

SPECIAL EDITION

Celebrating UNESCO's World Engineering Day for Sustainable Development 2023

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THE SINGAPORE ENGINEER

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How Singapore engineers
contribute to decarbonising our built
environment

PLUS

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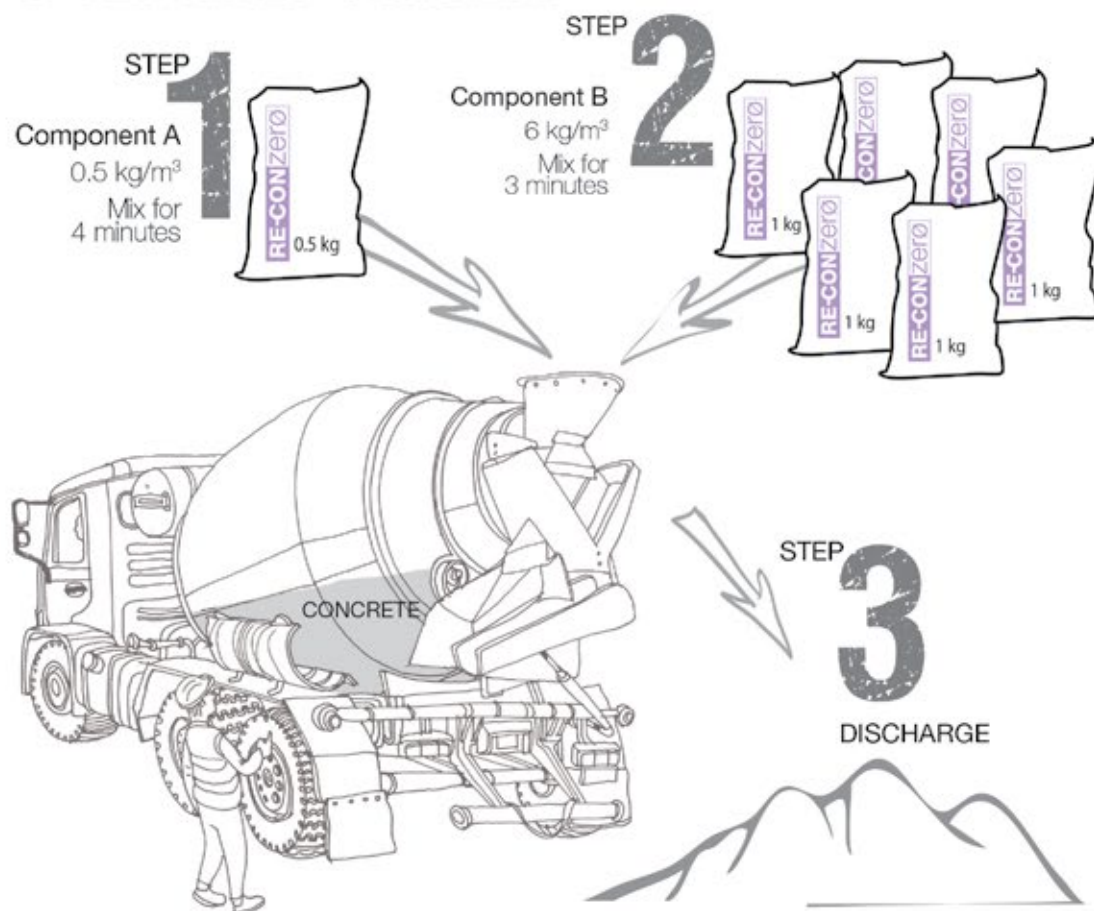
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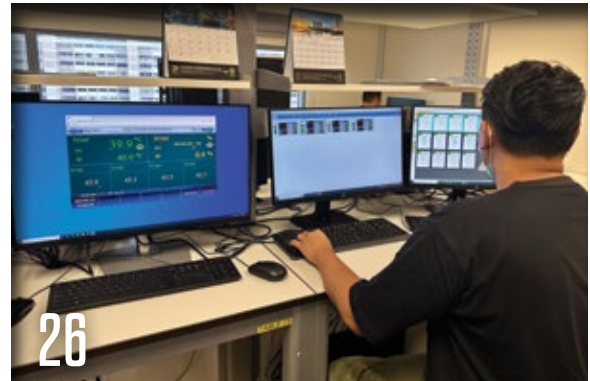
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Message from Prof Dr José Vieira, President, World Federation of Engineering Organizations (WFEO)

**Dear Colleagues from the Institution of Engineers, Singapore (IES),
Dear Fellow Engineers,**

I am proud, as WFEO President, to see how significant the UNESCO World Engineering Day for Sustainable Development (WED) has become. WED was originally a concept developed by WFEO, under the leadership of our Past President, Dr Marlene Kanga. The process led to the Day's proclamation by the UNESCO General Conference in 2019.

The first celebration on 4 March 2020, as well as the two following ones, had to be organised, in spite of the COVID-19 constraints and a context of high uncertainty, and yet, we have managed to raise awareness and enthusiasm amongst WFEO Members institutions, partners, UN agencies, universities and more. The contents created through the celebration events, interviews and live streams have reached millions of people.

WED is a UNESCO Official Day that belongs to and benefits everyone, not just WFEO and its members.

However, it is a good example of the purpose of the Federation, and it also illustrates how we are driven by a clear vision of how engineers and engineering are vital for building a better world. What we do is give opportunities for engineering leaders to make a difference at a global scale, so they can engage at high levels of participation in UNESCO, United Nations agencies and other international institutions' activities.

In parallel, we provide a framework for international cooperation in some technical areas of strategic



Prof Dr José Vieira

interest, with the possibility for our members to host dedicated committees. I am confident that in the near future, Singapore, one of the most advanced engineering countries in its region, will be willing to host such a committee.

In 2021, UNESCO published its second Engineering Report, in which WFEO took a very important editorial part, and which was issued on 4 March 2021. The Report acknowledged that engineering is critical to building more resilient societies and industries, and to successfully fight climate change and adapt to its consequences.

Moreover, it is crucial that scientists and engineers work closely together in such a context that fosters cooperation and creativity. The UNESCO Recommendation on Open Science, which was adopted in 2021, is now in its implementa-

tion phase. WFEO, together with the most prominent scientific federations and academies worldwide, is part of the Global Open Science Partnership that will help to serve this purpose.

We also need more partnerships with our members to achieve our strategic objectives in the field of engineering education. As stated by the UNESCO Engineering Report in 2021, it is crucial that more engineers with the right skills are trained in order to achieve the 2030 Agenda.

This can be done only through more integrated graduation standards systems, in partnership with international organisations such as UNESCO and the International Engineering Alliance.

Last year, WFEO launched the first ever multilingual training portal, called WFEO Academy, which is open to all WFEO members, at no cost, and provides online courses for engineers' continuous professional development. I urge you to visit this website, share this information amongst your colleagues and institution's members, and encourage donations to the portal, which is, of course, a not-for-profit initiative.

Thank you for your enthusiasm in celebrating WED. I hope that many Singapore engineers will also take the opportunity to engage with IES, and maybe soon, with WFEO activities!

A handwritten signature in dark ink, appearing to read 'José M. P. Vieira'.

José M. P. Vieira
WFEO President

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IES GREEN PLAN 2030 LAUNCHED

Championing a new trail to support Singapore's sustainable development in collaboration with more than 30 government and partner organisations.

The Institution of Engineers, Singapore (IES) launched the IES Green Plan 2030 at its 56th Annual Dinner, held on 17 January 2023, to spearhead initiatives in support of the government's efforts to safeguard Singapore against the impact of climate change for future generations.

Ms Grace Fu, Minister for Sustainability and the Environment, was the Guest-of-Honour at the dinner.

The IES Green Plan 2030 is an initiative by IES, the national society of engineers in Singapore, to provide national-level institutional support to advance Singapore's sustainable development imperative. It lays out engineering-centric action plans, from 2023 to 2030, to support the Singapore Green Plan 2030.

Guided by the Singapore Green Plan 2030, it is aimed at strengthening the nation's engineering capabilities and capacities to develop solutions to mitigate the impact of climate change and public health threats, by aligning with the five key pillars of the Singapore Green Plan 2030 – City in Nature, Energy Reset, Sustainable Living, Green Economy and Resilient Future.

The IES Green Plan focuses on harnessing engineering to strengthen Singapore's commitments under the United Nations' 2030 Sustainable Development Agenda and Paris Agreement. It will contribute to Singapore's aim to achieve its aspirations to reduce emissions to 60 million tonnes of carbon dioxide equivalent by 2030 and achieve net zero emissions by 2050.

With this plan, IES will supplement the Singapore Green Plan 2030's goals, for instance, in promoting cleaner-energy vehicles, by installing electric vehicle charging points at IES premises and building up capabilities for solar deployment, by conducting training courses for engineers in solar photovoltaics.



Mr Dalson Chung

“Climate change is an existential threat to humankind but acknowledging the need to act is not good enough. We must act immediately. As engineers, we can contribute to the goals set in the Singapore Green Plan, with our engineering expertise, innovations and creative solutions. It is with this objective in mind that IES has taken the initiative to develop the IES Green Plan 2030, in support of Singapore's sustainability journey. It is a bold, yet necessary plan to act as a springboard for future green initiatives and inspire more engineers to step forward to contribute towards Singapore's ambitions of a green future”
– Mr Dalson Chung, President of IES.

The IES Green Plan 2030 is structured along a framework organised according to the stakeholder groups that IES interacts with – Internal, National and International – and with emphasis on collaborative activities with partners.

The plan is also aimed at strengthening the position of IES to achieve its mission as the actionable voice of Singapore's engineers. The formulation of the plan is built upon a refreshed vision arising from the IES Repositioning Study 2021 to address the grand challenges facing Singapore and to transform engineering and engineers in support of Singapore's sustainability goals.

Upskilling of engineers

A key element of the plan is to equip Singapore's engineers sufficiently to create new possibilities and value opportunities for the society, economy and environment, thus capitalising on the ingenuity inherent in the discipline, to make use of technology to facilitate Singapore's transformation into a climate-resilient nation-state.

In support of the focus on upskilling engineers in this space, IES has partnered SkillsFuture Singapore (SSG) to release the Jobs-Skills Quarterly Insights (JSQI) in conjunction with the launch of the

IES Green Plan. The publication highlights a suite of green skills highly sought after by employers from engineers, for work related to sustainable practices. The top identified skills are energy management and audit, environmental sustainability management and sustainable engineering.

JSQI also noted an emergence of newer 'green' roles in areas like solar PV engineering and energy sustainability, where engineers have to be well-versed in skills required for the development of clean technologies, harnessing clean energy, and managing environmental sustainability, as well as in Internet of Things applications, programming & coding, and big data analytics.

With the support of SSG and other partners, IES will continue to empower engineers through continuous skills development as well as professional certification programmes such as the IES Chartered Engineering certification schemes, and courses offered by industry bodies and Institutes of Higher Learning (IHLs).

With full commitment from government agencies, IHLs, professional associations and partners, IES aims to galvanise the engineering community to transform Singapore into a city of green possibilities.

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Singapore Pavilion hosts first-ever showcase at COP27

Around 5,000 visitors visited the inaugural Singapore Pavilion at the 2022 United Nations Climate Change Conference (COP27) which ran from 6 to 20 November 2022 in Sharm el-Sheikh, Egypt. It was supported by more than 100 partners, from corporates, media, academia international organisations, and non-governmental organisations (NGOs).

Themed around 'Building a Future of Green Possibilities', the pavilion displayed exhibits that showcased the Singapore Green Plan 2030 and organised events that highlighted Singapore's vision of achieving a net zero future by 2050.

These included the Singapore-Egypt Joint Food Resilience Event, which was attended by Dr Yasmine Fouad, Minister of Environment of the Arabic Republic of Egypt, and the signing of two Memorandums of Understanding (MoU) on carbon markets cooperation, with Papua New Guinea and Peru.

Singapore's Minister for Sustainability and the Environment, Ms Grace Fu, noted in her National Statement at the COP27 High Level Segment that the pavilion represented a convergence of key climate action stakeholders, encapsulated the Singapore approach to climate action and showcased sustainability solutions that were making on-ground impact.

She also reiterated the COP27 Presidency's 'Together for Implementation' message and emphasised that Singapore remained open to sharing and exchanging knowledge and best practices for a successful green transition.

Fifty-nine events were held at the pavilion, including panel discussions, fireside chats, presentations, hackathons, book introductions and launch events.

Each event was aligned with one of the thematic days designated by the Egypt COP27 Presidency, and some saw the participation



Fifty-nine events were held at the pavilion for COP27, including panel discussions, fireside chats, presentations, hackathons, book introductions and launch events. Image: COP27 Singapore Pavilion Team.

of Egyptian leaders such as Dr Yasmine Fouad and Mohamed Farid, Executive Chairman, Financial Regulatory Authority (Egypt), Vice Chair, International Organisation of Securities Commissions.

The Singapore Pavilion was visited by foreign royalty, foreign ambassa-

dors and ministers, organisational and business leaders, academics, founders of organisations and other changemakers in the global ecosystem. The Singapore Pavilion also saw active participation from Singaporean youth throughout the thematic days of the pavilion.

Agreement on new 'loss and damage' fund for vulnerable countries

The United Nations Climate Change Conference, COP27, was held in Sharm El-Sheikh, Egypt, from 6 to 20 November 2022.

The conference closed on 20 November 2022 with a breakthrough agreement to provide 'loss and damage' funding for vulnerable countries hit hard by climate disasters.

"This outcome moves us forward. We have determined a way forward on a decades-long conversation on funding for loss and damage – deliberating over how we address the impacts on communities whose lives and livelihoods have been ruined by the very worst impacts of climate change", said Simon Stiell, UN Climate Change Executive Secretary.

COP27 resulted in countries delivering a package of decisions

that reaffirmed their commitment to limit global temperature rise to 1.5° C above pre-industrial levels. The package also strengthened action by countries to cut greenhouse gas emissions and adapt to the inevitable impacts of climate change, as well as boosting the support of finance, technology and capacity building needed by developing countries.

Governments took the groundbreaking decision to establish new funding arrangements, as well as a dedicated fund, to assist developing countries in responding to loss and damage.

