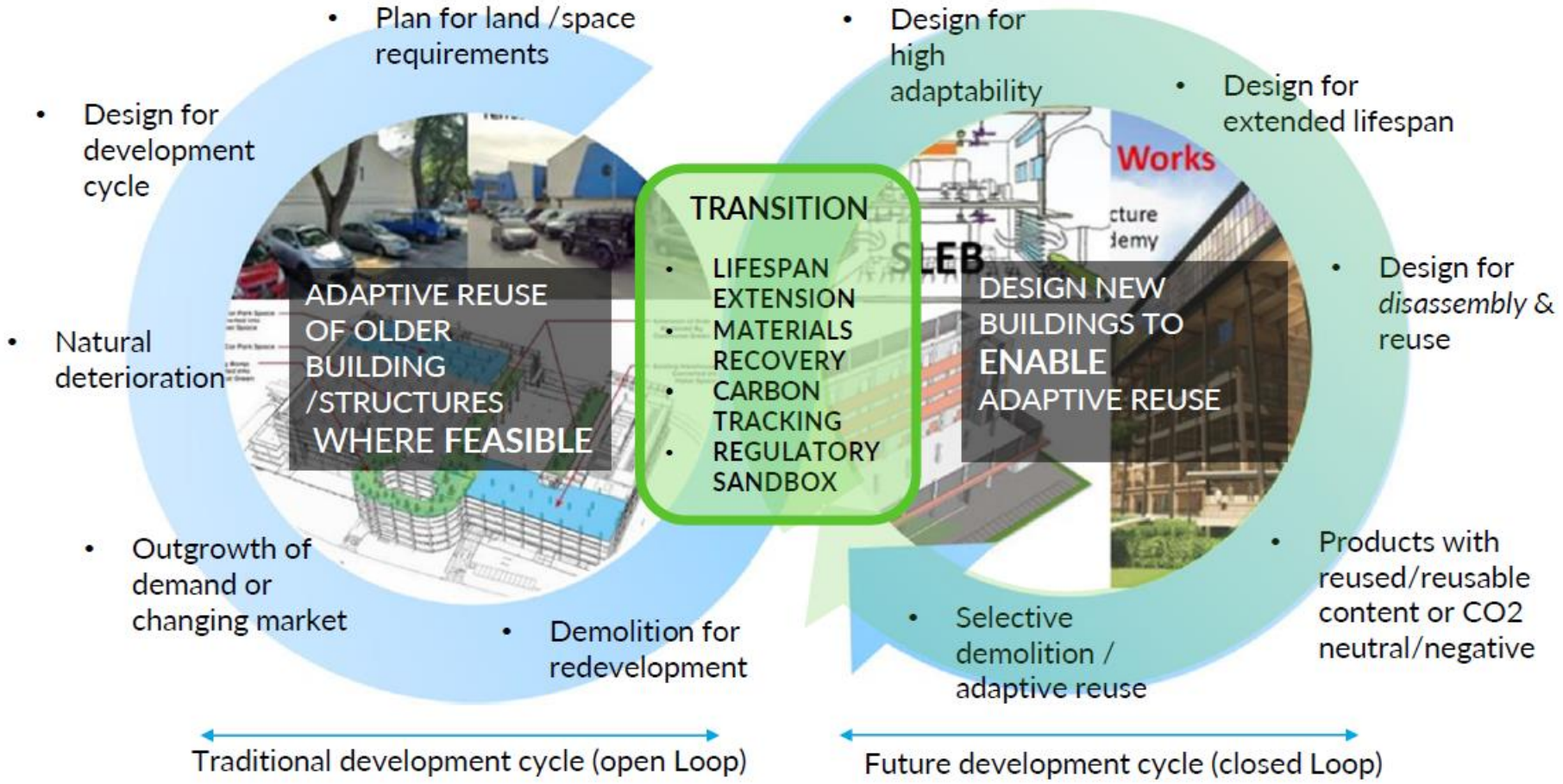
Redevelopment in Practice



Sustainability in Redevelopment.

A Closed-Loop Process for Design and Development for Old JTC Estates and Buildings

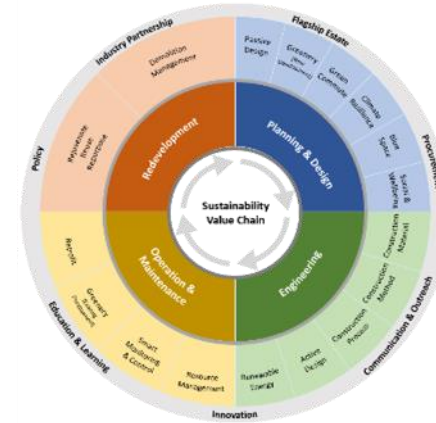
The envisioned outcome is a potential change from existing development cycle to a closed-loop process for design and development





Whole-life-cycle Approach

Industry Partnerships and Outreach in Practice



Sustainability in Outreach and Partnerships.

