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Issue 8 2020

FORGET

Realising Hong Kong's sustainability dream:

Kai Tak District Cooling System

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Foreword

The dramatic effects of COVID-19 on public health and global economies will inevitably cause a considerable drag on the progress towards the 17 United Nations Sustainable Development Goals (UN SDGs) set for 2030. Despite this challenge, the pandemic has reinforced the need for intensified efforts towards these ambitious goals.

This issue of FIRST showcases some of the works and research projects we have done in living up to our commitment to making meaningful contributions to achieving the UN SDGs. The cover article explains why it matters to all of us to shape a sustainable future and the key drivers that will deliver business benefits.

While the list of projects that exemplify our commitment is extensive, this issue brings to you a few specific impactful examples. The Kai Tak District Cooling System (DCS) reflects our trusted capabilities that cover all phases of this groundbreaking project for Hong Kong, from initial planning to design, to final implementation and ongoing operations.

Extreme weather events put water infrastructure at risk while continuing urbanisation increases demand. In some cases, an ageing water infrastructure needs a major overhaul. Read on to find out our ‘Design with Water’ framework and City Water Resilience Approach to the planning of an integrated water management for Shanghai as the city looks to improve the resilience of its decades-old drainage system.

Every game-changing project begins with feasibility analysis and strategic planning. In this issue we also look at the recommendations we made for the Da Nang City, Vietnam on implementing a waste-to-energy facility under the public-private partnership model; and on the Sustainable City pLAn envisioned by the City of Los Angeles.

Also covered in this issue are the summary of our latest Foresight report, intrapreneurship programme, latest research results, as well as the stories of Vincent Cheng and Sam Chow, who shared their insights on leadership, career development and project success.

We hope you find this issue informative and useful.

FIRST is a publication produced by East Asia Arup University (AU) for our clients and partners, exploring design, innovation and technical solutions for the built environment. It takes its name from the unique model of AU: Foresight, Innovation, Research, Sharing, and Training.

If you have any thoughts, questions or comments, we’d love to hear from you at ***ea.arupuniversity@arup.com****.*

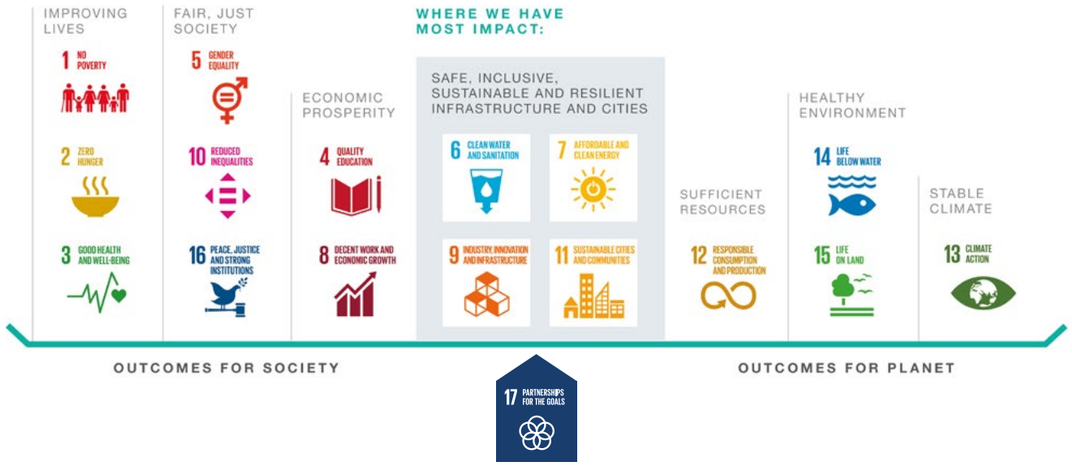
Click the heading to go to the relative page.

Shaping a sustainable future:

Why it matters?

At Arup, we are committed to making continued, meaningful contributions to the United Nations Sustainable Development Goals (UN SDGs). Not only does this commitment create shared value for our clients, it also gives back to our communities and helps to protect the environment. We apply our expertise, diversity of thinking and independence in the quest for a safe, sustainable and resilient future for all.

The 17 SDGs to transform our world:



East Asia consists of countries and regions that are widely different in their development stages and that have diverse historical, cultural and political backgrounds. Each has its own set of challenges confronting policymakers, project owners and community stakeholders. Ensuring the successful completion of local projects while delivering on our promise to meet these UN SDGs is easier said than done.

While we as designers, planners, engineers, architects, consultants and technical specialists have the expertise and skills to materialise that combined value, without the support and understanding of our clients our mission seems impossible. So a crucial question is why sustainability development matters to your business or organisation?

In this challenging and rapidly changing world, we advocate that adopting sustainable solutions are the best solutions not just for the planet and for society, yet increasingly also for bringing business benefits.

We are already witnessing a wholescale change in some sectors: energy companies investing more in clean energy; stock exchanges imposing stricter and more demanding requirements for environmental, social, and governance (ESG) reporting for listed companies; and institutions and corporations increasingly issuing green bonds to fund projects with environmental benefits. New policies, regulations and initiatives are driving a real change in practice.

We have identified a set of drivers that we believe help deliver business benefits for projects we work on with clients.

Economic drivers

- Reduce design and construction costs
- Increase asset value
- Reduce operating costs
- Increase workplace productivity
- Bring wider economic benefits

Environmental drivers

- Enhance mitigation and resilience against risks posed by climate change
- Improve indoor and outdoor air quality
- Add value through greenery and biodiversity
- Reduce carbon emissions
- Effective use of scarce natural resources

Social drivers

- Improve reputation and branding
- Promote health and well-being
- Better reputation and branding
- Promote social cohesion and inclusiveness
- More design flexibility and legacy
- Optimise flexibility and legacy
- Better security and safety

Governance drivers

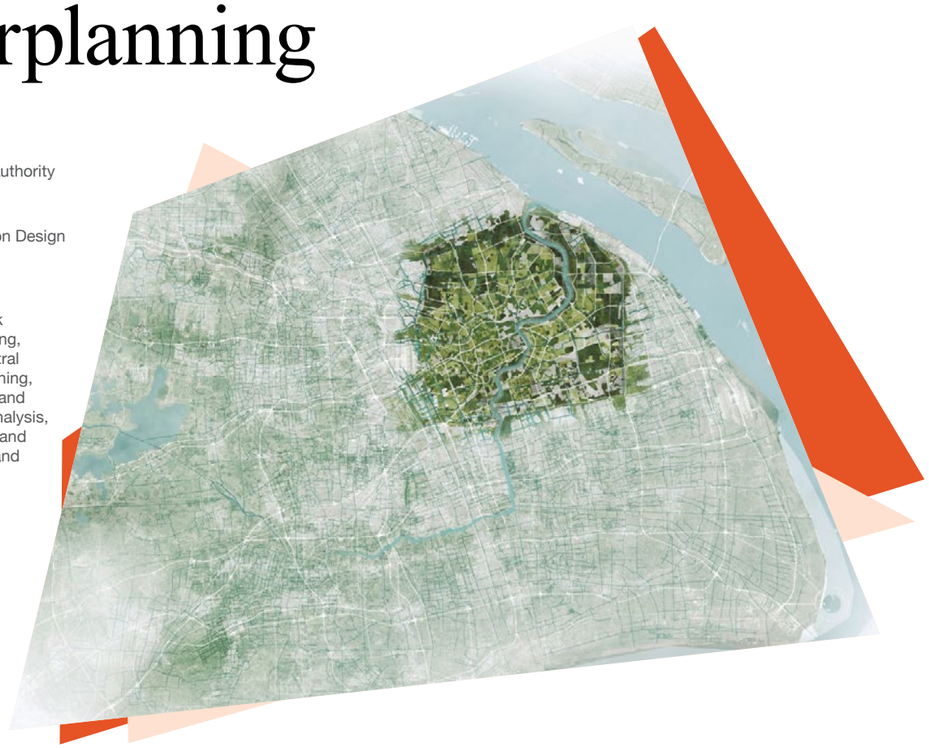
- Demonstrate political commitment
- Align with corporate social responsibility
- Benefit from regulatory incentives
- Capitalise on financial incentives
- Increase access to green capital

Key drivers defining how sustainable development brings business benefits.

In all our activities the UN SDGs challenge us to expand our perspective. We see our role not just as the best producer of outputs we are contracted to deliver, but also the enabler of positive and meaningful broader outcomes and impacts we and our clients are striving to achieve. Ultimately a focus on the drivers is not only good for business, it will result in significant wider positive impacts to our planet. That is how, together with our clients, we aim to shape a better world.

A visionary breakthrough:

Shanghai urban drainage masterplanning



Client:
Shanghai Municipal Water Authority

Collaborator:
Shanghai Urban Construction Design and Research Institute

Arup's scope of services:
Water engineering, flood risk management, civil engineering, landscape architecture, central urban drainage system planning, drainage capacity standard and pollution control standard analysis, advisory on layout principle and optimisation of grey, green and blue infrastructure

The Shanghai urban drainage masterplan has officially been signed off by the Shanghai Water Authority, signifying a breakthrough for Arup in the Chinese water market, showcasing our capability to contribute to the building of resilient cities. The masterplan was the result of an 11-month collaboration between Arup and a local design institute. The team first won an international competition and subsequently was awarded the development of the masterplan.

Urban drainage system requires significant upgrade

Over the last 30 years, Shanghai has seen rapid urbanisation and population growth. By 2018 the city's urbanised area was 7 to 8 times larger than in 1985. This massive scale of urban development has increased the impermeable area coverage of the catchment at the expense of green space. The city has seen a 50% increase in stormwater runoff across the city, leading to an increase in flooding events.

A large area of Shanghai is served by a 'combined drainage system', which carries both rainwater and wastewater in the same underground network. During dry days, this combined flow drains into wastewater treatment plants. During rainstorms, when the designed capacity of the wastewater treatment plant has been exceeded, untreated wastewater effluent from the city will be discharged into rivers, i.e. sewage overflow, causing river pollution. As such, Shanghai has a pressing need to upgrade its existing drainage system. This problem will be exacerbated by the imminent threat of climate change which is likely to affect rainfall patterns.

In December 2018 the city's authorities launched an international design competition to look for advanced yet implementable strategies for the highly populated city centre using international expertise.

In their winning design, Arup and local partner Shanghai Urban Construction Design & Research Institute demonstrated a well-thought-out plan that covers an area of 640km^2 with a design population of 15 million. The comprehensive plan was a result of a collaboration between Arup's global offices in mainland China, the UK, the US, Spain and Hong Kong SAR, and extensive consultation with experts from Arup's Global Water Skill Network.