Governments also agreed to establish a 'transitional committee' to make recommendations on how to operationalise both the new funding arrangements and the fund, at COP28 in 2023.

Singapore launches national hydrogen strategy

Speaking at the Singapore Energy Lecture, which marked the start of the Singapore International Energy Week 2022 (SIEW 2022), Mr Lawrence Wong, Deputy Prime Minister and Minister for Finance, outlined Singapore's national strategy to develop hydrogen as a major decarbonisation pathway.

SIEW 2022 was held from the 25 to 28 October 2022.

Hydrogen for decarbonisation

The government has been studying various decarbonisation pathways to achieve net zero emissions, while strengthening energy security. Low-carbon hydrogen (including its derivatives such as ammonia) has emerged as a key potential pathway for Singapore. Hydrogen has the potential to be adopted across different sectors, as a low-carbon fuel or feedstock. Hydrogen does not release any greenhouse gases when combusted. When produced through low-emission methods, such as through the electrolysis of water using renewable energy, it can have close to zero emissions.

For Singapore, hydrogen can complement and diversify the power mix, alongside solar, imported electricity and other potential low-carbon energy sources, such as geothermal energy. Besides reducing domestic

emissions, low-carbon hydrogen and hydrogen-derived fuels are also potential alternatives to fossil fuels in the maritime and aviation sectors.

Singapore's hydrogen journey

Many hydrogen technologies are still under development and a global supply chain has yet to be established. However, there has been strong interest internationally from the public and private sectors, to accelerate the research on and development of hydrogen technologies.

Singapore will take steps to prepare for hydrogen deployment domestically and work with partners to build a hydrogen supply chain in Asia, based on five key thrusts.

First, Singapore will experiment with the use of advanced hydrogen technologies that are on the cusp of commercial readiness. An Expression of Interest will be launched for a small-scale commercial project, on utilising ammonia for power generation, including developing ammonia supply chains for marine bunkering. Such a project will enable the viability of ammonia to be assessed – both as a hydrogen carrier and as a direct fuel – and the development of regulations and an ecosystem to support it.

Second, Hydrogen will be a key focal area for Phase 2 of the Low Carbon Energy Research (LCER) Programme.

In October 2021, SGD 55 million was awarded for projects under Phase 1 of the programme, for research into low-carbon technologies. A further SGD 129 million will be set aside for Phase 2. The aim is to unlock key technological bottlenecks, through collaborations between academia and industry, so that Singapore is able to import, handle and utilise low-carbon hydrogen and its derivatives safely and at scale.

Third, the government will work closely with industry and international partners to enable the formation and scaling up of supply chains for low-carbon hydrogen. This will include advancing the development of Guarantee of Origin certification methodologies, ensuring that methodologies are interoperable across jurisdictions, and building a trading and financing ecosystem to facilitate global trade of low-carbon hydrogen.

Fourth, mass deployment of hydrogen will require new infrastructure to import, store and transform the hydrogen into power. Land and infrastructure plans will be developed and the implementation paced.

Fifth, the adoption of hydrogen will bring about new economic opportunities for Singapore and its enterprises and workers whose training will be supported.



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CDL pledges to support COP27 Action Declaration to strengthen climate policy engagement

Independent media and research B Corp, Corporate Knights, and the Global 100 Council announced a joint Action Declaration on Climate Policy Engagement, at COP27 in Sharm el-Sheikh, Egypt. This initiative garnered the support of over 50 global companies, whose annual revenues of almost USD 900 billion account for 1% of global GDP.

As a signatory to the Action Declaration, real estate conglomerate, CDL, reaffirmed its commitment towards supporting climate action aligned with the Paris Agreement, while working with its stakeholders, including industry partners, trade associations and policymakers.

The Action Declaration brings together corporate leaders who are committed to improving public-private policy engagement to move the world to the clean economy needed to address climate change. It aims to close the say-do gap on countries' emissions reductions by:

- Supporting climate action aligned with the Paris Agreement when engaging with policymakers.
- Working with their major industry/trade associations to advance alignment with the Paris Agreement.
- Monitoring and disclosing climate policy alignment for their companies and their major industry/trade associations.

The Action Declaration's signatories include influential global players, such as Unilever, Ingka Group (IKEA), Commerzbank, Tech Mahindra and Enel. Corporate Knights primarily invited companies previously included in its Global 100 Most Sustainable Companies and Best 50 Corporate Citizens in Canada rankings to sign the declaration. Signatory companies represent major industries from mining and finance to healthcare and tech, except oil and gas producers.

In 2021, CDL stepped up its decarbonisation commitment with more ambitious carbon emissions reduction targets validated by the Science Based Targets initiative (SBTi). By 2030, against a 2016 base year, CDL will:

- Reduce its Scope 1 and 2 Green House Gas (GHG) emissions by 63% per m² leased area.
- Reduce its Scope 3 GHG emissions from purchased goods and services by 41% per m² Gross Floor Area (GFA).
- Reduce absolute Scope 3 GHG emissions from investments by 58.8%, including hotels managed by CDL's wholly-owned hotel subsidiary, Millennium & Copthorne Hotels Limited.

In addition, in February 2021, CDL signed the World Green Building Council's (WorldGBC) Net Zero Carbon Buildings Commitment, pledging to achieve net zero operational carbon by 2030. CDL has since extended its pledge towards a net zero whole life carbon-built environment, including reducing embodied carbon.

Through this expanded commitment, CDL's new and existing

wholly-owned assets under its direct management and operational control, will operate at net zero carbon and achieve maximum embodied carbon reduction in new developments, compensating for any remaining residual operational and upfront embodied emissions via offsetting, by 2030.

CDL's robust ESG integration and disclosures are recognised by 13 prominent global ratings, rankings and indexes.

Mr Sherman Kwek, CDL Group Chief Executive Officer, said, "The climate emergency calls for urgent and collective action that transcends borders and industry sectors. Stakeholders must act with unity and resolve to amplify impact in the global Race to Zero".

Mr Toby Heaps, CEO and co-founder of Corporate Knights, said, "We are activating a sizeable economic constituency that wants to see more ambitious policy and swifter climate action. By uniting forces, we can show governments around the world that they have the support of the private sector and its major trade and industry associations".



Artist's impression of Copen Grand which is the first Building and Construction Authority (BCA) Green Mark Platinum Super Low Energy (SLE) EC in Singapore. Copen Grand also incorporates renewable energy technology in the form of photovoltaic systems that tap on solar power to partially meet the energy requirements of the clubhouse (pictured here), function room, swimming pool and gymnasium. Copen Grand is jointly developed by CDL and MCL Land.

How Singapore engineers contribute to decarbonising our built environment

by Mr Ang Kian Seng, Group Director, Environmental Sustainability Group, Building and Construction Authority



Mr Ang Kian Seng

As part of the whole-of-nation movement, ambitious targets have been set and achieved.

We have been experiencing the severe effects of climate change around the world. The past decade has been the warmest on record, and in recent years, heavier downpours have led to flooding in parts of Singapore and many other countries. With such events occurring around the world, more urgent collective action needs to be taken to lower greenhouse gas emissions.

In 2021, Singapore launched the Singapore Green Plan 2030, a whole-of-nation movement to advance Singapore's national agenda on sustainable development. It lays out ambitious and concrete targets over the next 10 years, and strengthens Singapore's commitments under the UN's 2030 Sustainable Development Agenda and Paris Agreement. It guides efforts to achieve the nation's long-term net zero emissions aspiration by 2050.

As buildings account for over 20% of Singapore's emissions, greening our buildings is key to Singapore's efforts to transit to a low-carbon and climate resilient future. Since 2006, the Building and Construction Authority (BCA) has worked steadily towards a low-carbon built environment through successive green building masterplans. The latest edition of the Singapore Green Building Masterplan (SGBMP) was launched as part of the 'Energy Reset' Pillar of Singapore's Green Plan 2030 and lays the foundation to achieve our net zero aspirations.

Singapore has set three key targets for the SGBMP, or "80-80-80 in 2030":

- 80% of buildings by Gross Floor Area to be green by 2030.

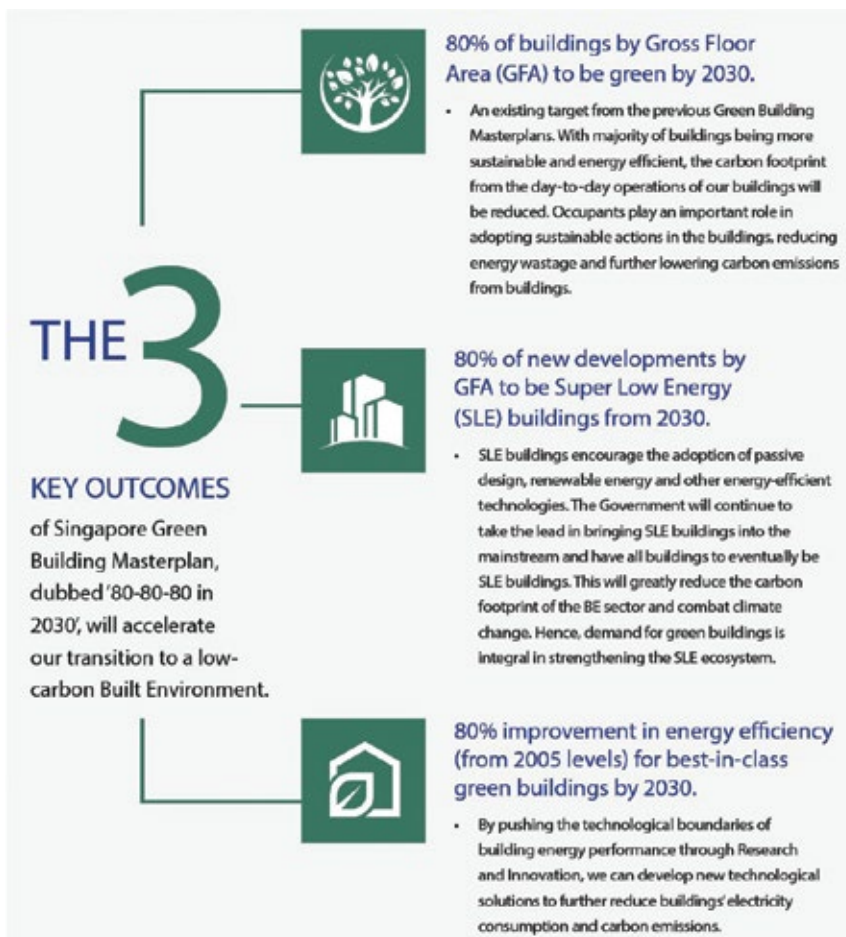
- 80% of new developments by Gross Floor Area to be Super Low Energy buildings from 2030.
- 80% improvement in energy efficiency (compared to 2005 baseline levels) for our best-in-class buildings by 2030.

Green buildings in Singapore

Engineers play a critical role in our journey to decarbonise our built environment through designing and

implementing energy-efficient systems and technologies which are evident in some of Singapore's recent green buildings. They are guided by the BCA Green Mark Scheme since it was launched in 2005.

BCA recently revised the Green Mark scheme and developed the new BCA Green Mark 2021 that is aligned with the UN's Sustainability Development Goals. It aims to raise energy performance standards and



The SGBMP Targets, or '80-80-80 in 2030'. Infographic: BCA.



Energy-efficient technologies were piloted at Keppel Bay Tower under BCA's Green Buildings Innovation Cluster (GBIC) programme. Image: Keppel.

place greater emphasis on important sustainability outcomes such as designing for maintainability, reducing embodied carbon across a building's life cycle, and creating healthier environments for building users.

Today, best-in-class buildings in Singapore are able to achieve 65% to 70% improvement in energy efficiency over 2005 levels.

The Keppel Bay Tower, certified Green Mark Platinum Zero Energy, is the first commercial building in Singapore to achieve this accolade. Under BCA's Green Buildings Innovation Cluster (GBIC) programme, Keppel Land was awarded a grant to implement new and emerging energy-efficient technologies at Keppel Bay Tower. Energy-efficient technologies such as a high-efficiency air distribution system, an innovative cooling tower water management system and smart LED lighting solutions were piloted at Keppel Bay

Tower. Later, an assembly of photovoltaic (PV) panels spanning over 400m² were installed on the roof of the 18-storey Keppel Bay Tower, as well as its six-storey podium block, generating an energy yield of about 100,000 kWh per annum.

Another notable green building is the Samwoh Smart Hub which has gone beyond Zero Energy to be certified Green Mark Platinum Positive Energy and is Singapore's first positive-energy industrial building. Through numerous smart building management systems, including the extensive use of sensors to optimise the temperature and humidity inside the four-storey structure, energy consumption of the building is kept to a minimum. Samwoh Smart Hub also has 2,588 solar panels installed to generate electricity, of which at least 25% will be returned to the national grid. Beside the hub, Samwoh has an asphalt production plant that is 15% more energy-efficient than a conventional asphalt

production plant – with the energy savings equivalent to taking 265 cars off the roads, annually.

DBS Newton Green, certified Green Mark Platinum Zero Energy, is also an outstanding example of a sustainable building. DBS completed the net zero retrofit of the 30-year-old building in collaboration with architecture house, KAIA Architects; mechanical & electrical engineering firm, CCA & Partners; and sustainability consultancy, GreenA Consultants. All are homegrown firms actively involved in Singapore's net zero space. The building uses low energy appliances such as heat pump water heaters and energy-efficient fans, coupled with re-engineered plumbing, which has reduced energy consumption in common areas such as lobbies, pantries, and social spaces by 70%. Furthermore, 10% of the floor area that was previously air-conditioned was converted to naturally



Samwoh Smart Hub, Singapore's first positive-energy industrial building. Image: Samwoh Corporation.



DBS Newton Green has been certified as a Green Mark Platinum Zero Energy building. Image: DBS Bank Ltd.

ventilated spaces that do not need air-conditioning. The building's balance energy needs are met by over 1,000 m² of solar panels deployed on the rooftop.

We hope that these innovative green buildings will inspire engi-

neers and all built environment stakeholders to continue working towards a low-carbon built environment and push the boundaries of sustainability. BCA looks forward to continued partnership with all, in transforming the way we build Singapore.