Industry Partnerships

Green Compass: A Sustainability Transformation Guide for Businesses

- Co-developed by **JTC**, **A*STAR** and **TÜV SÜD**, the Green Compass offers a set of assessment tools, methodologies, and training workshops to help companies navigate towards environmental sustainability improvements.
- It help companies to measure their sustainability maturity, identify gaps, and formulate improvement pathways in alignment with their business strategies.



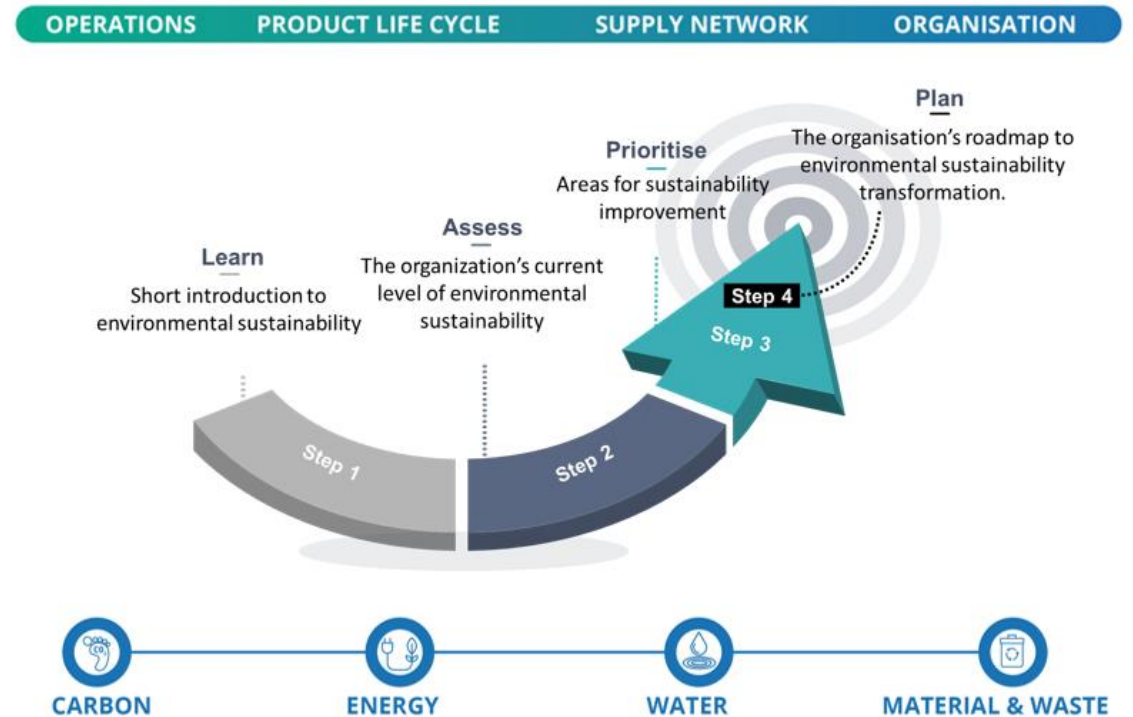
BUILDING INDUSTRIES

Benefits of sustainability to businesses and industries

- ✓ **Future-proof** operations against supply-chain, resource or demand-side shocks
- ✓ **Reduce costs** through improving environmental sustainability and consuming less resources
- ✓ **Increase revenue streams** by improving visibility among customers and partners that value sustainability

Possible roadblocks

1. Lack familiarity with sustainability concepts
2. Unclear how to get started
3. Lack a systematic approach to identify opportunities and high-impact initiatives



Creating Greenery and Biodiversity Together.

Create more green spaces and enhance biodiversity to build more conducive industrial estates



Tree planting @ Jurong Island



- JTC collaborated with NParks and stakeholders at Jurong Island to plant 34,000 plants on the island since 2020 to enhance the environment – more than quadrupling the tree population on the island

Jurong Eco-Garden at CleanTeck Park @JID



- Plan with local context and augment existing natural assets
- Digital planning based on virtual site analysis on hydrology, greenery topography

Tree planting @ SAP



- Partnered with companies for tree planting at Seletar Aerospace Park (SAP)
- Lessees can contribute physically or monetarily
- Pledged money is used for tree-planting in their estates

Refurbishment of The Oval @ SAP



- The refurbishment of the Oval in Seletar Aerospace Park (SAP), an airplane-theme park for exercise, leisure and dining
- Allow natural growth of ecosystem and biodiversity within the estate