A global perspective turned into local solutions

After reviewing the previous drainage masterplan and studying relevant cases across the globe, the project team challenged the traditional approach of focusing solely on large 'grey' infrastructure solutions. Instead, a visionary 'blue, green and grey' approach was proposed to support an integrated water cycle plan across the city, which would also benefit other aspects across the Greater Shanghai, including ecology, economy and public health.

As global policymakers continue to find ways to cope with the inevitable impacts from climate change, innovations such as new governance models, water sensitive urban design, integrated flood control planning and decentralised infrastructure are now being made part of future water strategies.

The Shanghai project team attended a workshop during a site visit to Leeds, the UK.

Arup's approach seeks to maximise the potential of current facilities and existing infrastructure before proposing anything new.

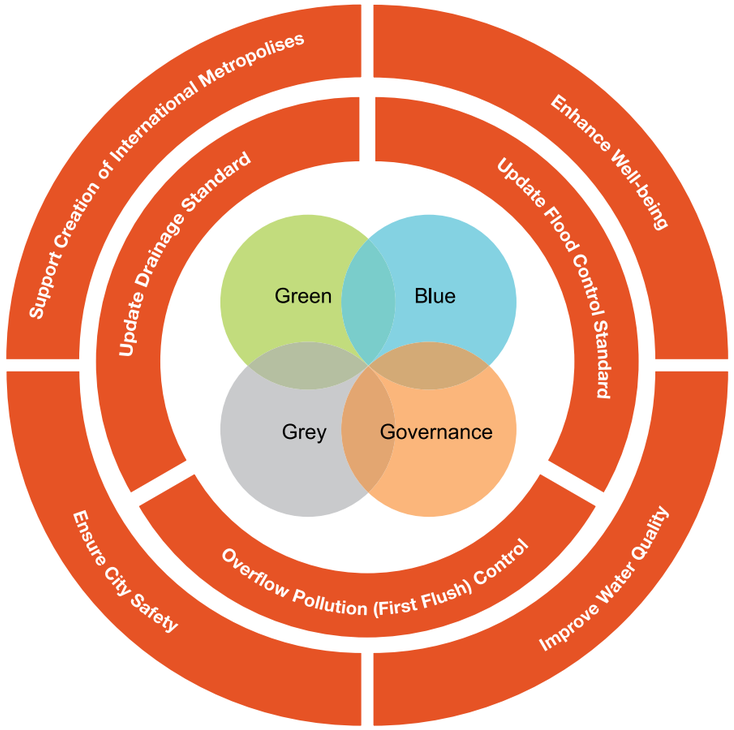
Integrating governance, green, blue and grey

Arup's approach seeks to maximise the potential of current facilities and existing infrastructure before proposing anything new, with an initial focus on improving the management of the existing network. As an example, the 'Design with Water' approach looks at water systems, flood risks, wastewater and water quality as one. By placing the water cycle at the heart of the urban planning process, actions taken to protect and enhance the water cycle can deliver multiple wider benefits.

Arup undertook a typology study using mapping and machine learning. Four systems were identified during the development of the masterplan — green, blue and grey infrastructure, as well as governance.

A governance review was undertaken using the City Water Resilience Approach. The review looked at six specific themes and tested the water governance across Shanghai against 29 indicators. Stakeholder engagement in stormwater management was recommended to restore existing assets to their full capacity and further optimise their operations.

Green infrastructure is an approach to water management that protects, restores, or mimics the natural water cycle. It includes a series of surface level interventions to retain or delay stormwater flows. The team conducted a detailed analysis of the land uses of the Shanghai urban area based on their knowledge of the city's history to establish a total of 12 different types of land-use typologies. By employing remote sensing imagery and machine learning, they were able to categorise the study area into different development types with respective green infrastructure used accordingly.



Integrating governance, green, blue and grey infrastructure as the design objectives.

An artist's impression of how a bioswale, an example of green infrastructure, will work at Huaihai Road.

Rivers play a very important role in urban drainage. An urban flooding model has been built in order to find opportunities and challenges of using this blue infrastructure. This is the first-ever model to integrate the river and drainage network of Shanghai.

Finally, where there was no other option, the team investigated the implementation of grey infrastructure which included the use of strategic drainage tunnels and localised storage.

The integrated system brings additional above-ground urban elements into storm water management functions, including roads, green space, rivers and other open spaces.

The integration of green, blue and grey infrastructure, supported by effective governance, will help the city meet its stormwater improvement targets, build climate change resilience and improve the health and well-being of citizens.

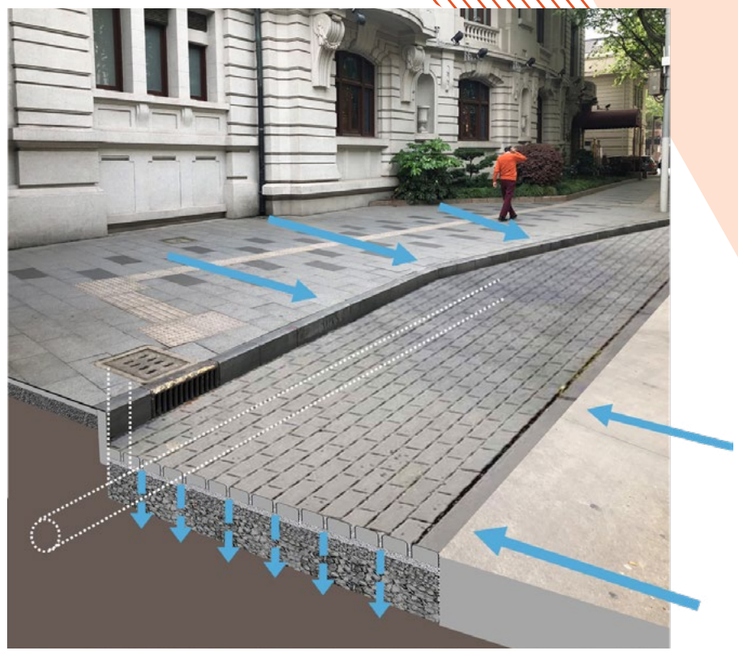
Arup's next-generation blue and green infrastructure will be integrated into all urban projects, from urban network systems to individual buildings. It will also be integrated with other critical infrastructure, including transportation, water, energy, digital and waste, for urban planning, design and urban redevelopment.

Values for the future

The success of the masterplan enriches Arup's 'Design with Water' framework, an approach to develop an integrated water management plan that addresses the critical issues related to demand management, including existing infrastructure capacity, watershed coordination, water-use efficiency, city resilience, flood risks, stormwater management, water reuse, and climate adaptation.

In particular, the idea of a water-orientated urban planning approach will be a showcase to the next-generation urban ecological development. It will also strengthen Arup's capability of effective management of the water environment, critical to achieving the UN SDGs. Specifically, the UN describes water as "a common currency" which "links nearly every SDG and which will be a critical determinant of success in achieving most other SDGs".

In the next phase, Arup will work closely with the authorities to implement the plan for this city shaped by water. As commented by Zhang Jie, an academician of the Chinese Academy of Engineering and leader of the expert panel of the competition, this masterplan will "lead the direction of drainage planning in China".



Another example of green infrastructure, permeable paving – an artist's impression of a permeable pavement at South Maoming Road.

An urban square for everyday recreational use can also serve to store stormwater during flooding period.

The urban flooding model integrates the river and drainage network of Shanghai.

Realising Hong Kong's sustainability dream:

Kai Tak District Cooling System

Overview of the Northern Plant upon completion.

Client:
Electrical & Mechanical Services Department (EMSD)

HKSAR Government

Arup's scope of services:
Implementation study of District Cooling System (DCS) at Southeast Kowloon Development: MEP engineering and economic feasibility

Design and Construction of Phases I to III of the DCS at Kai Tak Development: MEP engineering, civil engineering, environmental impact assessment, construction administration and construction supervision (project management)

Geographic map of the additional DCS plant and its associated pipe works.

Following the successful implementation of two central cooling plants of the Kai Tak District Cooling System (DCS), of which construction works were completed in 2017, Arup was commissioned by EMSD as one of the key consultants to work on an additional cooling plant designed to cater to more demands as a result of more air-conditioned areas planned for the district and the inclusion of a sports stadium with a retractable roof and bowl cooling.

For more than two decades, Arup has worked with EMSD, from concept and design to implementation, to bring one of the most important sustainable infrastructures to the city, realising the Hong Kong government's sustainability vision.

Feasibility study leads to ambitious plan for Hong Kong's first DCS

Ever since Hong Kong's former Kai Tak Airport was relocated to the Lantau in 1997 and 1998, Kai Tak was envisioned as part of Hong Kong's new Central Business District (CBD), which is now taking shape. The DCS is one of the major infrastructure facilities that support the sustainable development of Kai Tak.

To promote energy efficiency and conservation, the Hong Kong SAR Government has been constructing a DCS in Kai Tak to serve a planned total of about 1.73 million m^2 of non-domestic air-conditioned gross floor area, requiring about 284 megawatt of refrigeration cooling capacity, covering 320 hectares of area.

The DCS is an energy-efficient air-conditioning system, consuming 35% and 20% less electricity as compared with traditional air-cooled air-conditioning systems and individual water-cooled air-conditioning systems (WACS) using cooling towers respectively. The technology has been widely adopted in other parts of the world, such as Singapore, Europe and the United States.

EMSD commissioned Arup as early as in 1998 to conduct a Preliminary Phase Consultancy Study on the feasibility of building a central cooling system that delivers air-conditioning services to the commercial and public service buildings across the Kai Tak development area. This study was completed in April 1999 and concluded that there were economic and environmental benefits for adopting such air-conditioning systems.

Progress

Arup was engaged as the project manager and designer for different phases of the project under Design-Build-Operate (DBO) contracts. Construction works for Phases I, II and III (Package A) were completed in Q1 2013, Q3 2014 and Q4 2017, respectively. The works for DCS Phase III (Package B) and III (Package C remaining works) were completed in June 2020 and August 2020 respectively under the supervision of Arup.

Completed and in operations, the Southern Plant currently serves the Cruise Terminal Building while the Northern Plant serves the new developments at the North Apron area of the former Kai Tak Airport. Operation of the additional DCS is expected to commence in 2022-23. The construction is planned for completion by end 2028.

Environmental, cost and design benefits

Implementation of a DCS in Kai Tak boasts significant environmental benefits and contributes to air quality improvement and carbon reduction. The additional DCS will bring about significant environmental benefits. Upon full utilisation, the project is estimated to save about 53 million kilowatt-hour of electricity a year, corresponding to an annual reduction of about 37,000 tonnes of carbon dioxide emission.