As we approach UNESCO's World Engineering Day for Sustainable Development 2023, we would like to show our appreciation to engineers all around the world for their valuable contributions to the built environment.

Leading the way in creating green and sustainable homes

The Housing & Development Board (HDB) is Singapore's public housing authority, with the responsibility to plan and develop Singapore's housing estates, build homes and transform towns, to create a quality living environment for all. With about 80% of Singapore's resident population living in some one million HDB flats, HDB continually seeks to create a high quality living environment that is green, liveable and sustainable.

New public housing projects are consciously planned with greenery and sustainable features, while older estates are continually enhanced with green features, where feasible. Through these efforts, HDB plays a key role in supporting Singapore's efforts to achieve the overall goal of growing in an efficient, clean, and green way.

Estates designed to be cool and sustainable

HDB estates are designed to create a sustainable living environment. Every HDB precinct is designed to embrace local climatic conditions. Passive design strategies are adopted, that improve ventilation, reduce heat gain and minimise the reliance on mechanical cooling. These strategies include orienting most HDB blocks in the north-south direction and designing blocks to optimise wind flow. By designing residential blocks with open corridors and designing all habitable rooms with windows, there is minimal dependence on artificial lighting in the daytime. Lush greenery is also incorporated throughout the precinct to reduce the urban heat build-up effect.

HDB also makes use of new technologies in the planning and design process, to help further optimise the use of various elements of nature to create the best possible homes. For instance, adoption of the 'Urban Environmental Modelling' smart planning tool, enables HDB to analyse wind flow, solar irradiance and shaded areas, within a town, and determine how best new flats can be designed and sited, and more greenery can be planted to

mitigate the effects of heat in hot spots, in order to provide maximum thermal comfort for residents.

Such modelling and simulation capability has enabled HDB to enhance the planning of new towns such as Punggol, Bidadari and Tengah, where wind corridors are identified, and urban design guidelines on the building forms and orientations were established, to optimise wind flow to cool the living environment naturally.

New housing developments, from 2016, also come with 45% to 60% green cover, including tree cover that provides canopy shading to cool the estates and improve thermal comfort for residents. The developments have to meet a minimum Green Plot Ratio (GnPR) of 4.5, which means the greenery should be at least 4.5 times the site area.

Every HDB flat an eco-friendly home

Beyond creating sustainable estates, HDB also took a significant step to make every flat an eco-friendly home. Since 2014, all new public housing developments are designed with a suite of eco features to manage water, energy and waste, more efficiently. They include:

- Lifts that include an energy regenerative system to recover about 30% of energy from kinetic movement and braking.
- Energy-efficient lighting, such as LEDs with motion sensors, placed at staircases and carparks, that help to reduce energy consumption from the grid.

- Centralised recycling refuse chutes for recyclables in all blocks, to promote household recycling.
- Rainwater harvesting system that makes use of collected rainwater for irrigation and cleaning of common areas, to encourage water conservation.
- Provision of dual bicycle racks to encourage green commuting.

HDB's first eco-town

In its efforts to create environmentally sustainable homes, HDB recognised the need to continually innovate and experiment with new ideas and technologies. Hence, in 2010, HDB announced Punggol as Singapore's first eco-town which is set to be a 'living laboratory' for ideas and technologies promoting sustainable development.

HDB mapped out a sustainable development framework for Punggol, focusing on energy, water, waste and resource management, urban mobility solutions, as well as estate maintenance solutions, and covering the following:

- Energy – Use of solar photovoltaic systems, elevator energy regeneration systems, energy-efficient lighting in common areas, smart grids and smart meters. These solutions are expected to reduce energy consumption in the common areas by 20%.
- Water – Rainwater harvesting, smart water meters and water quality monitoring. With these solutions, the target is to achieve a net water reduction of about 10%, over the next five years.

- **Resources and waste** – Resources are utilised optimally and waste is minimised through recycling. HDB provides recycling points at every level in the residential blocks, by building a second centralised refuse chute that is dedicated for recyclables. This will not only enhance the convenience of residents in the disposal of recyclable waste but also improve the collection efficiency of waste collectors.
- **Urban mobility** – Creating more opportunities for environmentally-friendly transport to be used. Besides encouraging residents to share cars, the use of electric vehicles is promoted through a car-sharing scheme. Charging points for the electric vehicles are also strategically located, for greater convenience of the residents using electric vehicles.

Maintenance – To achieve economic sustainability, solutions are employed to address rising maintenance costs. These include the use of fuel cell emergency power supply and self-cleansing paint that reduces maintenance costs by stretching the lifespan of paint systems.

HDB Green Towns Programme

In line with Singapore's efforts to promote sustainable development, HDB rolled out a new HDB Green Towns Programme in 2020, to make HDB towns more sustainable and liveable by 2030. The HDB Green Towns Programme, which supports the Singapore Green Plan in building a more sustainable future for Singapore in the face of climate change, is an ambitious 10-year plan to improve residents' quality of life, through the large-scale implementation of green features. The programme will focus on addressing three areas in sustainability and liveability – reducing energy consumption, recycling rainwater, and cooling HDB towns. It will bring together initiatives that have already been implemented or trialled successfully in some HDB estates, as well as new initiatives that have the potential for scaling up.



With close to 10,000 HDB blocks located islandwide, HDB is currently the largest driver for the installation of solar PV systems in Singapore. Image: HDB.

Tapping the sun

Harnessing solar energy is part of HDB's holistic efforts to promote green and sustainable living, as well as a key initiative under the HDB Green Towns Programme. Given Singapore's geographical size, lack of natural resources and tropical weather with lots of sunshine, solar energy is the most feasible source of renewable energy. HDB's journey in developing solar capabilities began in 2008, when it embarked on sustainable and innovative solutions to enable Singapore harness solar energy on a large scale.

Today, HDB is the largest driver for the installation of solar photovoltaic (PV) systems in Singapore. Under the SolarNova programme that HDB jointly leads with the Singapore Economic Development Board (EDB), HDB aggregates public sector demand for the installation of solar panels across HDB blocks and government sites. This generates more clean energy and helps to reduce carbon emissions, thereby mitigating the effects of climate change.

HDB has committed to a solar target of 540 megawatt-peak (MWp) by 2030. This could potentially generate 648 GWh of clean energy annually, reducing carbon emissions by 324,000 tonnes per year. This can generate enough energy, annually, to power 135,000 4-room HDB flats.

There are currently about 10,000 HDB blocks in Singapore, and the intention is to install solar panels on as many HDB blocks as possible. To-date, more than 8,400 HDB blocks have been committed for the installation of solar panels, to help reduce Singapore's carbon footprint.

On average, the solar energy generated by a typical HDB block is sufficient to meet the energy demand for the common services (e.g. lifts, lights and water pumps). This enables the blocks to achieve net-zero energy consumption for the common areas, and can help town councils to moderate increases in operating and maintenance costs. Excess solar energy is channelled back to Singapore's electrical grid.

Singapore's Electric Vehicles Vision

The electrification of vehicles is one of the key initiatives that will help achieve the national target of net zero emissions by 2050.



LTA has procured and deployed 60 electric buses, with the eventual aim of phasing out all diesel-engine buses by 2040.

Singapore aims to significantly reduce land transport emissions, in absolute terms. The modes of transport that can help achieve this goal include walking, cycling, taking public transport and using electric vehicles (EVs).

The Singapore Green Plan 2030 includes a strong push to electrify the vehicle population. From 2025, all new diesel car and taxi registrations will cease. From 2030, all new car and taxi registrations will need to be of cleaner energy models. These targets are part of Singapore's vision to have all vehicles run on cleaner energy by 2040.

With lower carbon emissions to cheaper operating costs, EVs are poised to power the future of the nation's land transport system. The transition to EVs is a key thrust in greening Singapore's land transport system.



The government plans to install up to 60,000 charging points by 2030, up from the estimated 2,200 currently available.

The Land Transport Authority's (LTA) '8 Facts to Charge Up Your Knowledge About Electric Vehicles' (<https://bit.ly/8EVfacts>) provides more information on the efforts to

promote wider EV adoption as part of Singapore's Green Plan.

(The contents of this article are contributed by the Land Transport Authority.)



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Journey to net zero and the critical role of digitalisation

By Peter Ferguson, General Manager, Southeast Asia, Johnson Controls



Peter Ferguson

The built environment industry has become increasingly aware of its responsibility to do more.

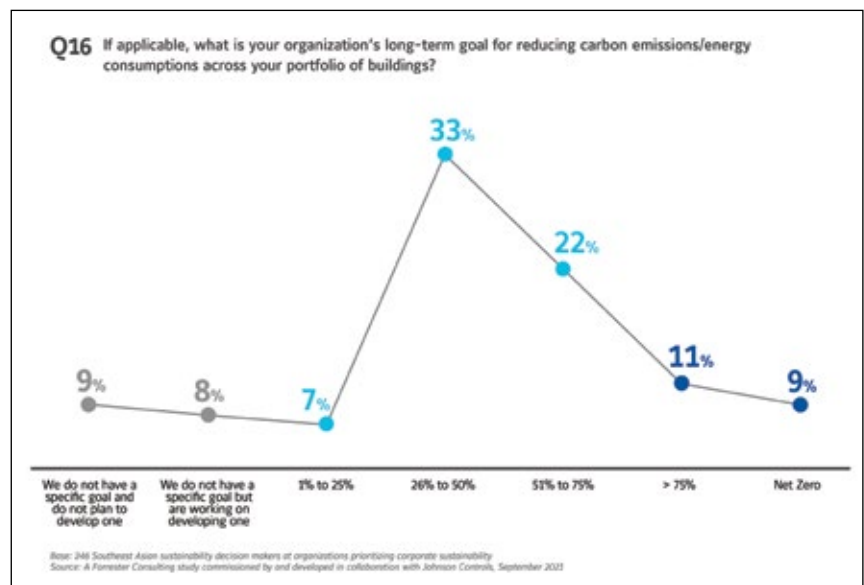
During the recent FIFA World Cup 2022, the eight World Cup stadiums, in Qatar, became one connected digital space with real-time situational awareness and incident management, thanks to the pivotal role of Johnson Controls.

Johnson Controls' OpenBlue digital platform provided the command centre experts visibility into operations across the eight football stadiums in Qatar. Each stadium has its own interactive 3D digital twin that delivers live data on all aspects of occupant safety, comfort and sustainability, allowing for dynamic predictions and fully flexible solutions for changing scenarios. This approach resolves incidents – such as how crowd size and weather changes might affect energy efficiency and playing conditions – significantly faster than a traditional solution. This is setting new standards for the future of large venue operations.

Nearer home in Southeast Asia, we have also been partnering building and facility owners, to digitalise building management to achieve important outcomes including smart operations, wellness and safety as well as decarbonisation. In recent years, there has been a sharp increase in the awareness, adoption and impact of environmental, social and governance (ESG) metrics in Asia. Some 70% of business leaders from Southeast Asia have identified sustainability as an increasing priority, but many face hurdles around coordination across multiple teams, partners and sites, according to a survey commissioned by Johnson Controls.



Johnson Controls' OpenBlue digital platform provided the command centre experts visibility into operations across the eight football stadiums used during World Cup 2022.



Results of a survey of the views of decision-makers in Southeast Asia on sustainability.

Journey to net zero

The built environment industry has growing awareness of its responsibility to deliver a resilient, sustainable future, given that buildings

account for about 40% of the world's carbon emissions. Furthermore, rapid urbanisation around the world is expected to double the building stock by 2050.

While energy efficiency – which has long been a key agenda in the built environment – is a necessary step to achieving net zero, it is not sufficient. Digitalisation is a critical step in the journey to net zero, too. For example, Johnson Controls' OpenBlue digital platform leverages AI and cloud technology, harvests data from sensors embedded in edge equipment and creates a holistic data model of real-time operations. Known as a digital twin, the data forms an accurate model of key building operations. The digital twin learns and acts through smart elements, such as remote diagnostics and compliance monitoring, to inform company leaders what factors are contributing to their Scope 1, Scope 2 and even Scope 3 emissions.

The journey to net zero requires more extensive efforts. Johnson Controls has crystallised what is needed for companies to decarbonise their buildings into an eight-step process. The Johnson Controls OpenBlue Net Zero Buildings is a full spectrum of sustainability offerings that includes desired outcomes and risk management models. Employing this eight-step decarbonisation methodology and partnering complementary companies, Johnson Controls provides a single source turnkey delivery for customers to assess, benchmark, plan, execute, track and achieve net zero buildings.

Recently, the OpenBlue Net Zero Buildings as-a-Service model has helped the Powerhouse Alliance, a Norwegian collaboration for energy innovation, to implement an energy system that harvests twice the buildings' annual energy consumption by drawing heating and cooling energy from the ocean, to power buildings, electric buses, cars and boats, through a local microgrid. Johnson Controls is now rolling out this turnkey solution in Asia Pacific with Singapore as a key market.

Walking the talk

Everyone has a part to play in reining back the earth from breaching the 1.5° C global temperature rise limit. This means 'rapid, deep and sustained reductions in global



Johnson Controls has developed an eight-step process to help buildings reach net zero.

greenhouse gas emissions of 43% by 2030 relative to the 2019 level', as stated in the Sharm el-Sheikh Implementation Plan that was agreed to, at the COP27 Summit.

Johnson Controls is committed to cut our Scope 1 and 2 emissions by 55% and Scope 3 emissions related to our customers' use of our products by 16%, in absolute terms, by 2030 relative to our 2017 baseline, along with actions supporting emissions reductions in our supply chain. In December 2022, we were awarded the EcoVadis Platinum Sustainability Rating, the highest distinction granted for the sustainability of supply chains. We are determined to achieve our commitment of Net Zero Scope 1 and 2 emissions by 2040, 10 years ahead of the goal set out in the Paris Climate Agreement.

Through our example, our business and our partnerships, we want to make a difference. While the challenges can look daunting, I am optimistic that engineers and engineering companies, like Johnson Controls, will step up to enable a resilient, sustainable future.

Recognition for sustainability

Johnson Controls has been recognised as one of the World's 100 Most Sustainable Corporations by Corporate Knights, for the ninth year in a row.