Coral Reef Garden @ Sister Island



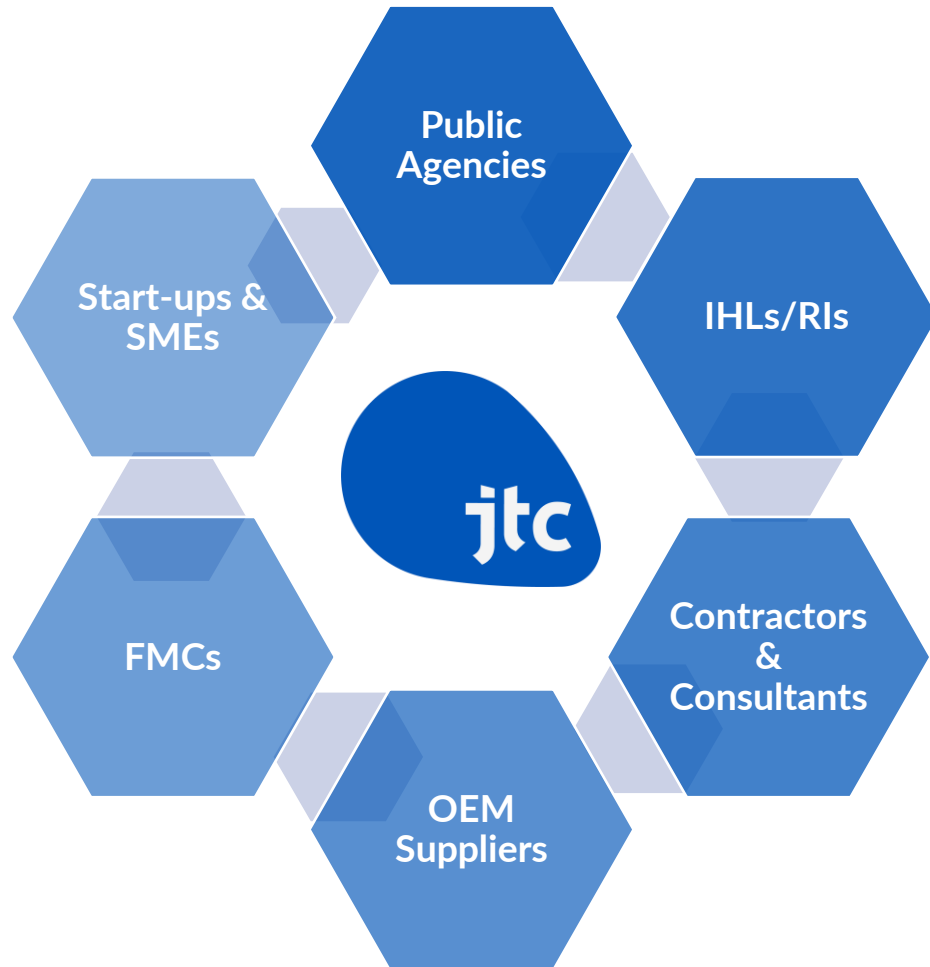
- Led the construction of underwater structure to restore natural reef habitats
- Reached out the industrial community to encourage corporate ownership on Singapore's natural biodiversity heritage

Waterbody @ Meranti, Jurong Island



- Create a vegetation-covered waterbody to mitigate flood at JI due to climate change
- Plant and monitor 25,000 shrubs and 1,500 trees to promote biodiversity and function as carbon sink

JTC drives collaborative R&D for Singapore's BE sector.



Collaborative approach to bring various parties in the Built Environment value-chain together to develop R&D solutions.

Practical research by triple-pronged approach to push for adoption:

- **Facilitate regulatory approval** with testbeds
- **Promote market acceptance** by forming partnerships with industry players.
- **Adapt overseas technology** into Singapore's context to avoid duplication



Sustainability and Innovation Partnerships for Progress.