Apart from energy conservation and efficiency, the DCS allows each building owner to cut down on upfront costs for installing chiller plants in their buildings. The cost reduction is about 5-10% of the total building cost. With more floorspace saved from installing a chiller plant as well as the associated electrical and mechanical equipment, the owner can design the building in a more flexible way.

DCS can also counter urban heat island effects. Since the plants are located away from the buildings, the noise, vibration and thermal plume nuisance are also resolved as no heat rejection plant, normally in the form of cooling tower, is required in the buildings. Also, DCS can contribute to air quality improvement and the vision of achieving low carbon economy; and a more adaptable air-conditioning system to meet the varying demand as compared to individual air-conditioning systems. For each individual building, its cooling capacity can be increased or reduced by request without carrying out extensive modification or retrofitting works for the buildings concerned.

Economic appraisal

Well before arriving at the decision to implement the Kai Tak DCS, we conducted an economic appraisal to study potential consumer demand, the competitive landscape and constraints of providing cooling services to buildings in the district, such as urban and utility planning requirements and operator availability.

In doing so, we performed cost modelling and financial analyses to evaluate the potential of DCS as a service and its competitiveness against alternative cooling technologies. To determine if DCS is financially viable, we formulated different tariff schemes and worked out revenue projection analyses, factoring in the risk of investor and financial incentive required to encourage potential DCS to subscribe to the DCS service. The proposed tariff scheme is expected to achieve full recovery of capital investment over the 30 years of project lifespan.

To ensure the water-cooled air-conditioning produced by the Kai Tak DCS is competitive versus traditional air-conditioning systems in terms of cost savings from the end-user's perspective, we further carried out a TCO (total cost of ownership) comparison to prove that subscribing to the Kai Tak DCS is more cost-effective and energy efficient based on the assumption that the Kai Tak DCS is operated at full capacity.

Site planning and interfacing issues

Kai Tak as the location of Hong Kong's former airport had been in operations for decades before relocating to the Lantau during 1997-1998. As such, there had been numerous existing underground utility services previously. Some record plans of the decades-old utilities were difficult to be obtained. Site and ground investigations were therefore carried out to detect the existing utility services and map geophysical assets.

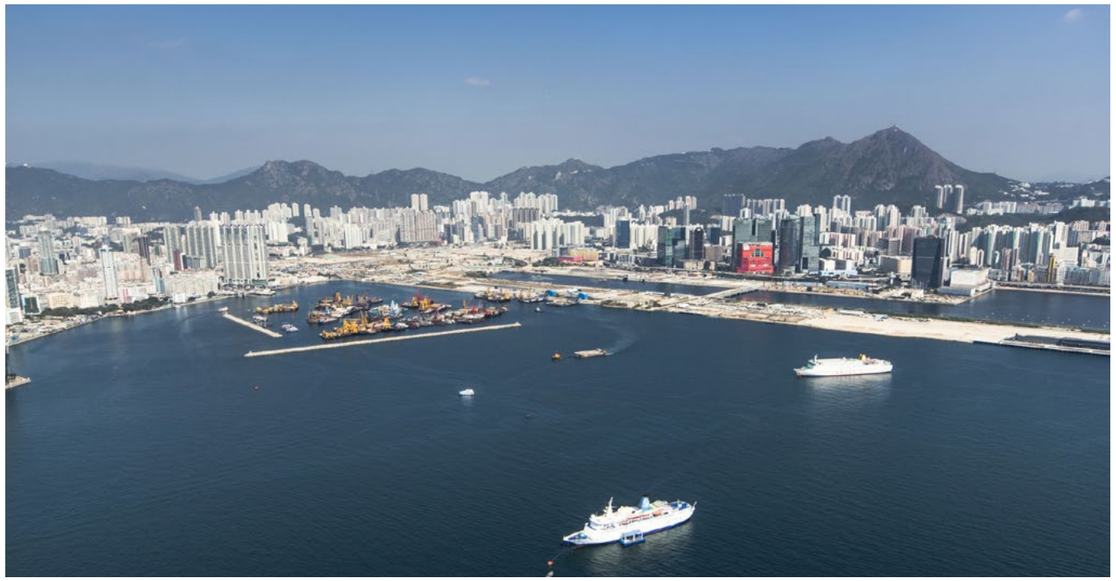
Since the construction sites of DCS plants and pipe works are extensive and the construction period is long, there are inevitably interfacing issues with other infrastructures, such as Central Kowloon Route (CKR). To address interfacing issues, Arup adopted an integrated planning approach to minimise complications on construction, with lots of co-ordinations with concerned parties, including two government agencies, at an early stage and to agree on protective and contingency measures to prevent interference with surrounding facilities, such as drainage culverts, Kai Tak Tunnel and CLP tunnel, during construction.

For the pipe-laying works, both open trench method and trenchless excavation method were adopted.

Challenges in DCS water pipe laying works

The construction of the Kai Tak DCS project comprises three major components: central chiller plant rooms, seawater pump house and distribution chilled water, and substations in user buildings. Given that a range of old underground utilities had existed and that new utilities had to be installed alongside the DCS pipes, key challenges stemmed from the use of tunnel boring machine (TBM) for trenchless excavation construction, co-ordination of piping alignments with existing and new underground utilities and water seepage during excavation.

Early planning and precautionary measures were paramount in ensuring the success of implementation. Due to the highly urbanised surroundings, various trenchless construction methods, such as pipe ramming, auger boring, pipe jacking, utility tunnelling and hand-dug tunnelling, including the use of TBM, had been proposed.



Early planning and precautionary measures were paramount in ensuring the successful implementation of the Kai Tak DCS.

Precautionary measures to determine trenchless excavation method

To ensure a smooth water pipe laying process, various precautionary measures were taken to probe the actual underground conditions and determine the appropriate type of trenchless excavation method, including trial pits to expose and verify the existence, extent, location and elevation of all underground utilities, natural or man-made obstructions and structures.

Therefore, proper positioning and underground detection tools were used to locate underground utilities and check the underground conditions, along with the proposed pipe jacking route; and to assess the feasibility of the proposed route, locations and inverts of jacking and receiving pits.

Conflicts with existing and new underground utilities

While occupied by other existing underground utilities, the underground space needed to further accommodate the DCS chilled water distribution main pipes, seawater supply and discharge pipes, along with other new utilities. DCS pipes were therefore laid at the bottom of the carriageway, as deep as 7m below the ground level, in order to avoid conflicts with such utilities as power cables, telecom cables, Towngas pipes, fresh and saltwater mains, sewers, etc.

Arup was actively involved in the early co-ordinations with other government departments, including the Civil Engineering and Development Department (CEDD) and Highways Department (HyD), in order to resolve DCS piping alignment and spatial orientation issues. The efforts helped DCS pipes fit into the underground spaces allocated for utilities and routed in an effective configuration for construction and maintenance. The DCS pipes were also arranged to run with other existing underground utilities or services, such as drainage culverts and Kai Tak Tunnel, to minimise interference with these facilities during construction.

Water-cooled Air Conditioning System (WACS). The central chiller plant supplies chilled water and conveys it to the user buildings via underground chilled water pipe network.

Management and operation

The system performances of the Kai Tak DCS are monitored by an automatic computerised system, namely the District Cooling Instrumentation, Control and Communication Systems (DCICCS). DCICCS consists of the optical fibre network for data transmission and the automatic computerised monitoring system for central control and remote monitoring.

The monitored data are transmitted through optical fibre network connected from all substations to the Control Rooms. In the Control Rooms, the DCS plant operator is able to carry out the remote-monitoring to monitor system performance real time from all substations and all chiller plants, such as the chilled water supply & return temperatures of all substations, the readings of energy meter of consumer buildings and the Coefficient of Performance of the whole DCS.

Trusted partner in DCS project delivery

Since the Kai Tak DCS is the first of its kind in Hong Kong, early planning and initial design are critical to its successful implementation. Despite the complexities and challenges, the Arup team gained valuable first-hand experience, giving us a unique perspective and understanding of the solutions that will be required for other DCS projects in Hong Kong and abroad.

From nothing to something, Arup has demonstrated exceptional capability and expertise in contributing to the successful design, building and operation of the first two phases of the Kai Tak DCS. As the Hong Kong SAR Government's trusted partner in DCS projects, Arup has a strong understanding of government policies, procedures and concerns, and is experienced in working with regulatory bodies and different agencies in facilitating interdepartmental communications and resolving technical/operational issues.

During implementation, we utilised various tools to help the client define environmental, social and economic sustainability objectives. To support architects and urban designers in meeting these objectives, we assembled multidisciplinary teams of engineers and researchers, as necessary, to bring rigorous and evidence-based analysis of environmental site planning and infrastructure.

In addition to the Phase 3 of the Kai Tak DCS, Arup was also awarded consultancy contracts by the EMSD to implement two other DCS projects in other new development areas (NDAs) in Hong Kong, such as Kwu Tung North. Separately, we were awarded a consultancy contract to implement the West Kowloon Cultural District (WKCD) DCS, which is owned and managed by West Kowloon Cultural District Authority.

Implications for Asia's sustainability development

Sustainability objectives are best met when they are integral to a masterplan; considered from the outset rather than an afterthought. As it was planned for the first time ever, the development of Kai Tak DCS required fundamental changes to Hong Kong's city planning regulations and codes.

The Hong Kong SAR Government accepted our suggestion to officially include the development of DCS as part of the early stage of planning and development for large-scale NDAs and redevelopment areas, where a larger number of potential consumer buildings could be identified to support the DCS. The regulatory changes have paved the way for the planned implementation of other DCS projects in Hong Kong's future NDAs.

With the successful implementation of the Kai Tak DCS, many Southeast Asian countries such as the Philippines, Malaysia, Singapore and Vietnam with similar climate and urbanisation demand are learning from us. Such unique experience has strengthened both Arup's and Hong Kong's role as a regional and global leader in realising climate resilience infrastructure.

From nothing to something, Arup has demonstrated exceptional capability and expertise in contributing to the successful design, building and operation of the first two phases of the Kai Tak DCS.

Neuron Health:
Keeping indoor air quality in check

■ Neuron Health is the healthy building module of Arup's smart building solution that monitors and controls indoor air quality (IAQ) and optimises energy consumption.

The deployment of Neuron Health in a prime office building in Hong Kong showcases Arup's innovative smart building solution that monitors and controls indoor air quality (IAQ) while optimising energy consumption

Not only has the COVID-19 pandemic rewritten the way we live, we work and we greet, it also has a profound impact on future city planning and building design. The stay-at-home and social distancing policies have led to an increased demand for a healthy indoor environment, which is characterised by the positive impacts on occupants, especially air quality.