The company will continue its efforts towards the following:

- Achieving Scope 1, 2 and 3 science based absolute carbon emission reductions by 2030.
- Reaching climate goals ahead of the Paris Climate Agreement goal of 2050 and achieving net zero operational emissions by 2040.
- Sourcing 100% renewable energy by 2040.
- Committing to invest at least 75% of new product R&D in climate-related innovation and sustainable products and services.

The new era of sustainable design

‘The Singapore Engineer’ spoke to Mr Kintaro Izumida, Vice President and General Manager, Japan and Asia Regional Operations, Johnson Controls-Hitachi Air Conditioning, during the launch of the company’s new air365 Max Pro HVAC solution in Singapore, on the company’s strategies for the region and the benefits of the new product, particularly in terms of sustainability and Indoor Air Quality.



Mr Kintaro Izumida

‘The Singapore Engineer’ (TSE): What is your strategic direction in the Singapore and Southeast Asian markets?

Mr Kintaro Izumida (KI): Singapore is not only one of our key markets, it is also the epicentre for advanced developments. We expect our success in Singapore to spread all over Southeast Asia.

The importance of the Singapore and Southeast Asian markets has become extremely great, with the increasing demand for smart HVAC systems and for clean indoor air, especially after the COVID-19 pandemic.

We are embracing the new era of sustainable HVAC design as well as the IoT revolution and the application of AI (Artificial Intelligence) which bring the power of connectivity and big data to the forefront.

We prioritise growth in Singapore and Southeast Asia – a region with heavy use of air-conditioning. We will invest more in this region.

Our route to market is a 100% indirect business model, characterised by strong collaboration with channel partners and customers.

TSE: What are some of the main building types (office buildings, industrial buildings etc) where the new air365 Max Pro HVAC solution can be successfully deployed?

KI: Our air365 Max Pro units are designed to work in harmony with both outdoor and indoor spaces. With our various modules, air365 Max Pro offers a vast array of capacities from 8 HP to 88 HP. Due to its large capacity and flexibility in installation, the air365 Max Pro fits perfectly into any healthcare, education, industrial or office facilities.

Lighter and smaller than ever before, they are easier and cheaper to transport and can be easily installed anywhere within the building. Additionally, the High External Static Pressure (ESP) setting for air365 Max Pro units enables them to be located even in ventilated machine rooms, rather than just outdoors. This may reduce installation costs as well as the impact on the external facade of the building. Overall, they occupy less space in buildings, rooftops or balconies, thereby providing building owners the flexibility to design rooftop gardens aesthetically.

The air365 Max Pro is compatible with as many as 16 series and 134 models of Hitachi indoor units, featuring the most advanced indoor comfort innovations.

TSE: How does the product improve energy efficiency?

KI: The air365 Max Pro, is powered by Hitachi SmoothDrive 2.0 technologies. These technologies contribute to the very high levels of energy efficiency defining the Hitachi VRF (Variable Refrigerant Flow) HVAC solutions, under part-load operation.

The SmoothDrive 2.0 helps the scroll compressor to run continuously and smoothly, even under part-load conditions. The integration of the inverter technology into SmoothDrive is key for greater accuracy of the overall refrigerant flow. The SmoothDrive 2.0 continuously tracks the indoor temperature in each zone and identifies gaps with the set temperatures. Combining real-time indoor monitoring and the VRF system data-point, SmoothDrive 2.0 constantly calculates the right amount of

refrigerant needed to maintain seamless indoor comfort.

It has been confirmed that SmoothDrive 2.0 contributes to 39% less energy-consumption at 33% part-load operation.

In addition, the all-new SIGMA (Σ) shaped heat exchanger and gas injection scroll compressor extend the compressor operating range and increase heating or cooling capacity, leading to a wider outdoor unit operating temperature range and better efficiency. With this, the air365 Max Pro achieves a Best-in-class Tick mark product rating, with COP up to 5.13 & IEER up to 6.20 (based on NEA certification).

TSE: What is the refrigerant used and how is its use minimised?

KI: The air365 Max Pro uses non-ozone-depleting R410A refrigerant. Compared with our previous generation VRF product, air365 Max Pro uses 10% less refrigerant, on average, and 14.6% less refrigerant, at the maximum (Simulation Condition: Comparison between Single 8~28 HP Class (Tier 2) under 95% connection ratio), thereby helping to reduce the environmental footprint and maintenance costs.

TSE: Could you comment on the ease of maintenance of the HVAC system?

KI: For large building and complex environments, like hospitals, a proper design of the HVAC system is essential to ensure high indoor air quality (IAQ) and comfort within the facilities. As a hospital requires stable temperature, humidity and air pressure control, proper HVAC maintenance is crucial, to avoid potential breakdowns that will be

catastrophic for the functioning of the facility.

The Hitachi VRF System air365 Max Pro is an end-to-end solution that is easy to work with, from design to installation, operation and maintenance, and offers high energy efficiency and seamless comfort for users.

We have introduced the new air-Cloud Tap (mobile app to support servicing and installation) which enables the system settings to be accessed by simply tapping on a smart phone held over the Hitachi Air Conditioner equipment, thus replacing manual configuration. An intuitive interface enables easy setting of the VRF System, without an internet connection, as it is Near Field Communication (NFC)-enabled.

Through simulation performed at Johnson Control-Hitachi's engineering site, it has been confirmed that configuration can be completed two times faster than through conventional manual configuration, especially since it is possible to 'copy and paste' settings from one ODU (or IDU via an individual controller) to multiple units, using smart phones. This will be ideal for hotels, classrooms, businesses with multiple meeting rooms or large buildings with multiple VRF outdoor units installed. It is definitely an 'easy to work with' tool for every professional.

TSE: Looking to the future, what is your strategy for product development?

KI: Our parent company, Johnson Controls, has a great commitment to Environmental, Social & Governance (ESG) criteria. We have conducted a variety of sustainability activities in pursuit of our promise to customers to 'advance the safety, comfort and intelligence of spaces and places to power your mission'. Johnson Controls has set ambitious ESG commitments to prioritise stakeholder wellbeing and is committed to achieve net zero carbon emissions by 2040. One of our initiatives is to provide more sustainable products and services.

We have three very important

objectives in our product development – sustainability, wellbeing and digitalisation. The importance of HVAC systems has become greater, all over the world, especially due to the effects of climate change.

“For Johnson Controls-Hitachi Air Conditioning, Southeast Asia is very important. The region presents a great opportunity for growth. It is crucial that we achieve growth in Southeast Asia. And Singapore is the starting point.

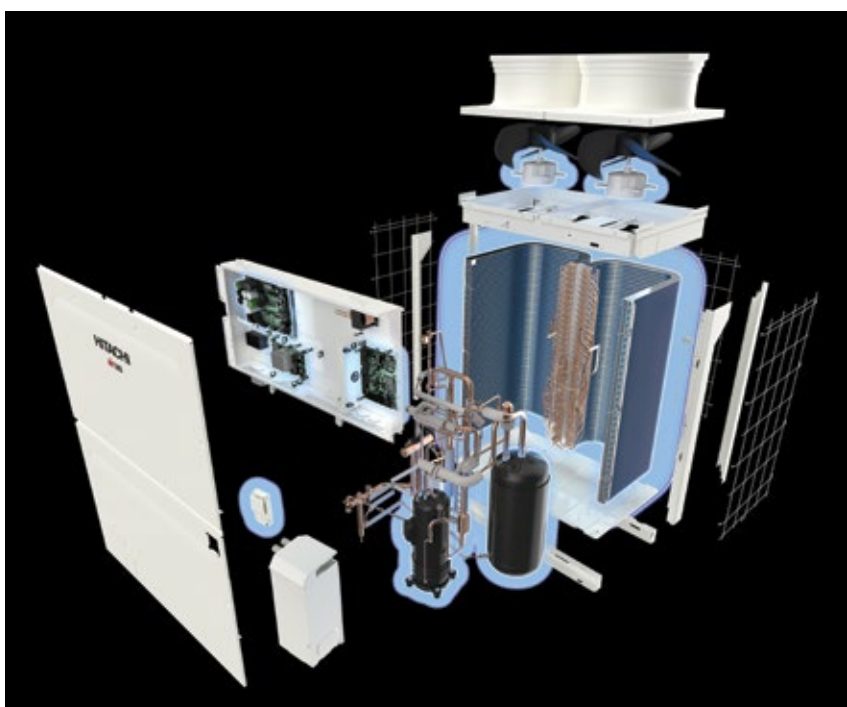
If we succeed in Singapore, we will succeed in the region. This is our basic strategy. To achieve our goal, we have good products, good marketing and good people”– Mr Kintaro Izumida, Vice President and General Manager, Japan and Asia Regional Operations, Johnson Controls-Hitachi Air Conditioning.

Today, they have become a part of social infrastructure. In the past, HVAC systems had a negative impact on the environment, because of their energy consumption and the use of fluorocarbons in the refrigerants. Therefore, we can say that innovation in the area of HVAC can greatly contribute to the environment. So, we will continue to make efforts to develop energy-saving products that use refrigerants with low ODP (ozone depletion potential) and low GWP (global warming potential).

People have also become more attentive. The quality of air has an impact on people's health. It is one of our important missions to provide good quality indoor air, through our products and solutions.



Rooftop installation of the air365 Max Pro.



Exploded image of the air365 Max Pro.

Johnson Controls-Hitachi Air Conditioning launches the air365 Max Pro HVAC solution

Johnson Controls-Hitachi Air Conditioning achieved an important milestone with the launch of the air365 Max Pro VRF solution in Southeast Asia, starting with Singapore. The air365 Max Pro is designed with seamless comfort, energy efficiency and easily workable features. It is currently available in Australia and New Zealand and will also be available in Europe and North America, later this year.

Built with best-in-class efficiency, the air365 Max Pro offers efficient energy consumption, made possible by the SmoothDrive 2.0 technology which helps reduce running costs during part-load operation which also leads to reduced CO₂ emissions.

The air365 Max Pro, with a wider operation temperature range, provides seamless comfort for building occupants, by solving problems such as unstable temperatures, cold/hot air drafts, seasonal room temperature changes, and more. Users can expect constant regulated indoor temperature through the SmoothDrive 2.0 technology allowing for precise temperature monitoring.

This outdoor unit (ODU) has a NFC touching point on the ODU surface. With Hitachi's hardware and smart app features working together, HVAC professionals, architects, and building owners can see the air365 Max Pro as a complete solution, saving time and money at every stage from design to maintenance. The air365 Max Pro can be easily operated with the airCloud Pro, and easily

installed and maintained with airCloud Tap.

Johnson Controls-Hitachi Air Conditioning

Johnson Controls-Hitachi Air Conditioning is a global air conditioning manufacturer established in October 2015, as a joint venture between Johnson Controls and Hitachi Appliances (now Hitachi Global Life Solutions).



Johnson Controls-Hitachi Air Conditioning has launched the the air365 Max Pro HVAC solution in Singapore.



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The importance of refrigerants in building a greener Singapore

As they have a vital role play in the air-conditioning industry, their impact on the environment, energy efficiency, and green building standards is a topic of ongoing discussion. In this article, Carrier shares some of the basics on the subject and points to the way forward.

What are refrigerants?

A refrigerant is a substance that is used in HVAC (heating, ventilation and air conditioning) systems to transfer heat from the inside of a building to the outside. It is typically a fluid that is vaporised and condensed in a closed loop system to transfer heat. There are several types of refrigerants available, including chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), hydrofluoroolefins (HFOs), hydrochlorofluoroolefins (HCFOs) and natural refrigerants, such as ammonia, carbon dioxide and hydrocarbons. Refrigerants are classified based on their physical and chemical properties, such as boiling point, toxicity, flammability, ozone depletion potential (ODP) and global warming potential (GWP).

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 34 [1] assigns a safety classification system for refrigerants, based on their flammability and toxicity, and assigns a number (R-number) and a letter (A-G) to each refrigerant based on their flammability and toxicity (Figure 1). R-1233zd(E), for example, has an A1 safety classification. This means that it is a low-pressure refrigerant with a global warming potential (GWP) of less than 150, is non-toxic, non-flammable and has no known ozone depletion potential (ODP). Meanwhile, the European standard EN 378 also classifies refrigerants in terms of their flammability and toxicity, and assigns a safety class based on the results of laboratory tests.

Impact of refrigerants on the environment

The history of refrigerants can be traced back to the late 19th century,

when the first mechanical refrigeration systems were developed. These systems used chemicals, known as refrigerants, to absorb and release heat, in order to cool the air. Over the years, various types of refrigerants have been used and it was discovered that many of these refrigerants had a negative impact on the environment.

In the past, chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) were commonly used as refrigerants, but due to their ozone-depleting properties, they have been phased out, in accordance with the Montreal Protocol, an international agreement to protect the ozone layer which has the function of shielding humans and the environment from harmful levels of ultraviolet (UV) radiation from the sun.

As a replacement, hydrofluorocarbons (HFCs) were widely adopted. However, they have a high global warming potential (GWP) which contributes to climate change. In response, hydrofluoroolefins (HFOs) and hydrochlorofluoroolefins (HCFOs) were developed as low-GWP alternatives to HFCs, with a GWP of less than 150.

Another environmental concern associated with refrigerants is their potential to leak into the atmosphere. Leaks can occur due to poor installation, lack of maintenance or equipment failures. Once released into the atmosphere, these refrigerants can have a significant, adverse impact on the environment.

Impact of refrigerants on energy efficiency

In terms of energy efficiency, refrigerants play a critical role. The efficiency of an air-conditioning system

is directly related to the refrigerant used. Low-GWP refrigerants can help reduce the overall energy consumption of HVAC systems, in a few ways. Low-GWP refrigerants have a lower pressure drop than high GWP refrigerants, which means that they require less energy to circulate through the system. They also have a lower discharge temperature than high-GWP refrigerants, which means that the compressor can operate at lower temperatures.

This can result in lower compressor power consumption and, thus, lower energy consumption. In addition, low-GWP refrigerants generally have a higher heat transfer coefficient than high-GWP refrigerants, which means that they can transfer heat more efficiently. This can result in improved system performance, and thus lower energy consumption.