JTC INNOVATION CHALLENGE 2022

Organised by  BUILDING INDUSTRIES

Supported by 



JURONG ISLAND INNOVATION CHALLENGE 2021

Organised by  BUILDING INDUSTRIES

Powered by  BUILDING INDUSTRIES



BE AMP

Build Environment

An Initiative by     OPEN INNOVATION PLATFORM

PROTOTYPICAL FESTIVAL

INVENTING OUR FUTURE





For more information about JTC's innovation platforms, please scan the QR code



Sungei Kadut Eco-District

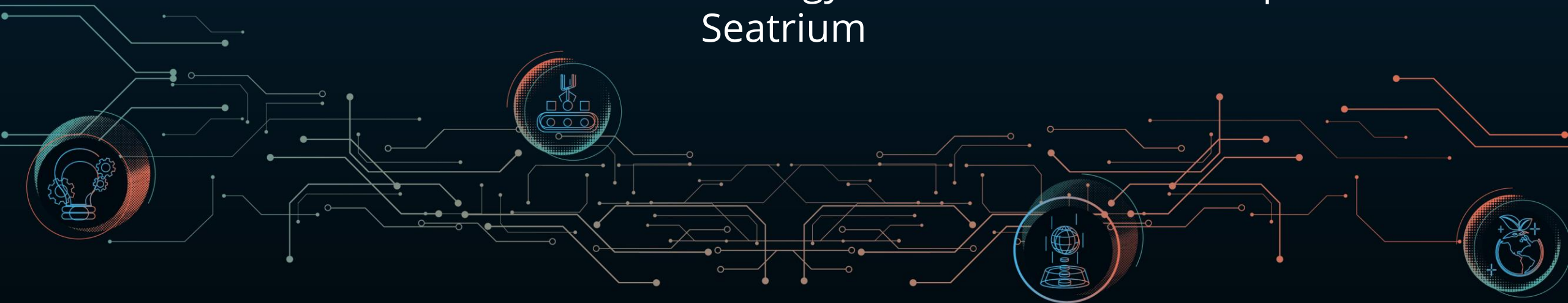
Thank you.



Recent Developments in Offshore Renewable and New Energy and its Relevance to Advanced Manufacturing

Dr Ang Joo Hock

Assistant Vice President, Technology & New Product Development
Seatrium





Recent Developments in Offshore Renewables & New Energy & Relevance of Advanced Manufacturing

Dr Ang Joo Hock
Assistant Vice President
Technology & New Product Development
Seatrium Ltd

27 July 2023



Presentation Outline

- 1 Introduction of Seatrium
 - 2 Urgency of Global Transition Towards A Low Carbon Economy
 - 3 Recent Developments in Offshore Renewables and New Energies
 - 4 Advanced Manufacturing as Enabler to Low Carbon Economy
 - 5 Future Potential of Robotics & Artificial Intelligence in M&O Sector
-

A transformative Combination of Sembcorp Marine and Keppel Offshore & Marine



Keppel Offshore & Marine



Seatrium



Creation of a premier global player offering offshore renewables, new energy and cleaner solutions in the offshore & marine sector



World-class engineering capabilities, global operational capabilities, well-established track records

Capitalising on the Energy Transition

Accelerate Strategic Pivot into High-growth Renewable and Clean Energy Segments

Further diversify business portfolio to extend into new areas of renewable energy, electrification, gas value chain, ocean living, as well as carbon capture and storage solutions

Well-positioned for global transition to a low-carbon economy

The reach and platform to capitalise on the global energy transition

Combined Entity will be able to immediately realise economies of scale, and be strategically positioned to seize opportunities in the improving industry landscape



[**> S\$20bn**
Net Order Book]

[**>40**
Ongoing Projects]

[**~28,000**
Combined Workforce]

Comprehensive Products and Services Across Marine, Offshore and Energy Value Chain



PRODUCTS

SERVICES

OIL & GAS



Drilling - Semi



Drilling - Ship



Drilling - Jackup



Production - TLP



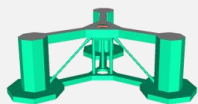
Production - FSO / FPSO



Production - FLNG

External

RENEWABLES



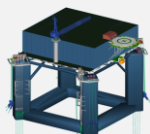
Floating Wind



WTIV



WTG Carrier



Floating Substation



Wind support vessels

SUPPORT / TRANSPORT VESSELS



Accommodation



Bunker Vessel



Hybrid / LNG tugs



LNG / Electric Ferry



Hydrogen/ ammonia/ Methanol Powered



Gas Carrier

UTILITY



Gravity based Terminals



Bunkering Station



GraviFloat – Energy Hub



CO2 injection units

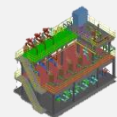


Power generation

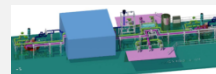
GAS VALUE CHAIN



Gas Liquefaction



Gas regasification



Cargo Handling System

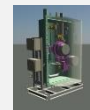


LNG FGSS

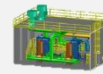


Cold energy recovery

NEW ENERGY VALUE CHAIN



Hydrogen Marine Electrolyser / Fuel cell



Ammonia Regasification



Green Ammonia/ Hydrogen Production and Bunkering plant



CO2 capture units

OTHER PRODUCTS



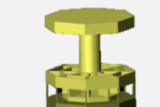
Research/ Scientific vessel



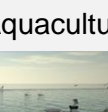
Arctic Expedition Cruise



Cruise Vessel



Anchorage Hub



Aquaculture

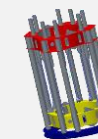


Defense Hub

EQUIPMENT



Jacking System



VAM System



Air lubrication system



Ballast Water Treatment

EQUIPMENT/ DIGITAL



Data acquisition



Asset Health Monitoring



Digital Twin and simulation

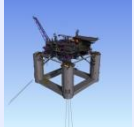
Strategic Advancement of Existing Products and Expertise