A recent Harvard University study reveals that long-term exposure to air pollution leads to a higher COVID-19 mortality rate. Since city dwellers spend most of the time indoor, it is vital that modern buildings are technologically equipped to ensure that IAQ is up to the standards expected.

Drawing on Arup's multidisciplinary expertise in the building design with innovation in mind, we have developed Neuron, an integrated system that combines Building Information Modelling (BIM), Internet of Things (IoT) and real-time data analytics into a single platform.

The smart building platform not only helps buildings achieve energy savings, but also creates a better indoor environment that looks after the health and well-being of the occupants. This control console provides a foundation to connect different building systems and equipment, making them easily accessible and facilitating operation and maintenance.

Neuron Health use case

Earlier this year, Neuron Health was deployed in a Grade-A office building in the eastern part of Hong Kong Island, specifically for the lobby area. With both eco- and health-friendly features, the integrated system is configured to monitor the IAQ against performance requirements set by the WELL Building Standard. All information is sent to Neuron's digital platform for real-time data retrieval and analytics.

Facility managers can take the actions recommended by the system to enhance the IAQ based on the magnitude of pollutants and concentration levels. For example, a UV-C light emitting device equipped with an ION air purifier is installed in the building to improve its IAQ when the condition drops to a certain level. The IoT sensors and the platform work together to monitor the IAQ.

Data turned into actionable intelligence

Not only does data analytics provide insightful information, which can be used to optimise a building's energy performance and remove inefficiencies, it also helps improve the overall performance of a building's equipment, resulting in lower energy costs and a longer lifespan. Other benefits include improved occupant comfort, productivity, etc.

The emergence of innovative technologies like Neuron Health enables faster, more accurate collection, aggregation, analysis and storage of data for risk assessment and remediation planning. For example, the collected data can help assess and manage indoor pollution levels and predict potential pollution threats.

It also helps facility managers and even developers revisit the building design and fix those issues. For example, they might want to find out whether there is a need to install more vents for better ventilation or find ways to improve the indoor air quality, such as using less carpeting or ducts and high-quality paints with low volatile organic compounds (VOCs).

Buildings of tomorrow

Showcasing future scenarios for buildings of tomorrow, data-driven healthy and resource-efficient buildings embrace human-centric designs through innovative technologies and sustainable concepts – integrating digital transformation, health, well-being and human experience into a built environment.

Looking ahead, the advent of new technologies fuelled by the deployment of 5G networks, cloud, big data and IoT will allow facility managers to move beyond surveys, outdated reports and 'gut-feel' about various measures to improve the condition of a built environment.

When it comes to returns on investment (ROI), a sustainable building design will enhance the capital and rental value of the asset over time. The energy cost-saving, operational efficiency, occupant comfort and health benefits solidly justify the upfront investment costs of the deployment of building technology systems in financial terms.

Da Nang WtE facility:
Let no waste go to waste

Client:
Asian Development Bank (ADB)

Arup's scope of services:
Technology options analysis, concept level design, financial modelling and analysis, PPP deal structuring, market sounding, economic analysis and environmental and social analysis.

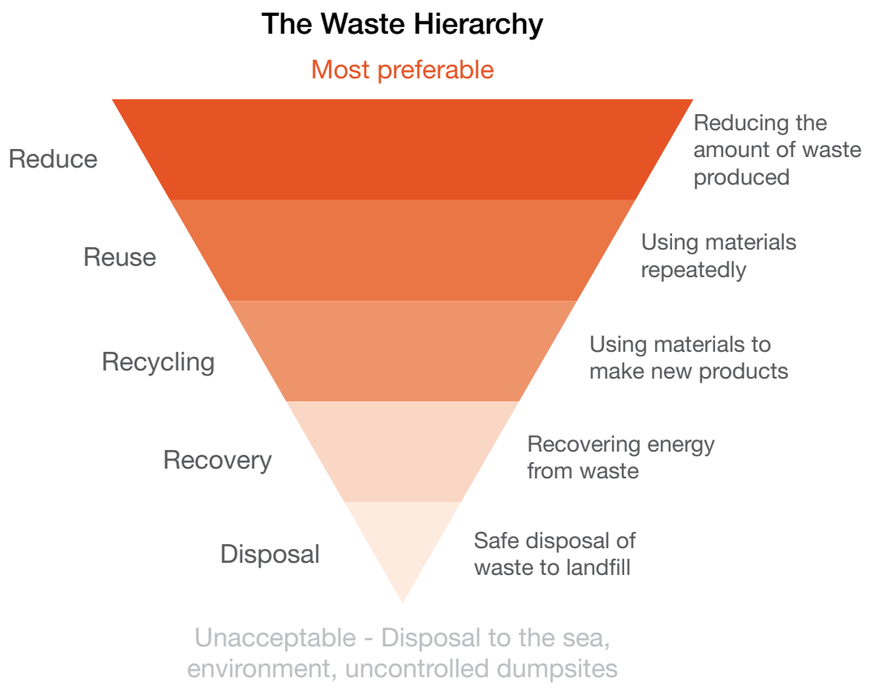
Comprehensive feasibility study on implementing a waste-to-energy (WtE) facility under the public-private partnership (PPP) model in Da Nang, Vietnam.

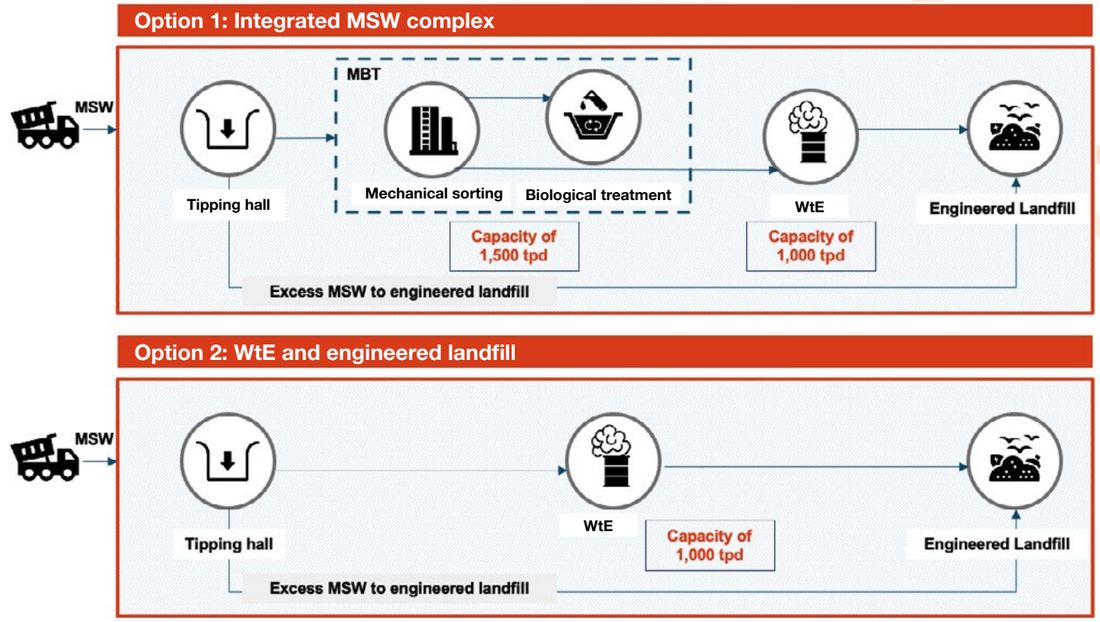
Da Nang's growing population and middle class is expected to result in increasing levels of consumption and associated municipal solid waste (MSW) generation. Without investment in additional waste treatment facilities the city was expected to run out of landfill space by as early as 2020.

Working for Asian Development Bank (ADB) and the Da Nang Peoples Committee (DNPC), Arup conducted a comprehensive feasibility study that provided commercial and technical advice on the development, implementation and ongoing operation of a WtE facility, with the aim of leveraging private sector capability and financing under a PPP structure.

To cope with the growing demand for waste treatment, DNPC formulated a master plan for solid waste management in Da Nang City as part of its broader Da Nang Development Master Plan. The solid waste management master plan aims to minimise waste generation at source and enhance re-use and recycling initiatives to reduce the volume of waste requiring disposal.

The goal of the solid waste management masterplan is to facilitate Da Nang City's move towards international best practice in terms of the waste hierarchy.





The feasibility study proposed two primary project options.

The feasibility study leveraged Arup's unique ability to integrate technical and financial advice to provide a considered and holistic solution. Recommendations were based on establishing a detailed understanding of Da Nang's current and future waste generation and needs. Incineration with energy recovery (WtE) was recommended as a suitable treatment technology given the need for an option proven at scale for waste with similar character to that being generated in Da Nang, and in comparable conditions.

The study covered the following aspects:

Capacity sizing

The capacity of the facility was based on the MSW forecast planning basis, coupled with consideration of the cost implication of treatment. Since there was uncertainty as to the quantity of MSW generation over the next 20-30 years the project's planned capacity needed to balance over and under provision and be flexible to handle varying quantities of waste.

Therefore, an engineered landfill with full environmental controls to handle excess waste was recommended as part of the solution. Increasing the WtE plant's treatment capacity over time through the addition of new incinerator lines to respond to changes in waste volumes was another option tabled to ADB and DNPC.

Waste technology options

A total of ten technology variants were assessed. After analysing the pros and cons of each technology, options comprising various combinations of Mechanical Biological Treatment (MBT), incineration with energy recovery (WtE), and engineered landfill, were considered further.

Given that the project would form the primary waste treatment and disposal facility for Da Nang for the foreseeable future, it was necessary to avoid technologies that had not yet been proven at a similar scale and for a similar waste type, due to the risk of failure.

Site selection

DNPC identified two possible sites for the project, each with its own specific strengths, limitations and challenges. Both sites were located at former quarries, and were a similar distance from Da Nang City, while the environmental and site challenges were different.

After careful analysis of the sites in conjunction with the technology and sizing we recommended a larger site in Hoa Nhon in line with the Master Plan. This site allowed for more significant future capacity expansion and development into an integrated waste and recycling facility, subject to appropriate environmental protections being implemented.

Project options

The feasibility study proposed two primary project options, including Option 1 (base case), an integrated MSW complex, and Option 2 (alternative case), a WtE and engineered landfill. In each case the landfill needed to be sized to accommodate any excess MSW generation over the WtE capacity.