However, it is crucial to remember that the overall energy consumption of an HVAC system depends on many factors, including the system's design and operation. Low-GWP refrigerants should be used as part of a comprehensive strategy to increase the energy efficiency of an HVAC system, even though they can aid in lowering energy consumption.

Meeting Singapore's green building standards and other initiatives

For building owners and HVAC professionals, the choice of refrigerant used in the HVAC systems can have a significant impact on their ability to meet green building standards and certifications. In Singapore, the adoption of green building standards is highly encouraged. These standards aim to reduce the environmental impact of buildings,

by promoting the use of energy-efficient technologies for refrigeration and air-conditioning systems. For example, the Building and Construction Authority (BCA) has developed the Green Mark scheme which rates the environmental performance of buildings, based on a variety of criteria, including the use of energy-efficient refrigeration and air-conditioning systems. To achieve a Green Mark rating, buildings must use refrigerants with a low GWP and meet other energy-efficiency requirements.

At a global level, organisations like the U S Green Building Council (USGBC) have set specific requirements for refrigerant choice and system performance, in order to promote energy efficiency and reduce the impact on the environment. For example, according to the USGBC, using a refrigerant with a high GWP value, such as R-134a, may disqualify a building from earning LEED credits. On the other hand, using low GWP refrigerants such as hydrofluoroolefins (HFOs) and natural refrigerants like R-290 (Propane) and R-744 (CO₂) can help a building qualify for credits and align with global sustainability goals.

To promote the use of more environmentally friendly refrigerants, Singapore has implemented several measures. For example, the National Environment Agency (NEA) has developed a voluntary energy efficiency labelling scheme for air-conditioners [2]. This scheme rates the energy efficiency of air-conditioners, based on the type of refrigerant used and the system's energy performance. NEA has also supported the phase-out of high-ODP refrigerants under the Montreal Protocol and encouraged the use of more environmentally friendly alternatives.

The way forward for refrigerant selection

What is the next step, then? The solution is not that straightforward. When choosing a suitable refrigerant, there is a need to consider the issue holistically. As an example, some low-GWP refrigerants may be worse for the environment,

than the current ones. They may take more energy to run, lose capacity, be more costly, require a larger equipment footprint, and can be flammable. Before choosing a refrigerant, it is important to evaluate all the variables and find the one that offers the best balance between performance, safety and environmental impact. Before making a choice, it is also essential to take into account the applicable laws, the cost and availability of the refrigerant, and its compatibility with the materials and equipment used in the HVAC system.

Carrier

Founded by the inventor of modern air-conditioning, Carrier is a world leader in high-technology heating, air-conditioning and refrigeration

solutions. Carrier experts provide sustainable solutions, integrating energy-efficient products, building controls and energy services for residential, commercial, retail, transport and food service customers. Carrier is a part of Carrier Global Corporation, a leading provider of healthy, safe, sustainable and intelligent building and cold chain solutions.

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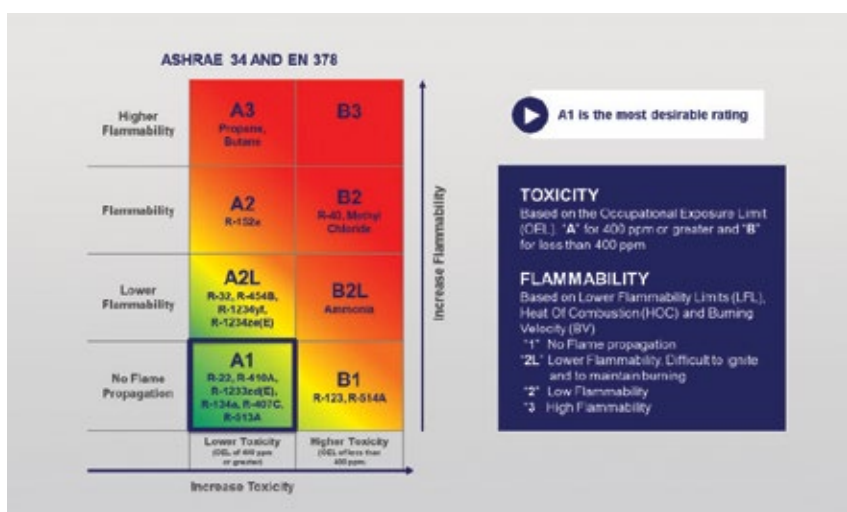


Figure 1: Refrigerant classification.



Figure 2: New refrigerant selection cycle.

Decarbonisation and energy resilience in the built environment

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Technology, industry transformation and government initiatives are helping to drive a more sustainable and energy resilient built environment in Singapore. SIT is working with partners to support Singapore's sustainability efforts.

Singapore's energy sector is undergoing a transformation, through a multitude of pathways, to achieve decarbonisation. With the strong impetus to reduce carbon emissions from energy supplies, renewables such as solar, wind energy and other types of low carbon alternatives, have seen significant cost reduction over the last decade, along with which, a strong global supply chain has emerged around the renewable economy. A key enabler for reliable and secure, large-scale penetration of renewable energy, which is intermittent in nature, is energy storage, including the widespread use of electrochemical batteries; large-scale, hydro-power storage; and chemical storage using chemicals such as hydrogen. Enhanced inter-connection between energy systems, through regional power grids, enables higher energy resilience and a deeper level of decarbonisation.

In addition to the energy supply, energy management for grid-interactive buildings, consumption and demand side flexibility play an equally important role. Decarbonisation of the built environment, especially the building sector, requires more than just constructing new buildings and converting existing buildings into net-zero energy buildings.

There are five fundamentals to the zero carbon building policies – energy efficiency, renewable energy, grid integration and energy storage, building electrification,

and life cycle impact of materials. With a much higher percentage of distributed energy resources in the future energy system, optimised algorithms for energy management, enhanced coordination of supply and demand, optimal use of energy storage and increased demand response capabilities will contribute to timely adaptation to the new energy paradigm.

At the Singapore Institute of Technology (SIT), we have conducted a number of research projects in relevant areas, including decarbonisation of the built environment, enhancement of energy resilience through distributed energy resources, building energy efficiency, energy management, renewable energy integration and energy storage.

Solar and wind energy, two of the main types of variable renewable energy (VRE), play an important role in fighting climate change, by achieving deep decarbonisation of global energy systems while meeting rising energy needs. In past years, solar and wind generation which are carbon-emission-free in their operation, have seen significant cost reductions.

One distinct feature is that, compared with power generation from traditional fossil fuels, power generation from VRE resources is intermittent and unpredictable, as they are greatly dependent on weather conditions. Therefore, it is a great challenge to design and dispatch an

energy supply system, with a large share of power generation from VRE resources, that can meet the demand reliably.

Energy storage becomes a key enabler to balance the intermittent energy supply and the variations in energy demand, to ensure the reliability and economic viability of the future low-carbon grids. Energy storage contributes to deep decarbonisation of energy systems that rely on carbon-emission-free, but intermittent VRE generation, while maintaining grid stability.

Energy storage technologies are not limited to the widely known electrochemical storage systems, such as batteries. They differ vastly in their material requirements and their values, both practically and economically, in low-carbon energy systems. Apart from investments in multiple energy storage technologies to advance their technological readiness, regional transmission design and demand flexibility are also important in shaping energy transition pathways.

There are four main types of energy storage technologies, namely, electrochemical, thermal, chemical and mechanical. The energy storage technologies have varying levels of readiness. The fundamental functions performed by energy storage are energy buffering and energy arbitrage.

More specifically, energy storage takes in energy when the VRE

generation is abundant and releases energy when VRE generation is low, or it takes in energy when electricity prices are low and releases energy when prices are high. Numerically, energy storage can be characterised by power capacity, energy capacity and round trip efficiency. Power capacity refers to the maximum instantaneous power that can be offered and is usually measured in megawatts (MW). Energy capacity refers to the period of time a technology can offer a certain power level and is usually measured in megawatt-hours (MWh). Round trip efficiency refers to the percentage of energy return from discharging an energy storage system, over the energy used to charge it.

Electrochemical storage systems include the mostly commonly known lithium-ion batteries, redox flow batteries (RFBs) and metal air batteries. An electrochemical storage system converts electrical energy into potential chemical energy while charging, and releases electrical energy from the chemical energy while discharging. The charging and discharging processes are governed by reduction and oxidation reactions which take place in a battery cell.

Lithium-ion batteries have a high power density as well as high energy density and round-trip efficiency, which make them compact in size, versatile and scalable. They are widely popular in applications such as consumer electronics and increasingly in electric vehicles and short-duration grid applications for up to 8 hours. Limitations on the availability of raw materials for lithium-ion batteries constrain potential cost reduction and performance improvements.

In the future, while lithium-ion batteries will stay a key player in the energy storage field, especially for shorter duration storage, their prospects for large-scale adoption in longer duration applications, beyond 12 hours, are unlikely to be high. RFBs have several advantages for stationary grid energy storage applications. The energy and power capacity of RFBs are decoupled, which makes it possible to custom-

ise sizing for particular applications. RFBs also have a longer life-span than lithium-ion batteries and a lower manufacturing cost. The limitations of RFBs lie with their lower energy density, lower cell voltage and a narrow window of electrochemical stability.

Thermal energy storage (TES) works by storing energy as heat which is generated using electricity, at which point, the heat is insulated. When needed, the insulated heat is released and converted back to electricity. Until recently, the majority of the world's electricity supply came from thermal power sources. In the new decarbonised energy systems, heat sources will slowly transition to other types of non-fossil-fuel-based sources such as geothermal energy, hydrogen, solar thermal and biomass. TES is highly suitable for longer duration storage, due to a combination of high power and low energy costs.

The relatively low round trip efficiency of TES is mainly due to the low efficiency in the heat-to-electricity conversion. Strategies, such as repurposing existing steam turbine power plants, using alternative power cycles, and developing high-temperature power conversion devices, can help tackle challenges of low efficiency in the heat-to-electricity conversion.

In chemical energy storage, electricity is used to produce a chemical compound which stores energy and, when needed, the stored energy is converted back to electricity. Hydrogen is considered as a leading chemical energy storage medium. Hydrogen can be produced in a single step, through electrolysis.

Once produced, hydrogen can be consumed either as a traditional feedstock for industrial or transportation processes or as a fuel to produce electric power. Compared with electrochemical and TES systems, the use of hydrogen has advantages including low cost relative to energy capacity and negligible self-discharge over a long duration of storage. The above-mentioned potential of hydrogen, which enables applications beyond its use in electrical systems, increases

its utilisation, for the same investment, which further improves the cost-effectiveness of hydrogen applications in the longer term.

Power generation assets that use hydrogen fuel can be used as a substitute for gas-fuelled plants, in balancing supply and demand in an energy system with high VRE generation. One of the main disadvantages of hydrogen is its low energy density. For wider adoption of hydrogen, improvements are needed for the entire supply chain covering hydrogen production, transport, storage, power production and innovations in end-user applications, to bring down the overall cost and achieve economies of scale.

Mechanical storage works by converting electrical energy into mechanical energy and storing it in the form of gravitational potential energy or kinetic energy. The stored energy is activated and converted back to electricity, when needed. Mechanical storage is the most suitable candidate, among all methods, for large-scale and long duration storage applications. The two main types of large-scale, grid-scale energy storage are pumped storage hydropower (PSH) and compressed air energy storage. High capital investment and stringent geographical requirements make green-field PSH less attractive, nowadays. Favourable opportunities lie with brownfield projects which make full use of existing hydro power plants and also the existing substations and transmission lines of retired gas-fired plants.

It is critical to design flexible power systems that can integrate large-scale VRE systems and meet future electricity demand, without violating system reliability criteria. In view of limited dispatchable generation, such as from natural gas and coal generation, in future low-carbon, energy systems, power system flexibility can be enhanced through deployment of various energy storage technologies, enhanced power network connectivity that better exchanges and balances spatiotemporal variations in VRE generation, and demand side management.

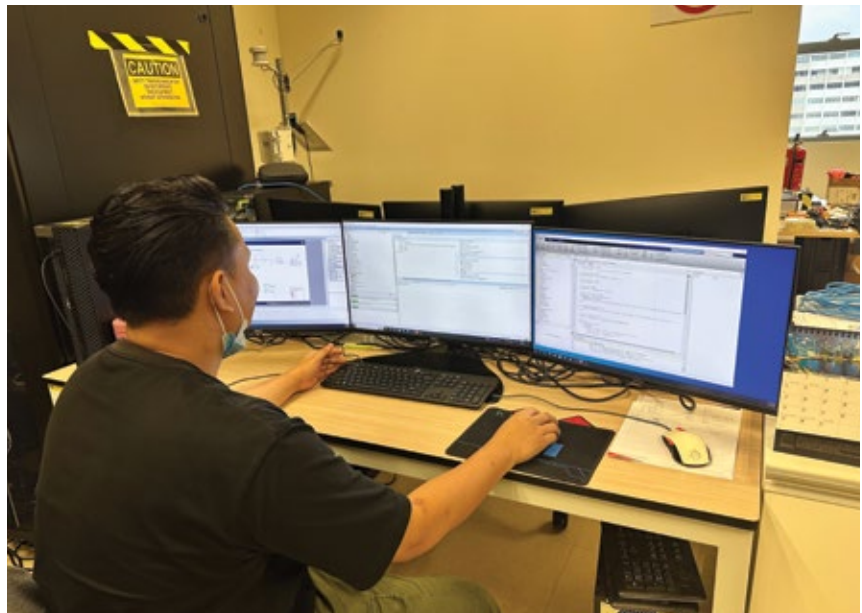
Contributing towards a more sustainable and energy resilient built environment

In the fields of renewable energy integration and energy storage, SIT is working with EDPR Sunseap on Pulau Ubin Micro-grid Test-bed Phase 3. The overall aim of the project is to investigate and expand techno-economic capabilities of integrated, multiple distributed energy resources (DERs) within a microgrid. The performance of different types of DERs, including both VRE-based generation and energy storage, will be evaluated through a combination of hardware and software deployment. Operational efficiency and economic effectiveness will be validated on an actual microgrid serving residential and commercial loads. The project is composed of two sub-projects.