Traditional Products

Expand Oil & Gas Experience to New Segments

New Products



SEMI SUMERSIBLE (FPSU)



Circular Hull (FPSO)



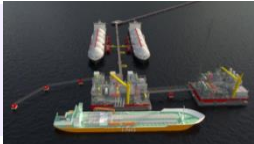
LNG TO POWER (FSRU /FSRPP)



LNG TUG



LNG FERRY



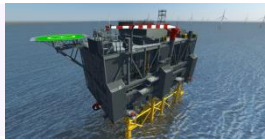
GRAVIFLOAT (O&G)



FLAOTERS (FPSO)



FIXED PLATFORM (O&G PRODUCTION)



FIXED SUBSTATION



LNG BUNKER VESSEL



WIND TURBINE INSTALLATION VESSEL

External (SELF ELEVATING UNIT)



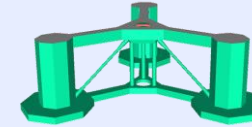
LNG TERMINAL (GRAVIFLOAT)

Technology Foresight and Trends

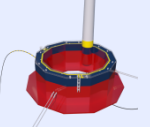
Product Diversification

Emerging Market

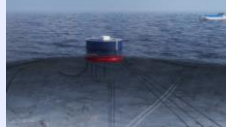
Building and leveraging Capabilities



SEMI SUBMERSIBLE (FLOATING WIND)



CIRCULAR HULL (FLOATING WIND)



CIRCULAR HULL (CO2 INJECTION)



NUCLEAR POWER



AUTONOMOUS VESSELS



HYDROGEN FERRY



GRAVIFLOAT (DEFENCE HUB)



FLOATERS (FLOATING CITY)



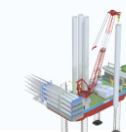
FIXED PLATFORM (H2 PRODUCTION)



FLOATING SUBSTATION



NH3 BUNKER VESSEL



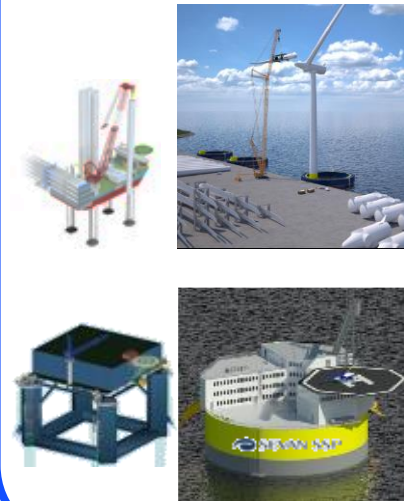
GREEN WIND TURBINE INSTALLATION VESSEL (SELF ELEVATING UNIT)



ENERGY HUB (GRAVIFLOAT)

Offshore Renewables

- A) Offshore Wind
- B) Solar & Tidal
- C) Nuclear



New Energies

- A) New Fuel Production/ Process
- B) New Fuels Transportation
- C) New Fuel Equipment



Maritime Decarbonisation

- A) Carbon Capture & Storage
- B) Energy efficiency technologies
- C) Electrification