Market sounding

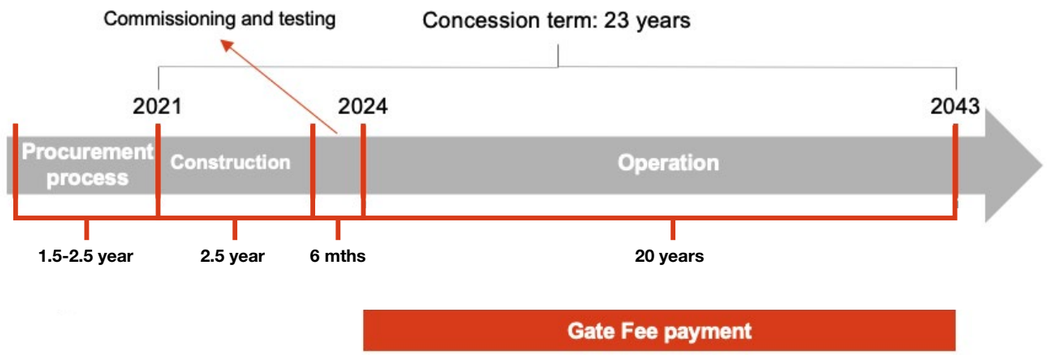
A detailed market sounding exercise was undertaken in order to determine the likely appetite of various market participants to bid for the proposed project and to seek industry feedback on key technical, commercial and financial elements. Market sounding participants included developers, investors, technology providers and lenders with representation from the local Vietnamese market and overseas firms, with varying track record of successful delivery of waste treatment projects.

The market sounding exercise provided the project team with valuable intelligence on how to maximise the appeal of the project to future bidders, and to ensure proposed solutions would be actionable and deliverable, from both a technical and commercial perspective.

Financial assessment

Arup's financial advisory team undertook a comprehensive financial viability assessment for each of the technical options presented. The assessment involved estimating overall project costs, including capital costs, annual operating expenses, asset refurbishment costs, financing costs, depreciation and taxes; exploring alternatives for additional revenue streams; and computing the required annual gate fee payment from DNPC that would generate reasonable investor returns over the PPP contract term.

Comprehensive scenario analysis was performed to explore opportunities to optimise (minimise) gate fee by, for example, starting with a smaller capacity facility with expansion assumed in later years, considering alternative approaches to gate fee indexation, and altering the length of the proposed concession term.



■ The project timeline of the project development and implementation.

Economic viability assessment

Under the local waste charging practices in Da Nang, any gate fees would be paid directly to the facility operator by DNPC, with DNPC recovering some of the cost from waste generators and users. It was imperative that robust economic and social benefits be demonstrated for the project. Arup's City Economics team supported the core project team by undertaking an economic cost benefit assessment for each of the project scenarios developed. Their analysis was able to show a significant benefit to the people of Da Nang, both in terms of economic and social outcomes. Non-quantifiable benefits such as potential for greater tourism flows, improvements in public health, reduction in visual and air pollution, and potential for enhanced recovery and recycling of materials such as iron and aluminium from bottom ash, were discussed.

Preliminary environmental and social impact assessment (PEIA)

The project has the potential to impact the study area socially and environmentally. The main social considerations included the need to offer viable alternative employment to the network of informal waste pickers at the existing landfill facility and a mechanism to ensure fair and transparent dealings with local communities requiring resettlement, which were explored in the PEIA.

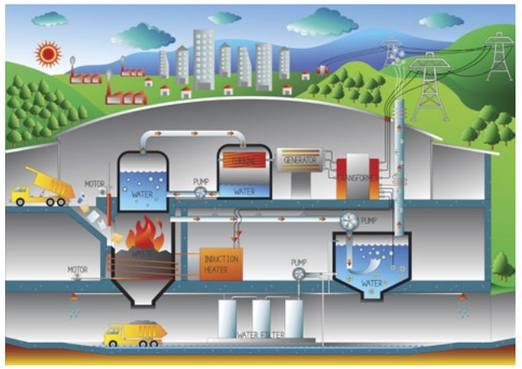
The potential environmental impacts were also studied, particularly air impact and ground water flow, with robust prevention and mitigation measures proposed. Capacity of the local environmental authorities was also identified as a concern, with recommendations to enhance the ability to assess compliance and to penalise non-compliance with the relevant contract clauses on environmental and social performance.

PPP structuring and Value for Money (VfM) assessment

The analysis culminated in developing a PPP deal structure for the project which was aligned with DNPCs project objectives and the anticipated (at the time) Vietnamese PPP law, whilst also providing a reasonable risk allocation that would appeal to a wide range of potential bidders to maximise competitive tension during subsequent procurement. The PPP deal design was developed to incorporate feedback received from various stakeholders, including national and municipal government agencies, and the local URENCO[1] entity responsible for waste collection.

As part of the PPP structuring work, preliminary views on the requisite capabilities that would need to be demonstrated by potential bidders were identified for subsequent inclusion in evaluation criteria for a prequalification stage of project procurement. In addition, overlaying the PPP deal structure with DNPC's project objectives, and international best practice, allowed development of preliminary bid evaluation criteria, which would be further built upon during subsequent procurement.

As a final step, the team carried out a VfM analysis to determine whether the risk transfer and anticipated innovation and efficiency that private sector could deliver would allow DNPC to implement the project more cost efficiently than under a traditional government delivery model, despite the need to allow for costs of private sector financing. The analysis showed that PPP would be advantageous.



■ Waste-to-energy (WtE) plant. Image for illustrative purpose only.

Limited local precedent required creative thinking

The lack of local precedent of PPP deals in the solid waste management sector, combined with an evolving regulatory environment, meant recommendations needed to be robust and in line with international norms. This included detailed research from across other Southeast Asian markets to ensure defendable positions were put forward.

However, given the detailed nature of operating, price and environmental regulations in Vietnam's waste sector, the international approach of using a competitive bidding process to finalise design and optimise price (gate fee), and subsequently obtain environmental approvals, was not consistent with local expectations. To address this issue, we supported ADB in a consultation exercise with the Ministry of Construction and the Ministry of Planning and Investment as part of a capacity building exercise to share international practice and exchange ideas with the aim of proposing a bankable project that could be replicable in future projects in Vietnam.

Results

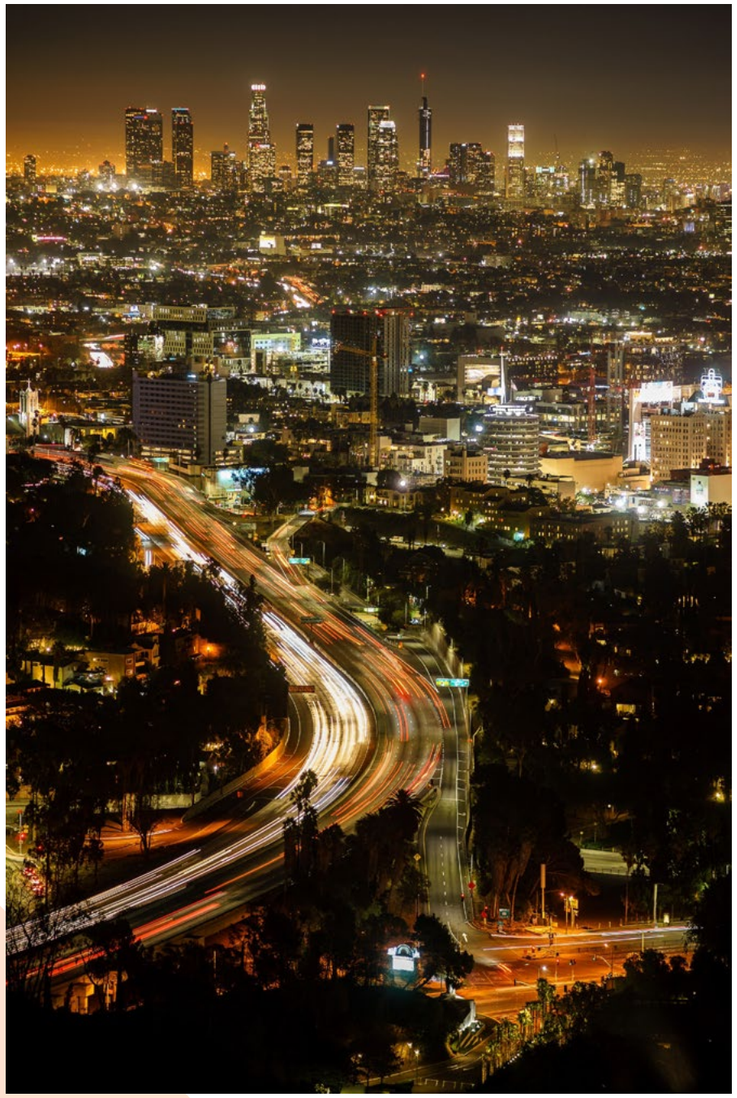
Arup was able to leverage a uniquely integrated team, bringing together and coordinating expertise across disparate disciplines. Importantly, the team was able to iterate technical and financial solutions to ensure an overall optimised project outcome for DNPC and the people of Da Nang.

Our work applied international best practice and involved significant market engagement, in turn shaping a transaction structure that would maximise investor appeal. Our work also highlighted the need for enhanced clarity of certain local regulations to reflect current market practice and better align with the PPP principles to facilitate greater private sector involvement in the waste sector.

As an outcome of the study, Arup is now working with the ADB and the Vietnamese Government on a subsequent project which seeks to address these regulatory issues.

1 URENCO: Urban Environment Company, a municipal government-owned company with primarily responsibility for waste collection, treatment and disposal activities

Sustainable City pLAn:
Setting out the Green New Deal



Arup advises Los Angeles' Sustainable City pLAn update.

Client:
The City of Los Angeles

Arup's scope of services:
Planning and sustainability advisory

A sustainability and planning advisory team from Arup's US offices make recommendations for priority actions and updates to the Sustainable City pLAn for the City of Los Angeles.

Arup has served as the lead technical advisor to the City of Los Angeles and C40 Cities to make a comprehensive update to its city-wide Sustainable City pLAn, first launched in 2015. Now known as the Green New Deal, the updated Sustainable City pLAn sets out a vision to protect the environment, grow the economy, and improve equity. The pLAn refresh, launched earlier this year, has further added a comprehensive climate action strategy to the original plan, including a pathway to carbon neutrality by 2050.