One is to enhance the PV efficiency through a green roof. The other is to develop and demonstrate the advanced vanadium redox flow battery in a microgrid, with high round trip efficiency.

SIT is also collaborating with Building System and Diagnostic Pte Ltd, Regentech Pte Ltd, as well as partners in Korea, On-Test Inc and Korea University, on a project that aims to develop a management system for mitigating fire hazards in energy storage systems (ESS), under hot and humid climates. The project will lead to a better understanding of how Singapore's climate might affect the ESS in terms of stability and efficiency. By utilising a combination of artificial intelligence-driven battery degradation analytics and new cooling methods (air and water cooling), the system aims to regulate the temperature of the ESS to ensure efficiency without compromising safety.

For grid control to adopt renewables and diesel power generation as source supply to meet load demand, modelling has also been done in the EDGE project, with SP Group, on a microgrid digital twin. The project involved modelling of the generation assets, inclusive of both renewables-powered and fossil-fuel-powered generation, and also of battery storage, to meet the



A research engineer working on the digital twin of a microgrid.

demands of SIT's future Punggol campus. Interconnection with the energy management controller was also studied, with the models built in OPAL RT to carry out case studies for hardware in the loop.

This allows SIT to mimic disruptions to generation, power surges and so on. The PV and battery degradation, with usage, was studied with models proposed for the degradation. The project represents efforts to decarbonise the built environment, with hybrid usage of both power generation using green renewables and main grid generation through traditional resources. Through better planning and scheduling to meet load demands, the comfort of dwellers will not be compromised and the journey towards decarbonisation is fulfilled.

Building energy efficiency is another key pillar to achieve net zero carbon in the built environment. The release of the Singapore Green Plan 2030, in 2021, and the launch of the Building and Construction Authority (BCA) Green Mark 2021 have more deeply emphasised the importance of the efficiency in cooling energy consumption by buildings in Singapore. Since its launch in 2005, the BCA Green Mark certification has pushed the boundaries in energy efficiency. Un-



Hardware in the loop simulation server for the microgrid digital twin.

der the Singapore Green Building Masterplan, the target is to achieve 80% energy efficiency improvement from the 2005 baseline level, by 2030.

SIT has been actively involved in helping the built environment sector to conduct testing and prototyping of cooling technology, to push the boundaries of existing cooling technology. One example is the Passive Displacement Cooling (PDC) system, which has been identified by BCA as one of the cooling technologies that can

help to create a super low energy building.

The PDC system is designed to support the basic principle of natural convection heat transfer which has the best heat transfer efficiency and latent heat cooling capacity. In collaboration with Shinhan-Tech Engineering Pte Ltd and MET Engineering Pte Ltd, a Passive Displacement Dual Cooling Coil (PDDCC) system was evaluated and its design improved, through the utilisation of Computational Fluid Dynamics simulations, mock-up parametric tests in the BCA Skylab and implementation in a hotel.

From this research, there were two developments that could lead to greater adoption of this cooling technology in the market.

The first was the development of a design guideline for the generic sizing of the PDDCC system. This design guideline is based on parametric analyses of the variation of critical design parameters such as floor-to-ceiling height, estimated internal heat load of the designated space, temperature setpoint of supplied chilled water, and the height of the fall duct for the cooling unit.

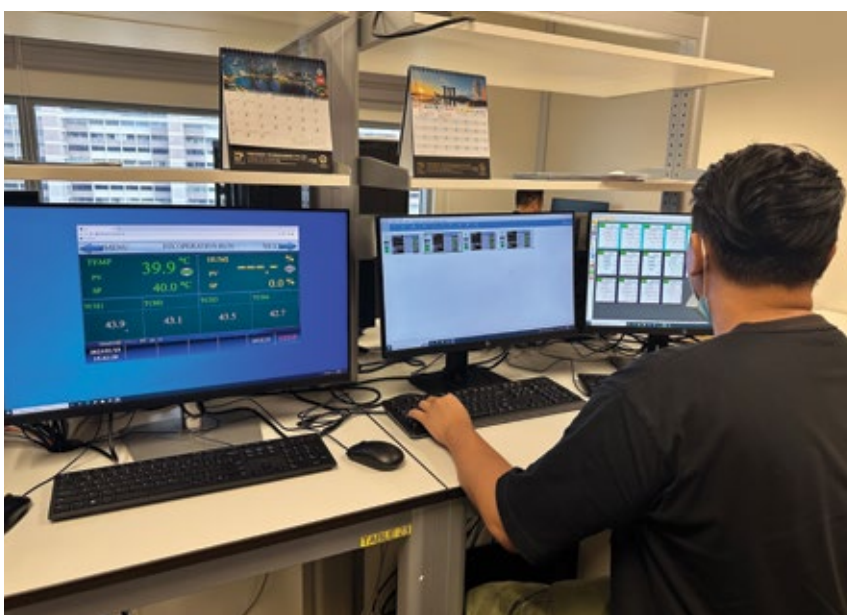
Designers with sufficient information on the intended use of the designated space can refer to the guideline for a suitable, preliminary sizing of the system.

The second development was using the data gathered from the experiments to provide inputs for Technical Reference TR 102 : 2022 – Code of practice for passive displacement cooling (PDC) system for air-conditioning application, launched on 26 July 2022 at a webinar organised by IES - Standards Development Organisation.

Future energy resilience and decarbonisation of the built environment require efforts on multiple fronts, and will depend not only on technological readiness but also on wider scale industrial adoption and governmental policy support. A multi-disciplinary and cross-sector approach is needed to facilitate energy transformation and create a circular, sustainable economy.



Battery testing chamber to perform degradation study for battery ageing, as part of the digital twin project.



A research engineer working on a remote monitoring system for battery cells.

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Sembcorp Industries and Singapore Polytechnic jointly launch initiatives in solar photovoltaics

A research lab that will serve as a testbed for exploring applications of PV technologies has been set up.

Sembcorp Industries (Sembcorp) and Singapore Polytechnic (SP) marked the opening of the SP-Sembcorp Solar PV Research Lab and Singapore's first end-to-end solar PV pilot demonstration recycling line in November 2022.

The launch was officiated by Senior Minister of State for Sustainability and the Environment, Dr Amy Khor, at SP's Regional Industry Networking Conference (RINC), held at the SP Convention Centre.

As the leading solar player in Singapore, Sembcorp has been collaborating with Institutes of Higher Learning, such as SP, to train solar professionals. Underlining these efforts, Sembcorp Solar Singapore was conferred the Singapore Energy Award 2022 by the Energy Market Authority for playing a core role in driving capability development in Singapore's solar industry.

First solar PV research lab in local polytechnic

Sembcorp and SP have set up the SP-Sembcorp Solar PV Research Lab within the SP campus to conduct proof of concept projects in solar PV, test monitoring systems with live generation data, and validate new technologies in actual deployment environments. Plans are also underway to develop various mock ups of rooftop solar structures for hands-on training for both SP students and adult learners in the Continuing Education and Training (CET) programmes.

Joint development of solar course curriculum

To upskill the talent pool, Sembcorp and SP have launched a course in solar PV systems planning, design, and installation. The course comprises 24

hours of online lessons, assessments and practical hands-on sessions in site surveys and installations, which will be carried out at the SP-Sembcorp Solar PV Research Lab.

Eligible solar professionals, including project managers, engineers and technicians, can register for the CET course at SP's website and use their SkillsFuture credits to enjoy course fee subsidies.

Sustainable end-of-life management of solar PV panels

Singapore's solar capacity has grown to more than 670 MWp and over 5,400 installations in the first quarter of 2022 (Energy Market Authority: Installed capacity of grid-connected solar PV systems for the first quarter of 2022).

As Southeast Asia ramps up solar energy deployment, a responsible end-of-life solution will support a circular economy for solar PV materials. In 2019, Sembcorp and SP collaborated to develop a pilot demonstration solar PV recycling line, which has since progressed to a stage to demonstrate the

commercial viability for large-scale recycling of used solar panels.

Mr Koh Chiap Khiong, CEO of Singapore & Southeast Asia, Sembcorp Industries, said, "Through our collaboration with Singapore Polytechnic, Sembcorp is enabling the energy transition for a sustainable future. The SP-Sembcorp Solar PV Research Lab not only presents an opportunity as a testbed for new photovoltaic applications, but also offers students and adult learners practical hands-on training, so they can be equipped with the relevant skillsets to support Singapore's climate ambitions."

Mr Soh Wai Wah, Principal and CEO of Singapore Polytechnic, said, "With the commissioning of the Solar PV Pilot Demonstration Recycling Line, we can bring our environmentally sustainable recovery technology closer to commercialisation in collaboration with Sembcorp. SP looks forward to expanding our expertise in solar PV research, and training more solar PV professionals to contribute towards Singapore's latest commitment to achieve net-zero emissions by 2050."



Singapore's first end-to-end solar PV pilot demonstration recycling line has been set up at Singapore Polytechnic.

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Mapei technology transforms waste into a resource material

by **Sven-Henrik Norman**, Corporate Product Manager,
RE-CON Line, Mapei SpA



Sven-Henrik Norman

The RE-CON Line provides solutions to help manage and recycle concrete and washing slurry.

The rising cost of fuel and virgin raw materials has caused an increase in the total cost of ready mix concrete production in recent years. These costs have even accelerated during and after the COVID-19 pandemic, due to disturbances in global logistics and raw material supply chains. In combination with the increasing awareness in society about the need for more circular production models, the

management of waste streams in concrete production has come into the spotlight as a major cost and environmental issue. Returned concrete and slurry from the washing of trucks, which previously could be disposed at low cost, is now becoming more and more expensive to handle.

Mapei has worked on this issue for many years and can offer prod-

ucts and solutions that transform returned concrete and washing slurry into resource materials. The Mapei RE-CON Line helps concrete producers to reduce the use of water and raw materials like sand, aggregates and cement, while also reducing water pollution.

The RE-CON Line circular process

The RE-CON Line of products

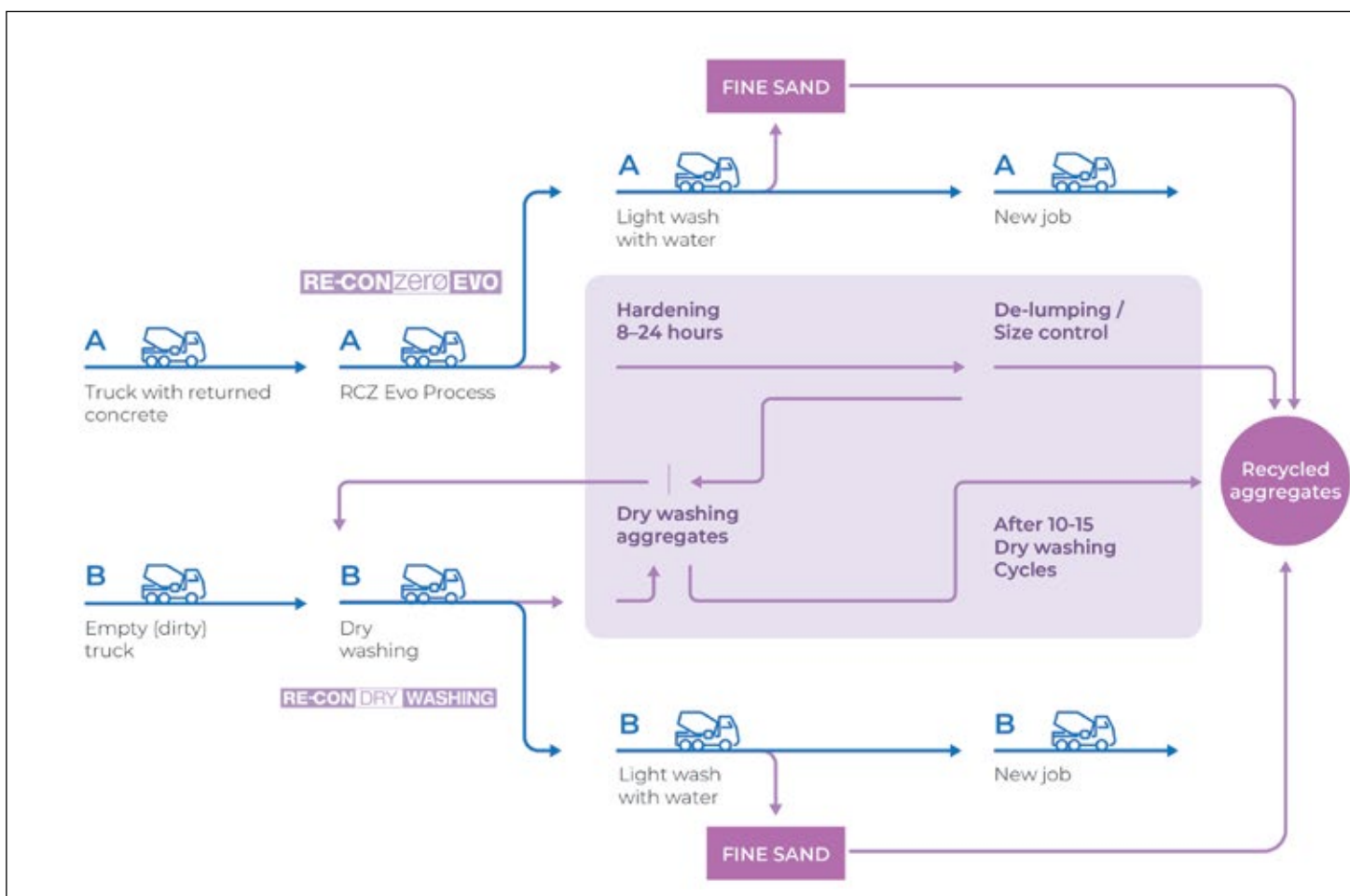


Figure 1: A sustainable cycle with the RE-CON Line.

helps concrete producers become sustainable by offering solutions that transform, reduce and recycle waste streams. A 50,000 m³ yearly production of concrete normally has a rate of returned concrete of 5%, i.e. 2500 m³ or approximately 5800 tons. It also has a waste stream of washing slurry.