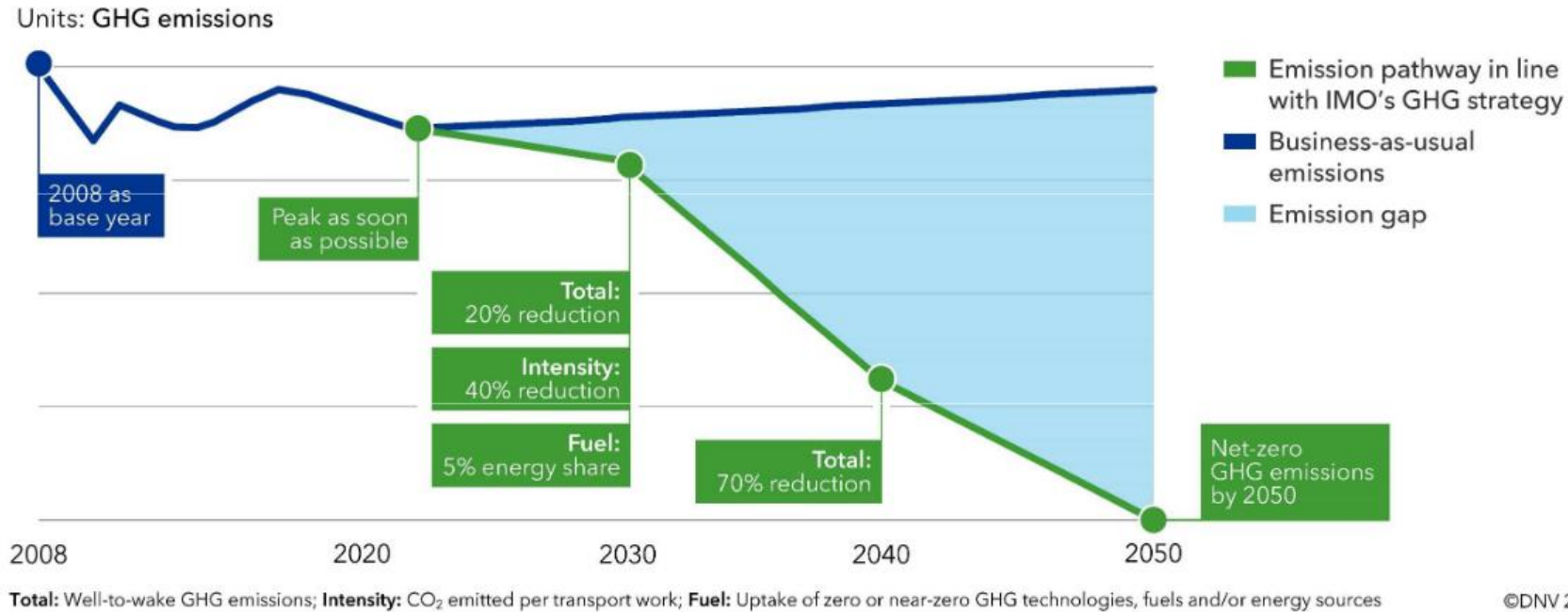


Robotics & AI

- A) Digital twins and condition monitoring
- B) Remote control/ autonomous
- C) Industry 4.0



MEPC 80 (July 23)- Enhanced IMO GHG Reduction Strategy



5 DNV © 11 JULY 2023



There is an urgent need for energy transition and decarbonisation of all sectors including the maritime sector. Renewables and fuel switching (new energies) are important levers for transitioning towards a low-carbon economy.

Offshore Renewable Value Chain Solutions

Contributing Towards Global Net Zero Ambition



Offshore Substations




 **Tennet** World's largest and Most Advanced HVDC Electrical Transmission System



 **Tennet** DolWin – Bottom sitting offshore HVDC Substation
External

Installation Vessels



 **MAERSK** Next-Gen Wind Turbine Installation Vessel for Maersk Supply Services



 **Dominion Energy** Dominion Energy - Wind Turbine Installation Vessel

Floating Platforms



SI-VAM Floating Wind Foundation



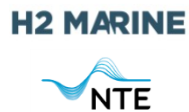
SWACH Floating Wind Foundation

New Energy Value Chain Solutions

Contributing Towards Zero-carbon Future



Hydrogen Production



Green Hydrogen facility for production, compression, storage, and bunkering for maritime transport

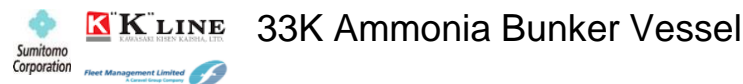


ZEG - Sevan floater concept development for Blue Hydrogen production

Ammonia Bunkering



70K Ammonia Bunker Vessel



33K Ammonia Bunker Vessel

Hydrogen as Fuel



HYDRA- world's first liquid hydrogen ferry



Hydrogen as marine Fuel Pilot Project with Shell & Penguin

Maritime Decarbonisation Value Chain Solutions

Contributing Towards Low-carbon Maritime & Offshore



Electrification



NORLED Three full electric ferries for NORLED



NORLED Ryfylke - First battery powered vessel to operate a full day without shore charging.