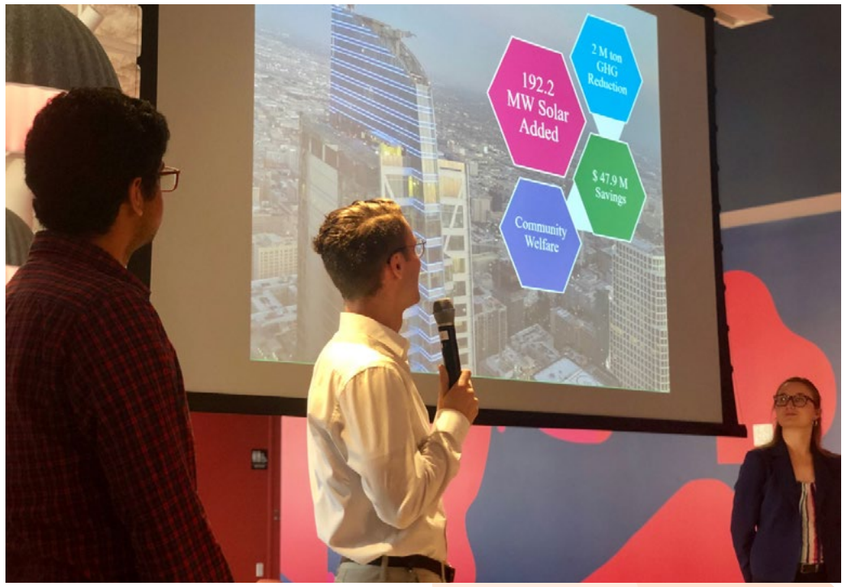
Arup provided a comprehensive analysis on greenhouse gas emission reduction pathways, carbon impacts of citywide goals and initiatives, environmental/human health co-benefits and economic impacts.

The analysis serves as a technical basis to the plan update and recommends strategies to reach Los Angeles' ambitious sustainability goals. We worked on several parallel tracks to understand the opportunities and challenges the City faces, which included conducting greenhouse gas and carbon analyses, as well as considering economic factors, environmental impacts, air quality, and job creation.

13 CLIMATE ACTION

Los Angeles' long-term sustainability goals

- Making every building in Los Angeles emission-free by 2050
- Building a zero-emission transport network
- Providing 300,000 green jobs by 2035, leading to 400,000 by 2050
- Making sure that good, middle class jobs go to Angelenos from low-income neighbourhoods that often bear the brunt of climate change
- Achieving zero waste by 2050
- Providing 100% clean energy, mainly from solar power, wind and hydropower
- Ensuring that all low-income Angelenos live within ½ mile of fresh food by 2035
- Planting and maintaining 90,000 trees citywide by 2021
- Ultimately, the plan aims to protect the environment and make the economy work for everyone.



Los Angeles' summer interns used the plan's framework to inform their research projects.

The pLAn update takes a broad approach and prioritises equity, health, and justice along with sustainability. Ultimately, it aims to deliver a better Los Angeles for the future, one that is compliant with the Paris Agreement, is carbon neutral, and is an equitable place for all. For this project, Arup worked closely with the City's sustainability officer to co-ordinate among as many as 28 government agencies, leading to a more integrated and inclusive approach.

While not mandatory, interns were engaged in the project to bring in a diversity of perspectives based on their specific field of study.

The project was also part of C40's Climate Action Plan Technical Assistance Programme, which Arup helped develop. The C40 Climate Action Planning Framework provided the structure for the work and was consistently referred to as the ultimate reference point for what the project needed to communicate and accomplish.

For Los Angeles, specific sustainability and carbon challenges include existing buildings, transportation and solid waste. In general, social and economic equity are challenges in Los Angeles and these also underpin sustainability decision making.

In the analysis, we addressed these specific and broader challenges by mapping out science-based quantitative goals for each area and then collaborating with the City's departments to propose specific initiatives that can be undertaken to reach those goals.

Our recommendations included working with the City departments to develop a series of actionable initiatives that support achievement of the plan's goals. Additionally, we are also helping the City to develop public policy in support of the plan's goals. For example, the LA Green New Deal establishes targets around both energy efficiency and decarbonisation of existing buildings. Arup is currently engaged in a study of different pathways for existing buildings to satisfy both targets, with an understanding of the potential implications to owners around cost, disruption and timing.

The pLAn update is just one of our many projects with the City of Los Angeles to shape the City's sustainable future. We are also working on the Department of Water & Power portfolio energy and water audits, a resilience training with Metro, and the First and Broadway Civic Center Park, which is the first project in the city to pursue LEED, Envision[1], and SITES[2] certifications.

Arup's engagement was made possible through our partnership with C40 Cities and its Climate Action Plan Technical Assistance Program. In addition to the City of Los Angeles, Arup's sustainability leadership in the built environment has resulted in impactful partnerships with major cities globally and across North America, including New York, Boston, San Francisco, Washington DC, and Toronto as they pursue sustainability and climate action plans.

Moving forward, it will be critical for the City to develop programmes and allocate funds specifically targeted to these challenging areas. Arup hopes to continue collaborating with the City in these areas.

1 Envision is a rating system that measures the sustainability of an infrastructure project from design though construction and maintenance.

2 SITES certification offers a comprehensive rating system designed to distinguish sustainable landscapes, measure their performance and elevate their value.

About Arup's partnership with C40 Cities

C40 is a network of the world's megacities committed to addressing climate change. C40 supports cities to collaborate effectively, share knowledge and drive meaningful, measurable and sustainable action on climate change.

By partnering with C40 Cities, Arup aims to affect meaningful, measurable and sustainable action on climate change. Led by its ambition to shape a better world, Arup will back cities to rapidly reduce emissions to prevent catastrophic climate change. Together, Arup and C40 will work with city mayors on programmes to improve energy efficiency, reduce waste and encourage a move towards a more circular economy.

Arup is trebling its previous commitment by pledging US$3 million of advisory support to C40 over three years. The partnership will build on innovative projects such as Deadline 2020 - a new approach to climate action planning for C40 member cities.

Together, Arup and C40 will explore how consumption patterns in cities need to change and how data can support decision making and the monitoring of progress against climate action plans.

18.8 million residents

Los Angeles is California's most populous city. The Greater Los Angeles metropolitan area has a population of 18.8 million.

US$700 billion GDP

Los Angeles is the second largest metropolitan economy in the US, with a GDP of more than US$700 billion annually.

Climate action

Despite Los Angeles's reputation as a 'car capital,' it is one of the cities championing climate action.

11% reduction in carbon emissions

In 2016 alone, Los Angeles slashed emissions by 11%.

Zero-emission port by 2035

The Port of Los Angeles is one of the greenest ports in the world, with a pledge to go to zero emissions by 2035.

30,000 new green jobs in five years

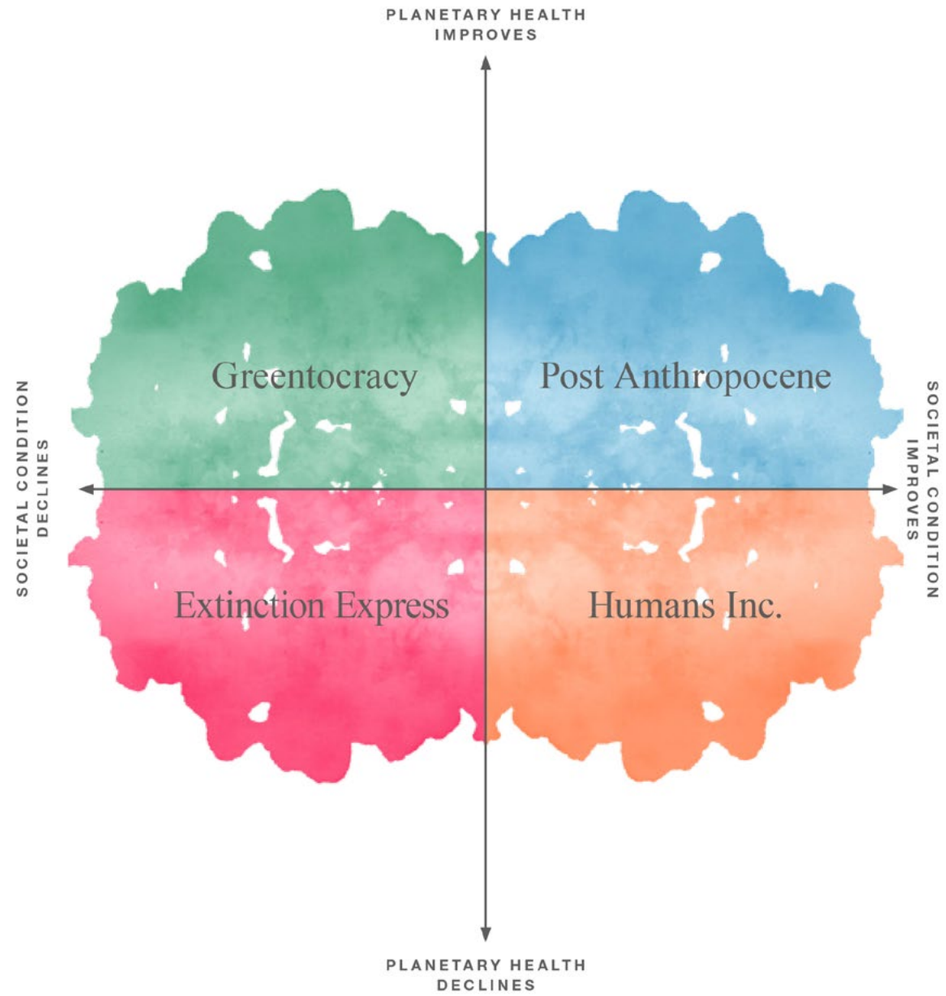
For perspective, there are 50,000 coal jobs in total in the US.

The future is a fiction.
It is a story we are all writing together.
So, what will the world of 2050 look like?

2050 scenarios:

A glimpse into four fictional futures

Utopian or dystopian? Hopeful or desperate? What the future holds for us will depend on how committed we are today to investing in a sustainable future, according to this Arup report.



From Australia's rampant bushfires and Asia's massive floods to an unprecedented pandemic, the mankind is surprisingly vulnerable to disasters and tragedies. If climate change and human's encroachment on the nature continues to take their toll, what the world will look like in 30 years?

According to **Four plausible futures: 2050 scenarios**, published in December 2019 by Arup's Foresight Research and Innovation and Sustainable Development teams, the future is still bright if everyone acts decisively today. On the other extreme end of the report's projection, we are destined for a dystopian future if we continue to take natural resources for granted. The report presents four plausible scenarios based on our assumptions against the parameters derived from the nine Planetary Boundaries, Arup's Drivers of Change cards, as well as the United Nations Sustainable Development Goals (UN SDGs).

The four plausible futures are: **Humans Inc., Post Anthropocene, Extinction Express** and **Greentocracy**. Each scenario comes with a timeline of events, a fictional character and key indicators helping the reader visualise what the world will look like in each scenario. They are intended to develop a vocabulary and framework to help us envision different futures and provide a platform to discuss the implications of the implied trajectories. Ultimately, they help to identify and visualise what is worth striving for and what to avoid.

Humans Inc.