If there is no possibility to re-use the returned concrete, it will have to go to a landfill as waste. The slurry must, in any case, be deposited in a landfill or in an approved deposit, as it contains heavy metal contamination like hexavalent chrome. The cost of this handling can be tens of thousands of Euros for the production in this example.

If the RE-CON line solutions are applied in concrete production, substantial savings can be achieved. Not only are handling costs eliminated, with the RE-CON Line solutions, the transformation of

the waste materials into recyclable aggregates also leads to savings, by reducing the need for virgin raw materials.

The process is best described in Figure 1. There are two alternatives for the trucks that return from a delivery at a building site to the batching plant. Either they contain some returned concrete (A), or they are empty of concrete but have about 200 kg of cementitious residue each, that covers the inside of the mixer drum in a thin layer (B).

In Flow Case A, the returned concrete is treated with the RE-CON ZERO EVO process which transforms the fresh returned concrete into a granular material that is emptied on the ground and left to dry and harden for 8 to 24 hours.

After this, the truck can take a light wash and is then available for the next job. For the concrete truck driver, the process has taken about 15 minutes and instead of a flow of concrete that needs to be handled and processed, the batching plant now has an available volume of aggregates. This material is called RE-CON ZERO aggregates and it can either be sold as a base course or backfill material, re-used in the production of new concrete, or used as a dry washing aggregate in Flow Case B.

When a truck returns empty but dirty (B), it goes directly to do the RE-CON DRY WASHING process. Approximately 1 m³ of aggregates, or 2500 kg, is fed into the empty truck and is rotated back and forth inside the drum for about 4 minutes. During this rotation, the aggregates clean the inside of the drum and absorb around 70% of the cementitious residue onto the surface aggregates, forming a new layer that will dry and harden in 12 to 24 hours. The truck empties the aggregates in a material storage unit and can then have a light wash where the remaining residue, in the form of fine sand with a minor element of cement, is collected for sedimentation and dewatering.

The need to dry wash an empty truck varies from case to case. Normally, it is only needed after

the last load of the day. But in a hot climate or in special cases, concrete trucks have to be cleaned also during the day, between deliveries. The dry washing aggregates can be re-used for about 10 to 15 times before its slurry absorbing abilities are no longer efficient enough. It is then used in process step (C) as replacement for virgin raw materials in new concrete or in (D) where it is sold externally as aggregates. In step (C) the use of RE-CON AGG admixtures can save a lot of water and, thereby, cement, by keeping the concrete made with recycled aggregates flowable for a longer time, after mixing.

Transforming returned concrete into aggregates

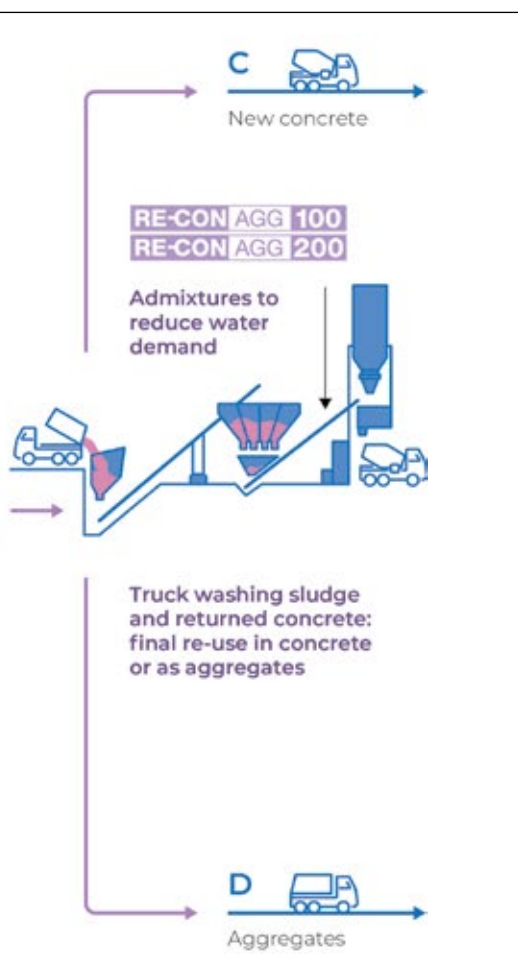
Since concrete generally needs to be used within 1 to 4 hours after the mixing, over-ordering and quality issues can result in a daily flow of tens of cubic metres of concrete back to a single mixing plant – a waste stream that requires significant resources, time and costs to handle and, in many cases, transport it to landfill.

Mapei revolutionised the handling of returned concrete, with the introduction of RE-CON ZERO in 2010. Returned concrete can now be transformed into a recyclable aggregate material.

The transformation happens, thanks to a patented, two-part system that includes a superabsorbent polymer and a hardener. The water in the concrete is bound by the superabsorbent and the hardener accelerates and stabilises the process. The returned concrete can be transformed in the truck mixer or in a separate process if the truck is needed quickly for a new job. The result is a recycled aggregate that can be used in new concrete or sold as backfill material, leading to substantial savings in handling costs. The aggregates can also be used in an intermediate process of absorbing truck washing slurry in the RE-CON DRY WASHING process.

RE-CON DRY WASHING

The RE-CON DRY WASHING method was invented by Mapei in 2019.



It greatly reduces washing slurry waste and washing water consumption from concrete trucks, by using the absorbing properties of the RE-CON ZERO EVO aggregates made from transformed returned concrete. The method makes it possible to recycle washing slurry into a recycled aggregate, instead of having to process, transport and deposit it at landfills. Much less water is needed to complete the cleaning of the truck mixing drum, after it has been dry washed. The residual washing water has a lower solids content, lower pH and a lower risk of containing heavy metals like hexavalent chrome. All this is due to the unique absorption of cementitious residue onto the dry washing aggregates. And there is one more advantage.

Mapei analysed and tested the dry washing aggregates, together with the renowned research institute, SINTEF, in Norway, and discovered that the RE-CON DRY WASHING particles absorb carbon dioxide (CO₂), through the process of carbonation. The RE-CON Line offers unique possibilities to produce

carbon negative aggregate materials and Mapei Research continues to work in this field.

With the RE-CON DRY WASHING method, the result is cleaner water and reduced waste from concrete trucks.

RE-CON AGG admixtures

There is a growing need to shift to use more recycled materials and to utilise manufactured sand and lower quality sands in higher ratios, in concrete production. Recycled aggregates generally have a higher water absorption, due to their porous surface structure. Manufactured sands with high fines content and low-quality sands containing clay minerals can cause a higher water consumption in concrete mixing. With a high water demand, a higher usage of cement automatically follows, since the water/cement ratio is dictated through industry standards.

With the help of the RE-CON AGG admixtures, increased ratios of water-demanding sand and aggregates can be used without

increasing the need for cement. The RE-CON AGG polymers block the porous surfaces and crystalline structures in demanding aggregates and sand, from absorbing the mixing water from the concrete in its fresh state.

Instead of getting soaked into the porosities or laminar mineral layers of the sand or aggregates, the mixing water stays available in the fresh concrete, keeping it flowable for much longer than it would have been without these admixtures. The alternative would have been to add more water and more cement to the mix, leading to higher costs and a bigger carbon footprint.

Using Re-CON AGG admixtures reduces demanding materials in concrete production – materials like water and cement.

This editorial feature is based on an article from *Realtà MAPEI INTERNATIONAL ISSUE 93*.
Image by Mapei.

Global competition for sustainable construction open for entries

The Holcim Awards are now open for entries. The Holcim Foundation for Sustainable Construction conducts the global competition to reward and shed light on real-world examples in practice, that can accelerate the global movement for sustainable design.

The foundation is calling on architects, urban planners, and engineers to submit sustainable design and construction projects that lead the way in the building sector. Submissions must be client-supported and have reached the detailed design phase.

The Holcim Awards 2023, a significant competition for sustainable design, offers total prize money of USD 1 million across five regions – Latin America, North America, Middle East Africa, Asia Pacific and Europe. USD 200,000

will be shared between winners of a Holcim Awards Gold, Silver, Bronze, and Acknowledgement prizes, in each region.

“We are looking forward to receiving submissions from around the world, and to seeing how these projects will contribute to a more sustainable built environment”, said Laura Viscovich, Executive Director of the Holcim Foundation.

Independent expert juries will evaluate entries using the Holcim Foundation’s goals for sustainable construction, that serve as a framework to drive system change – uplifting places, a healthy planet, viable economics and thriving communities.

The juries will be chaired by Tatiana Bilbao, Founder, Tatiana Bilbao ESTUDIO (Latin America);

Craig Dykers, Founding Partner, Snøhetta (North America); Lesley Lokko, Founder, African Futures Institute (Middle East Africa); Manit Rastogi, Founding Partner, Morphogenesis (Asia Pacific); and Belinda Tato, Founding member, Ecosistema Urbano (Europe).

Submitting entries in the competition is free, using a web-based form to provide information in English on the project design team, project summary, project sustainability profile including data points, as well as project images.

The competition is open for entries until 30 March 2023.

Winners will be announced on 18 November 2023, at the 18th International Venice Biennale of Architecture: The Laboratory of the Future.

The use of plastic waste to construct durable asphalt pavement

The project by Samwoh Innovation Centre and Singapore Polytechnic, supported by the Land Transport Authority (LTA) and the National Environment Agency (NEA), won the IES Prestigious Engineering Achievement Awards 2022, in the Applied Research and Development Category, as well as the ASEAN Outstanding Engineering Achievement Award 2022.

Plastic waste is one of the largest types of waste produced in Singapore, in terms of the amounts disposed. According to the National Environment Agency (NEA), about one million tonnes of plastic waste was produced here in 2021, 6% of which was recycled and the rest was incinerated and the residue sent to landfill.

In 2019, Samwoh Innovation Centre (Samwoh) and Singapore Polytechnic (SP) initiated a joint research study to evaluate the use of waste plastic in asphalt (plastic asphalt). The main objectives of the study were to:

- Evaluate the mechanical properties of plastic asphalt with different types of locally-sourced recycled plastics.
- Evaluate the leaching behaviour of the selected type of plastic asphalt.
- Evaluate the life cycle cost of the plastic asphalt.

Test samples were prepared with different types of recycled plastics, including low density polyethylene (LDPE), linear low density polyethylene (LLDPE) and polypropylene (PP). These plastics were selected for their lower melting points and hardness, which makes it easier for them to be blended into asphalt mixtures. The study was conducted based on the W3B mix, a dense-graded asphalt mix, specified according to the LTA specifications.

Extensive laboratory tests were conducted to evaluate the mechanical properties of the plastic asphalt, including resilient modulus, tensile strength ratio, moisture susceptibility and wheel-tracking test.

To address concerns on the poten-

tial leaching of contaminants associated with plastic wastes, environmental tests such as heavy metals leaching, microplastic analysis and accelerated weathering tests were conducted. The preliminary laboratory results showed that the plastic asphalt exhibited better mechanical performance and was not worse off, in terms of its environmental impact, compared to conventional asphalt.

The laboratory test results suggested that the plastic asphalt could provide at least a 40% increase in service life compared to conventional asphalt. While the cost of plastic asphalt mix is about 10% higher than conventional asphalt, the longer service life more than offsets the extra cost. Overall, plastic asphalt can lead to cost savings of about 20%.

To verify the performance of the plastic asphalt on an actual road, a field study was conducted. The

project is partially supported by the Land Transport Authority (LTA) and NEA, under the Land Transport Innovation Fund. The objective of the trial is to monitor and evaluate the engineering and environmental properties of plastic asphalt under actual traffic and weather conditions, for a period of 12 months. Two test sections were constructed along Jalan Buroh, where there is high heavy traffic volume, comprising a 100 m road length paved with plastic asphalt and a 100 m road length paved with conventional asphalt (control). The monitoring of the test sections of the road is in progress. The parameters monitored include rut depth, road roughness, skid resistance, pavement surface texture and cracks, as well as the quality of groundwater and surface runoff.

The study is to be completed by January 2023. So far, the field test results are very promising.



To verify the performance of plastic asphalt on an actual road, a field study was conducted.

A SUSTAINABLE FUTURE IS ON THE HORIZON WITH DIGITAL TWINS AND AI

by Cheryl Ajluni, Director, Industry Solutions, Keysight Technologies



Cheryl Ajluni

It is a top priority for all organisations today.

According to Accenture, one-third of Europe's largest companies have pledged to reach net-zero emissions by 2050. Yet the firm also found that enterprises must significantly accelerate their efforts over the next decade, as just 9% of companies are currently on track to achieve this goal.

One way organisations can reach net zero and address other sustainability efforts is through the combined power of digital twins and AI. These technologies provide companies with unparalleled insights into their operations, that can then inform sustainability improvements and help them achieve climate goals. For example, digital twins can be used to test various scenarios and help companies determine the best strategies for reducing energy consumption and emissions.

Technology advances accelerating digital twin adoption

Digital twins have already been deployed in various ways, for example, in helping healthcare researchers create highly accurate models of the heart, lungs or other organs, to improve clinical diagnoses, education

and training. The energy industry also offers numerous use cases for digital twins, including building digital models to guide oil drilling efforts in real-time.

But recent technology advances in simulation and modelling capabilities, increased deployment of IoT sensors and a more widely available computing infrastructure mean that companies can increase their reliance on digital twins. And when organisations augment digital twins with AI, they can realise additional benefits – for example, by running simulations to investigate 'what-if' scenarios and gain a deeper understanding of cause and effect.

There are numerous examples of how these technologies can enhance operations, including their ability to inform a greener world. With that in mind, below are a few use cases that demonstrate how digital twins and AI are driving sustainability improvements across industries.

Smart industry

By 2025, 89% of all IoT platforms will include digital twins, transforming how industrial and manufacturing

facilities operate, and providing granular insights to enhance sustainability efforts.

Examples include:

- Investigating ways to reduce energy consumption through a deeper understanding of where energy loss is occurring.
- Using predictive analytics to determine how emissions could be reduced by making various changes.
- Conducting risk assessments to identify operational weaknesses that could lead to accidents with an environmental impact.

GE Digital is one organisation that has pioneered the use of digital twins and AI for sustainability improvements. Through its autonomous tuning software, the company creates a digital twin of its gas turbines, to find optimal flame temperature and fuel splits.