Kolumbus

External

CO2 Capture



Shipboard carbon capture pilot with Stena Bulk

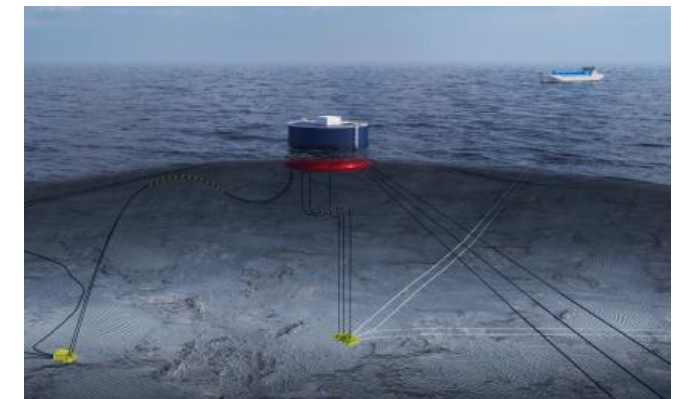


Preferred EPC partner for Aker Carbon Capture system for offshore installations

CO2 transport and Injection



YARA World's first LCO2 carrier for Yara



Completed concept design for the Stella Maris CCS project with Altera and partners

AI and Robotics Solutions

Contributing Towards Industry 4.0 And Smart Nation



Smart Yard



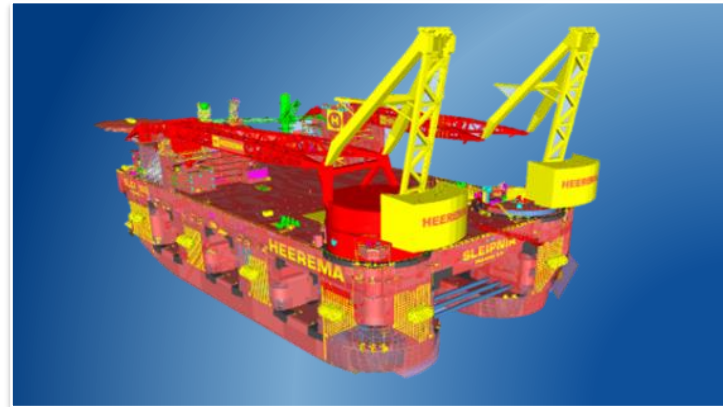
5G enabled yard for seamless connectivity



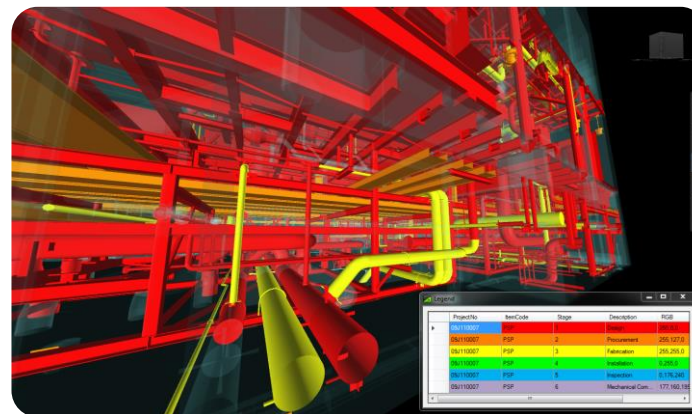
Onshore monitoring/ optimisation for energy efficiency

External

Digital Twin



Digital Twin for Slepnir

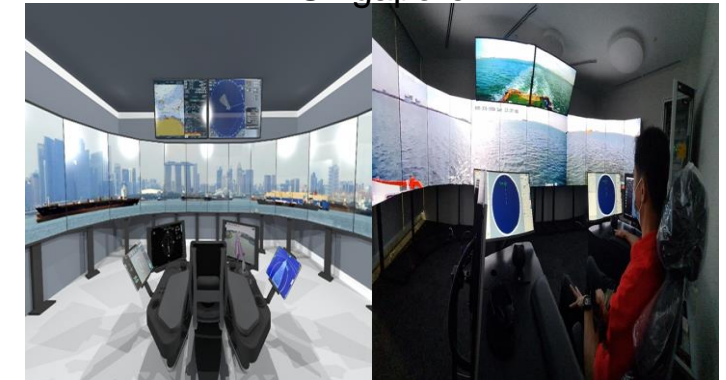


4D digital Design

Autonomous Ships



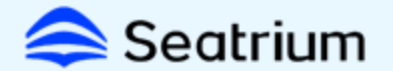
First demonstration of autonomous operations in Singapore