‘Human Inc.’ is the continuation of our current trajectory; a world in which societal conditions advance at the cost of planetary health. In this future, global temperatures have exceeded the 2°C target and coordinated action on a global level continues to struggle. Here, increased frequency and severity of weather events continue to have a detrimental effect on our cities and ecosystems, yet technological advances have reduced poverty, improved education and ensured jobs are abundant.

A somewhat converse and counter-intuitive development has taken place in some northern countries. Typically cold and arid, these areas have seen significant improvement in agricultural growing conditions as global temperatures continue to rise.

In Canada and Russia, large swathes of ice-prone land have become arable. Some other northern nations have even advocated increasing carbon emissions to accelerate the expansion of agricultural land and develop new areas for resource mining. These regions are becoming popular destinations for populations that have lost their habitable homeland to climate change.

Post Anthropocene

‘Post Anthropocene’ shows how societal conditions and planetary health might exist in a harmonious relationship, fortifying each other for mutual progress and benefit.

After crop failures and famines between 2025 and 2030, people reflected on the irreversible damage done to the planet caused by carbon emission and food consumption. Therefore, people joined forces to clean up the mess.

Thanks to extensive efforts, what was once known as rubbish or garbage has become most valuable resources and is mined both on land and sea. Virgin plastic is banned, and in 2047 a museum is opened to display plastic artefacts. Collaborative decarbonisation efforts have been made globally across sectors. Global mean temperature rise has remained below the 1.5°C target and the sea level has risen less than expected.

Both people and the planet are on the path to a regenerative world. Society consumes resources at the rate at which they can be replenished, populations are diverse, and societal structures are balanced.

Greentocracy

‘Greentocracy’ shows an improvement in planetary health but this has been enabled by severe restrictions on human society: poor living conditions, conflict and authoritarian regimes prevail. The global mean temperature rise remains below 1.5°C due to climate action and fostering biodiversity being at the top of the agenda. Nationalist governments pack their citizens into dense high-rise cities.

With nearly 60% of the global population relying on synthetic food sources, the first signs of detrimental health impacts are starting to show. Fears are compounded following a disturbing article in the leading academic journal, Nature in 2040, citing severe micronutrient deficiencies across large parts of the population due to over-reliance on synthetic food sources. It also questioned the influence of hyper- densification, limited living space and restricted access to nature.

No complaints are allowed in the present political climate. There are ‘Eco-re-education’ facilities for citizens who repeatedly violate environmental codes of behaviour. The planet has been saved, but civil liberties are low, press coverage is restricted, and expression must align with local laws.

Extinction Express

‘Extinction Express’ is the worst-case scenario, which depicts both declining planetary health and societal conditions. It is questionable how much longer humanity can survive.

Climate change and the inexorable consumption of Earth’s resources has resulted in fundamental destabilisation of natural systems. Resource, energy, water and food shortages are pervasive across the world. Environmental consciousness is largely non-existent. The Amazon rainforest is gone. Natural resources are being extracted everywhere. Geo-engineering and Generically modified organism (GMO) crop development are the only way to feed the global population. Seeds are controlled by Holycrop, an American-based business, which monopolises the market.

Domes are built over cities to enclose breathable air. Isolationism has been on the rise for years, and society is driven by a fear of the ‘foreign’ and ‘different’. This has been exacerbated by an unheralded number of climate refugees. Economic disparity has increased dramatically. This bleak future is even more dystopian as Caitlyn, the story’s protagonist, who left San Francisco because of political instability, drives around Sweden in her armoured car, trading rare earth commodities.

Endnote

These four worlds, each extreme yet plausible, impart a valuable message: there is no one future state, just as there is no one present state. Although there is no way to know what the world will look like in 30 years, the development of these four scenarios allows us to explore the possibilities of what our future could look like in 2050. These scenarios challenge our assumptions about the future and help us reimagine our role as a society.

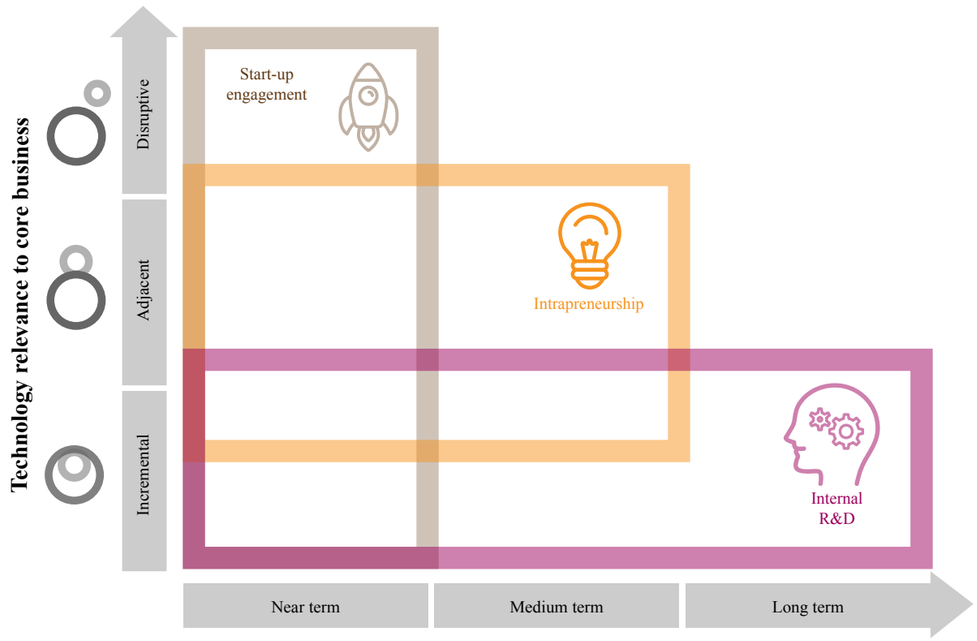
Click **here** to watch the video

Download the report from **here**

Building a culture of innovation

Developing a robust culture of innovation is what has made Arup a highly creative community of engineers and designers. In so doing, Arup combines in-house research, intrapreneurship and start-up engagement to turn innovative ideas into potentially disruptive solutions for clients.

Arup adopts a structured approach to fostering innovation, combining in-house R&D, intrapreneurship and partnerships with innovative start-ups specialised in construction, engineering and building design technologies. This three-tier approach enables Arup to develop or acquire the necessary technologies that meet short-term, medium-term and long-term development goals, respectively.



In-house research drives incremental innovation

Discovering new knowledge or ideas through applied research is crucial to driving incremental innovation within an organisation. Arup University's R&D programme is meant to direct researchers towards understanding and formulating practical solutions that meet specific business needs or address foreseeable challenges arising from urban planning, smart mobility, city resilience, workplace wellness, sustainable development, etc, all of which are in line with Arup's forward-looking approach to city planning.

A research project may include desktop research and ground investigations towards the discovery of new knowledge with an aim to develop new or improve existing products, processes or services. Employees can apply for funding of research and manpower costs, including partnerships with universities and research bodies.

Intrapreneurship accelerates innovation

On top of the in-house R&D programme, Arup University runs an 'intrapreneurship' programme that encourages employees to formulate innovative or potentially disruptive solutions that are different and considerably better than what we have been offering.

Each business or innovative idea is matched with a mentor, who is a subject matter expert, with the team, giving them support on their journey to turn an innovative idea into reality and potentially into a product.

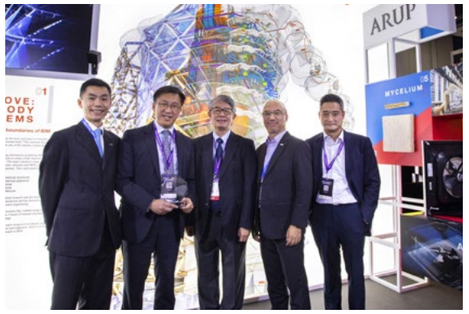
An internal corporate venturing team is responsible for prioritising proposed venturing ideas based on their technical feasibility, business impact and marketability. How an innovation is integrated into client projects varies from case to case, subject to the maturity of the solution and our experience with it.

The intrapreneurship programme allows participants to learn how to manage R&D activities as if running a start-up. Through seed funding and mentorship, Arup University aims to create a safe space for employees to undergo trial and error. This fail-fast model allows our leaders to calculate risks before they make bolder decisions.

Engaging with start-up ecosystem to enable disruptive innovation

Successful corporate innovation requires not only internal but also external talent and resources. Arup is open to partnership opportunities with innovative start-ups to tap into emerging technologies and business models that fit into our client solutions.

We have established relationships with the region's tech ecosystem comprised of start-ups from the Hong Kong Science and Technology Park, Cyberport and other incubators/accelerators; the Hong Kong Trade Development Council (HKTDC), venture capitalists, tech parks, co-working space managers and research bodies, with an aim to expand our technology portfolio that gives our project teams a technological edge and create new value for clients.



Arup's start-up engagement initiatives include mentorship, sponsorship and participation in start-up events, such as the CIC Construction Innovation Expo 2019 and...

HKTDC Entrepreneur Day 2020.

As part of our start-up engagement efforts, we provide mentorship and business advice for external entrepreneurs and innovators. For example, Arup mentors have recently provided mentorship support to students at Resilient HK Challenge, an initiative that brings together innovators and corporates working together to help Hong Kong adapt, overcome and grow beyond its challenges as a resilient city.

Arup is also working with external partners to build a collaborative platform that facilitates internal project teams in the creation of innovative solutions, exchange knowledge, and discover new opportunities for synergy.

Win-win-win for all

No matter the technology is mature or at an infant stage and whether it is developed in-house or through partnerships, Arup believes that there is no simple turnkey solution that caters to all.

By fostering a culture of sustainable innovation internally and engaging with innovative start-ups externally, not only can Arup gain a competitive edge, Arup can also continue to attract and retain talent and most importantly deliver innovative solutions to clients and end-users.

Intelligent scanning of rock armour

Arup has trained an in-house developed AI model that automatically analyses rock armour images captured by drones for abnormality detection.

As extreme weather becomes the norm amid rising sea levels, seawalls play an important role in safeguarding lives and properties that are typically concentrated in coastal areas. Rock armours are commonly used as seawalls as they have natural appearances, and are more flexible and easier to construct.

In the East Asia region, typhoons can cause catastrophic damage to coastlines. Breakwaters and seawalls are important structures to protect critical coastal facilities. Rock armours are typically constructed offshore, or at the shore, to help dissipate waves, prevent coastal erosion, and reduce wave overtopping.

For rock armour layers and underlayers above the water level, visual inspections from the top of the slope and by boat from the bottom of the slope are required to be carried out in addition to the normal profile check by survey. This process is done manually, usually once in two years. Also, the work is dangerous and time consuming for the engineers involved.