The technology senses environmental and physical degradation changes in real-time, facilitating automatic adjustments, to ensure that the gas turbines are running efficiently at low emissions and acoustic levels. With the technology, power generation plants

have realised carbon monoxide reduction by 14% and reduction of nitrous oxide emissions by 10% to 14%.

Smart cities

City planning, management, and optimisation is another area poised to transform, through the combined power of digital twins and AI. These smart cities offer numerous benefits – by addressing food insecurity, increasing mobility, and helping to identify criminal activity, to name just a few. Smart cities also have much to offer in the form of addressing sustainability goals.

With digital twins and AI, city governments can understand, quantify, and predict the impact of their decisions on the environment and test potential scenarios to determine the most environmentally beneficial situation.

For example, Transport for London (TfL) is using digital twins to gather data on noise, heat, and carbon emissions, throughout the Tube network. Prior to deploying the technology, TfL staff could inspect assets only when the Underground was closed, between the hours of 1am and 5 am. With the real-time network access afforded by the digital twin, TfL can now assess locations throughout the operating hours and also spot data that was previously undetected by the human eye, such as faults, and heat and noise hotspots. Officials believe the project will be a key component of the goal of a zero-carbon rail system by 2030.

As carbon neutrality becomes a priority for cities across the globe, the usage of digital twins and AI is expected to increase.

Smart buildings

Just as digital twins and AI can help city sustainability efforts, they are also increasingly being

utilised to create smart buildings. The technologies ensure that sustainability is top of mind, from the outset, enabling construction managers and other stakeholders to develop virtual representations that can evaluate a building's anticipated carbon footprint, during the design phase.

This was the approach developers took when designing The Hickman in London, which has become the world's first building to receive a Platinum rating for smart buildings, from SmartScore.

During construction, the digital twin was connected with the building's management system through a variety of sensors, providing an integrated view of data such as occupancy, temperature, air quality, light levels, and energy consumption. Not only did this enable the developers to optimise energy performance and reduce carbon emissions, it also laid the framework for future sustainability enhancements, as these can be simulated first via The Hickman's digital model.

There is increasing regulatory pressure on the construction industry to design greener buildings, so we can expect that more developers will follow The Hickman's lead and look to address sustainability concerns before breaking any new ground.

Becoming a more sustainable industry and, ultimately, a more sustainable planet, has been an elusive goal for the last several years. But with recent advances in AI and increased adoption of digital twins, this vision is poised for realisation. Now is the time for organisations to harness the combined power of these technologies to obtain insights, at every stage of operations, that will support a more sustainable, less carbon-intensive economy at a micro-level – and a greener world overall.

Winners of the Keysight Innovation Challenge 2022

Keysight Technologies Inc, a leading technology company that delivers advanced design and validation solutions, recently announced the winners of the competition.

From an impressive set of student presentations, the team from the Illinois Institute of Technology won the First Place, for the entry 'Tree of Life: Carbon Capture'.

The 'Tree of Life' is a novel IoT device that not only monitors carbon emissions in corporate and community environments, but will also identify the best way to sequester carbon, based on the areas where the device is placed.

The Second Place went to the team from the University at Buffalo, The State University of New York, for the entry 'Piezo-cantilever Sensor for Real-time Monitoring of 8 Greenhouse Gases with LoRa Communication'.

The team has come up with a solution to detect all the eight different greenhouse gases, all at one time, using surface functionalised microcantilever MEMS-based sensors, along with highly sensitive and highly precise sensing.

The Third Place was secured by the team from Vanderbilt University for the entry 'Eco-Buddy: IoT OBD2 Monitoring Device for Fuel Efficiency and Emission Consciousness'.

The EcoBuddy device monitors users' driving habits through the vehicle's OBD2 port and provides live driving feedback on how to improve fuel efficiency.

Decarbonising the manufacturing industry

The Consumer Sustainability Readiness Index is aimed at empowering the consumer to make more sustainable decisions and thereby put more pressure on product suppliers.

CONSUMER SUSTAINABILITY READINESS INDEX

The Consumer Sustainability Readiness Index (COSIRI) is a neutral, independent sustainability framework to benchmark the sustainability maturity of organisations and their Environmental, Social, and Governance (ESG) transparency and reporting.

Aimed at putting the power firmly in the consumer's hands, COSIRI enables consumers to make more sustainable purchasing decisions which will, in turn, put pressure on the manufacturing industry to decarbonise and become more sustainable.

COSIRI will also allow for greater transparency and visibility in ESG reporting in manufacturing. In this way, manufacturers will be able to better monitor and track their progress towards sustainability goals.

COSIRI WILL DRIVE CHANGE

The aim of COSIRI is to positively impact climate change by making it easier for consumers to select the most sustainable products/services.

The process is simple. Once the company rolls out the COSIRI star system with the QR code, scanning the QR code at the point of purchase gives the consumer a transparent view of the product's environmental footprint throughout the entire supply chain. Through empowering customers, COSIRI will spark transformative change in manufacturing and ensure that sustainability is at the forefront of the industry.

HOW COSIRI WORKS

COSIRI allows for a neutral, quantifiable assessment of an organisation's sustainability performance. Maturity is assessed across four dimensions. They are Strategy, Business Processes, Technology, and Organisation. COSIRI provides an unbiased, structured framework so that consumers can take an organisation's ESG performance into consideration when selecting products and services.

COSIRI shares the same value proposition as the Smart Industry Readiness Index (SIRI). Both are holistic, impact-oriented, neutral, comparable, information-proof, modular and expandable.

SMART INDUSTRY READINESS INDEX

SIRI was created in Singapore, in partnership with a network of leading technology companies, consultancy firms, and industry and academic experts.

SIRI comprises a suite of frameworks and tools to help manufacturers – regardless of size and industry – start, scale and sustain their manufacturing transformation journeys. SIRI covers the three core elements of Industry 4.0 – Process, Technology and Organisation.

As part of the World Economic Forum's Global SIRI Initiative, the International Centre for Industrial Transformation (INCIT) was established to bring SIRI to the next level.

Today, SIRI has been adopted internationally by both multinational corporations (MNCs) and small, medium enterprises (SMEs). Around 600 manufacturing companies across 30 different countries have completed the Official SIRI Assessment (OSA).



Eight guiding principles that drive ESG for companies.

INTERNATIONAL CENTRE FOR INDUSTRIAL TRANSFORMATION

INCIT is an independent, non-governmental, not-for-profit organisation that has taken over the management and coordination of the SIRI programme. Supported by the World Economic Forum and other international organisations, INCIT will work closely with partners from both the public and private sectors to catalyse industrial transformation on a global scale.

INCIT develops and deploys globally referenced frameworks, tools, concepts and programmes for all manufacturing stakeholders, in order to help spark manufacturing transformation.

Specifically, INCIT provides services relating to benchmarking tools like SIRI and COSIRI as well as new collaborative platforms like ManuVate.

MILESTONES AND KEY DEVELOPMENTS

- **Launch of INCIT (January 2022)**

INCIT – a non-profit, ESG institution which champions manufacturing transformation – is launched.

- **Launch of World Economic Forum Manufacturing Transformation Insights Report 2022 (10 February 2022)**

The Manufacturing Transformation Insights Report 2022 by the World Economic Forum is launched. The report offers new insights and findings from the Global SIRI initiative, which aims to build the world's largest data sets and benchmarks on the state of manufacturing globally.

In collaboration with the Singapore Economic Development Board (EDB), the report draws on data from close to 600 manufacturing companies in 30 countries that underwent the OSA.

- **Saudi Arabia's NIDLP partners INCIT to drive SIRI adoption in the Kingdom (24 June 2022)**

INCIT announces a collaborative partnership with the National Industrial Development and Logistics Program (NIDLP) of Saudi Arabia to drive the adoption of SIRI through-

out the Kingdom and accelerate the transformation of the manufacturing sector.

- **Beca partners with INCIT to train Certified SIRI Assessors (12 August 2022)**

INCIT announces a partnership with Beca, one of the largest independent engineering consultancies in the Asia-Pacific region, to facilitate SIRI training and assessments.

- **BSI: INCIT's newest global SIRI accreditation partner (August 2022)**

UK National Standards Body BSI becomes a global SIRI Training and Certification Centre.

- **INCIT welcomes new SIRI partner KoçDigital (September 2022)**

INCIT announces a partnership with Turkish Advanced Analytics and Internet of Things solutions provider, KoçDigital, to leverage SIRI to boost greater adoption of Industry 4.0 in the region.

- **INCIT partners Kazakhstan's AIFC Tech Hub to drive Industry 4.0 with SIRI (4 October 2022)**

INCIT announces a partnership with Kazakhstan's Astana International Financial Centre (AIFC) Tech Hub – a platform designed for global start-ups, entrepreneurs, investors and the industry's top technology experts to meet and collaborate.

- **DTI and INCIT partner to drive adoption of SIRI across the Philippines (19 October 2022)**

INCIT signs an agreement to collaborate with the Philippine Department of Trade and Industry (DTI) to facilitate the adoption of SIRI throughout the Philippines, with the aim of accelerating the transformation of the manufacturing sector.

- **INCIT launches ManuVate Global Innovation Platform (17 November 2022)**

INCIT launches the ManuVate Global Innovation Platform – a collaborative platform designed to help manufacturers across the globe address problems and gaps in their organisations, to better support Industry 4.0 transformation.

ENCOURAGING SMART AND SUSTAINABLE MANUFACTURING

Mr Raimund Klein is the Founder and Chief Executive Officer of INCIT – an independent ESG institution which champions manufacturing transformation globally and advocates the rise of smart manufacturing.

With expertise in business strategy, business planning, sales, business development, marketing strategy and operation development and more, Raimund is a staunch advocate for the digitalisation of manufacturing.

In his current role, Raimund actively fosters collaboration between public and private sector manufacturing-related organisations to catalyse industrial transformation across

geographies and industries. He also provides guidance for the development and deployment of globally referenced frameworks, tools, concepts and programmes for the international manufacturing community.

This enables INCIT to raise awareness about the latest transformation developments and manufacturing trends; provide benchmarks that are international, publicly available and quantitative; and facilitate the sharing of learning points, challenges and best practices for manufacturing transformation.



Mr Raimund Klein

GE Digital announces software designed for grid orchestration

GE Digital, an energy software leader, recently announced the release of GridOS, said to be the world's first end-to-end software portfolio, built specifically for grid orchestration. Designed to modernise and transform the electric grid into the clean energy grid of the future, GridOS is a platform and application suite enabling secure and reliable grid management while delivering the resiliency and flexibility needed by utilities worldwide.

New software tools are needed to meet the demands created by increasing grid complexity and to achieve reliable, sustainable, and affordable energy globally. GridOS delivers these tools with the cloud service provider and system integrator partner ecosystem necessary to accelerate grid modernisation and the clean energy transition.

"Electric grids worldwide have grown immensely complex in recent years, and as complexity has increased so have reliability risks. Given the crucial role that grid modernisation plays in the energy transition, we need advanced software solutions designed for grid orchestration to move faster and address risks to avoid becoming a bottleneck for the clean energy future", said Mahesh Sudhakaran, General Manager for Grid Software at GE Digital.

GE's grid software division is drawing on 40+ years of deep domain knowledge and customer innovation to hone and deliver proven software for the most progressive and reliable utilities around the world.

"Software is a critical component of energy transition. As part of the ESO's ambition to operate the national electricity network at zero-carbon by 2025, we have engaged innovative partners to advance available technologies. Solutions like these represent the evolution of software that is critical to accelerating energy transition on the electricity grid", said Craig Dyke, Head of National Control, National Grid ESO, UK.

The GridOS platform and application suite supports GE Digital's current grid operations portfolio that includes electric grid GIS for modelling, mapping and design, AEMS for transmission and market management operations, ADMS for distribution network operations, and DERMs forecasting and management.

The GridOS orchestration platform

GridOS integrates energy data, network modelling and AI/ML-driven analytics to power a suite of intelligent applications developed by GE, utilities and GridOS partners.

The GridOS orchestration platform includes:

- Zero Trust grid security model applied throughout the platform to protect resources from inside and outside threats.
- Federated grid data fabric with a common transmission and distribution model to enable a grid digital twin.
- A suite of intelligent grid applications that evolve and modernise

the grid control room for proactive and automated grid management.

- A hybrid cloud architecture to deploy and scale applications where they are needed – on-site or in a hybrid environment.

Building an expert partner ecosystem

GE Digital is bringing together a new partner ecosystem of leaders in cloud computing and system integration to focus on grid orchestration. This ecosystem enables more seamless alignment of Information Technology (IT) and Operational Technology (OT) within utilities, so that grid operators can quickly connect the dots, end-to-end, and address grid complexity. The partner ecosystem will accelerate future development of new applications for GridOS, solving mission-critical use cases for utilities at the speed needed to enable the future clean energy grid.

GridOS key partners include leading cloud provider AWS and global system integrators (SIs) Accenture, Infosys and others, each bringing unique strengths to the table. Cloud partners will enable pathways to grid flexibility and innovation scale, while system integrators are able to accelerate the delivery of new capabilities and the business shifts needed for the clean energy grid transition. Coupled with GE Digital's services and software, the partnership ecosystem builds on the resources of these global industry leaders to help utilities optimise performance and prioritise the acceleration of reliable and secure grid modernisation projects.

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Scaling your Tech Venture to the Global Markets

Transforming manufacturing globally

We drive positive
and sustainable change
across the industry.

As an independent non-profit entity,
the International Centre for Industrial
Transformation (INCIT) is an ESG institution
which champions manufacturing
transformation.

Along with our partners in both the public
and private sector, we have developed
comprehensive tools and frameworks to
enable global manufacturing to become
more resilient, productive and sustainable,
and better positioned for future success.



Smart Industry Readiness Index (SIRI)

Boost your Industry 4.0
adoption with SIRI and drive
your organisation's digital
transformation.



ManuVate

Collaborate with other
industry players to solve
manufacturing challenges
and foster innovation.



Consumer Sustainability Readiness Index (COSIRI)

Benchmark and boost
your sustainability efforts
through our newly launched
sustainability framework.



Visit **INCIT.org** to learn more about how we can help
you transform your manufacturing business.