Shore Command Centre

Advanced Manufacturing For Low Carbon Economy

Examples of Robotics Deployment



Fully Automated Pipe Fabrication Workshop



Additive manufacturing

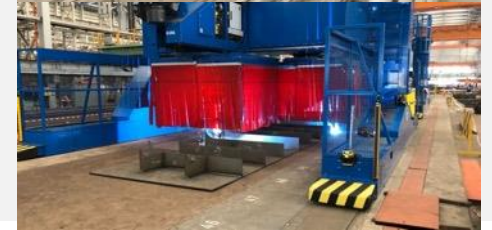


Robotic Welding in Structural Fabrication Workshop

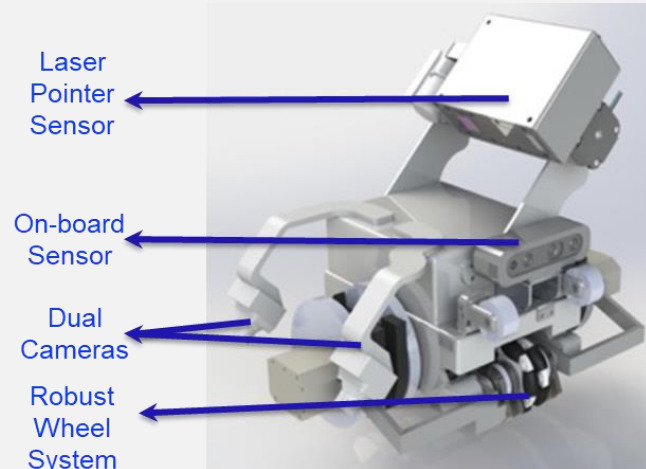
Goliath Gantry



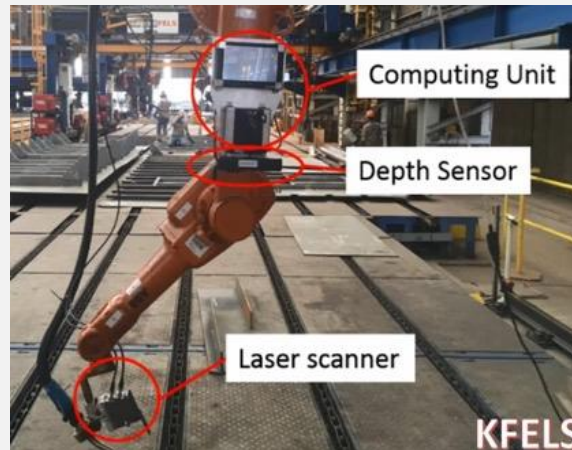
Panel Gantry



Robotic automation for visual weld inspection



ROBO FLEX – Complex Multi-Pass Welding

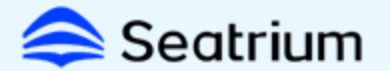


Hydro jet robot

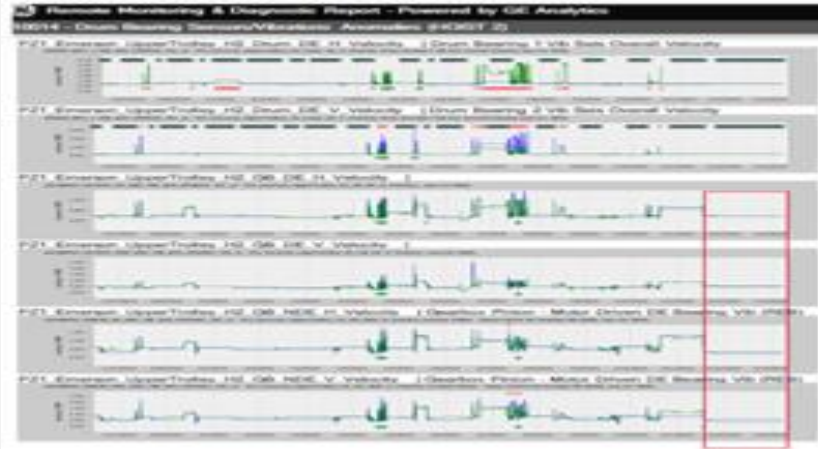


Advanced Manufacturing For Low Carbon Economy

Examples of AI Deployment



AI for predictive maintenance



Productivity enhancement

Yard Workforce

- People counting
- Helmet is categorized into trades



Safety enhancement

Vehicles

Can detect vehicles such as forklift, truck



Yard Workforce

Can detect presence of PPE



Future Potential of Robotics & AI in M&O Sector

To lower the costs and risks of manufacturing and facilitating a low carbon economy



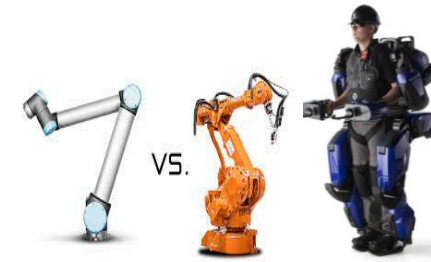
ROBOTICS



Large Format Additive Manufacturing



Autonomous robots



Robots, Cobots, Exoskeletons



Integrated smart factories

ARTIFICIAL INTELLIGENCE



Analytics, ML, Digital Twins



Generative AI



Immersive technologies/AR/VR/Mixed Reality



Web3, Blockchain Technologies

A Premier Global Player with
Deep Engineering Expertise



Engineering Our Future Together