In efforts to automate this process, Arup has developed an automated rock armour mapping system that can monitor changes to rock armour structures, particularly after severe events, therefore enabling repairs to be implemented in a timely manner before a major, costly failure.

In our study, an Unmanned Aerial Vehicle, commonly known as drone, was used to capture high-resolution aerial photos and produce orthophotos and Digital Surface Model.

Image data captured by the drone were then used to train the AI model built on Detectron2 – a PyTorch-based computer vision library released by Facebook in October 2019. Detectron2 reads images annotated with JSON files as ground-truth input.

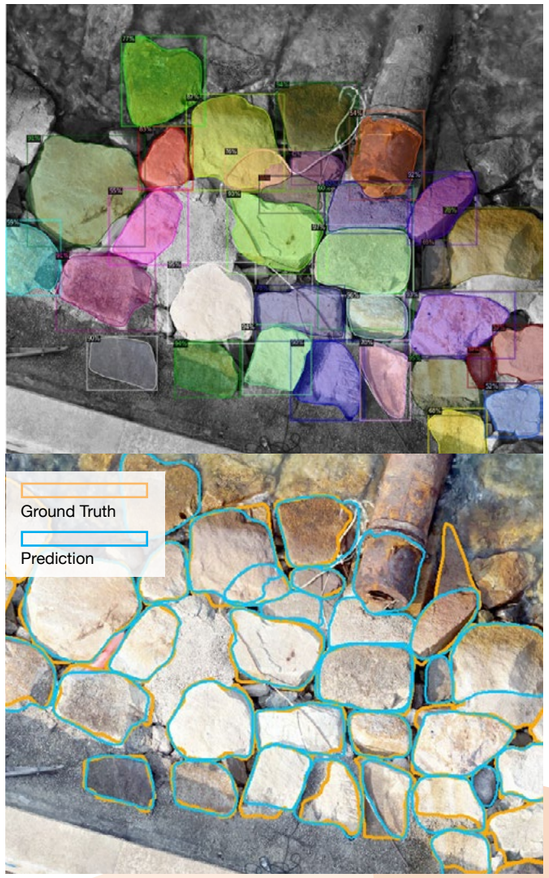
ArcGIS add-ins were also developed to convert the ground truth in shapefile and orthophoto formats into VIA JSON format.

Manual inspections of rock armour layers are time consuming and sometimes dangerous.

The images then underwent the instance segmentation process to recognise object boundaries and, in this case, identify rock armours from the trained database.

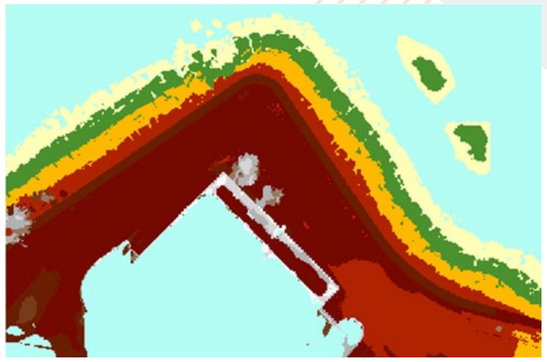
The results were converted back into GIS. In our analysis, polygons with the ground truth could be recognised and predicted from segmented orthophotos with an accuracy rate of about 88%. The trained model can be used to recognise and predict rock armours in other locations within Hong Kong.

Elsewhere outside of Hong Kong, Arup engineers can further train this model by inputting image data of other types of rock armours or seawalls in order to recognise and predict rock armours not seen in Hong Kong.



In the analysis, polygons with the ground truth could be recognised and predicted from processed and segmented orthophotos with an accuracy rate of about 88%

Elsewhere outside of Hong Kong, Arup engineers can further train this model by inputting image data of other types of rock armours or seawalls in order to recognise and predict rock.



The goal is to develop an automated or semi-automated processor (or a standalone software platform) that applies image segmentation technologies to quickly and accurately determine the sizes of rock armours. This will help Arup engineers check the hydraulic stability of armours in seawalls and breakwaters efficiently and cost-effectively.

In future, the model will provide clients with a permanent record to detect any rock movement over time. This learning-based anomaly detection and monitoring model can also be applied to other rock armour types or other seawall structures. This research project serves as a valuable trial for Arup's implementation of drones in advancing civil engineering and surveying.

Mangkhut's aftermath offers window of opportunity for Arup to study façade's resistance to severe winds

In September 2018, typhoon Mangkhut swept through Hong Kong. At its strongest, the Hong Kong Observatory issued the Hurricane Signal No. 10, the highest level of tropical cyclone warning signals in Hong Kong.

Despite the widespread damage it caused, Mangkhut provided a window of opportunity for Arup wind and building envelope engineers to study the impact resistance of glass façades against exceptionally strong winds, possible damage mechanisms and design options that mitigate the risk of wind damage.

According to the typhoon damage map we created (Figure 1), it is evident that most glass breakages occurred near seacoasts, or to be more exact, within 0.5km of the sea. To explain the reasons behind such damage patterns, our team conducted a detailed terrain analysis, constructing an ensemble of three wind speed scenarios based on different distances from open water.

In the first scenario, onshore wind blows directly from open water. In the second scenario, onshore wind blows from open water with 0.5km between the urban space and the coast. In the third scenario, onshore wind blows from open water with 1.0km between the urban space and the coast.

The findings also show that even 0.5km of city terrain reduces the gust wind speed at lower boundary layer heights (e.g. below 40m), due to its higher surface roughness.

Our team also conducted a Computational Fluid Dynamics (CFD) analysis on a selected coastal area where there were glass breakages. As shown in Figure 2, densely packed building blocks (along the purple line) prevent wind flow from permeating further inland.

The building cluster helps shelter the buildings behind from strong coastal winds. This is in perfect agreement with the observed damage distribution with most glass breakages observed along the first row of buildings. A much smaller number of cases were reported further inland.

Figure 1: Location map of surveyed damage spots after the 2018 Mangkhut.

(Note: The information shown on this map is not exhaustive and may not cover all locations with façade damages.)

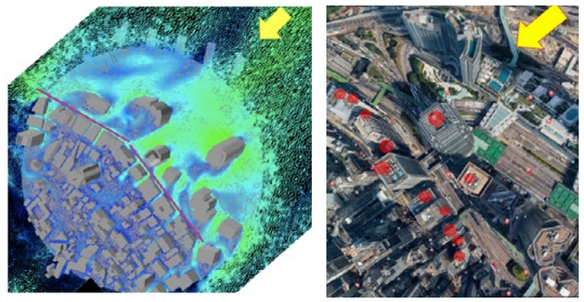


Figure 2: Sheltering effects from high building density. Accelerated flow due to shear layers from significant upward buildings.

Figure 3: A building with seriously damaged windows.

For buildings designed with the same standards, the risk of glass breakage — whether caused by overloading or wind-borne debris impact — is smaller due to a slower wind speed further inland. This explains why most window breakages occurred close to coastal areas.

The typhoon damage map further reveals that severely damaged windows are often found in building clusters rather than in isolation (Figure 3). Geographically, the clusters of damaged buildings are located: (a) close to coastlines; (b) surrounded by complex infrastructures and landscaping; and (c) sometimes near significant buildings.

For buildings located close to coastlines (a), they need to withstand the strongest gusts of wind, while (b) and (c) entail different airflow patterns, wind speeds and directions caused by a complex urban landscape. In order to visualise these effects, transient CFD simulations were conducted on selected damaged building clusters.

Figure 4 shows that once the wind flow from open water reaches the urban area, its momentum is transformed into pressure on the windward surfaces of buildings, resulting in acceleration. This is either due to the shear layers of upwind building blocks or other channelling effects. The negative effects of interference between buildings on wind pressure increase the risk of glass breakage in coastal building clusters.

The investigation yields constructive insights that help design best practices in protecting windows and façades from typhoon damage in the future.

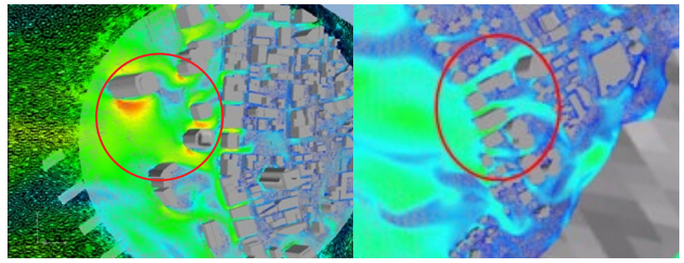


Figure 4: Negative interference effects of complex urban environments cause wind acceleration. Accelerated flow due to shear layers from significant upward buildings (left) and channelling effects (right).

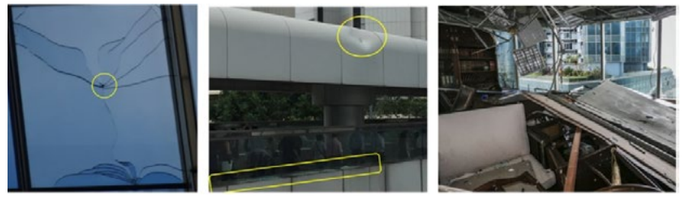


Figure 5: External conditions show evidence of impact damages caused by wind-borne debris.

In fact, relevant safety provisions, such as The Code of Practice on Wind Effects in Hong Kong (2019) and The Code of Practice for Structural Use of Glass (2018), in Hong Kong's building code were updated in the past two years to include different or higher standards needed to mitigate the risk of wind damage as revealed by this study.

Having said that, in view of the complex nature of the issue and the potential threat to the glass building envelope, it is worth the efforts for the industry and research bodies to conduct more studies in order to develop effective measures that can be taken to reduce the impact of a typhoon, and in particular, minimise property damage and risks of casualties.

Learning in a socially distant world

Peter Lam, Managing Director of HKT Engineering, was invited to deliver a talk to Arupians from across Arup's East Asia offices on the implications of 5G for the construction sector.

No matter working from home or in office, Arup University encourages employees to pursue training wherever their needs are best met.

As Arup employees adapt to remote and flexible working, Arup University ensures that they have what they need for ongoing remote learning. That is why providing remote training and learning has become one of our strategic imperatives.

Through Moodle, the companywide learning platform, Arup University provides continuous technical and soft skills trainings to employees, who are advised to keep socially distant amid a lingering pandemic.

Since March, Arup University has organised a range of technical training courses designed to upskill our employees in their functional fields.

Taught or developed by our Skill Leaders or subject-matter experts, these training sessions were conducted in a virtual classroom or as self-learning modules on the Moodle platform.

Apart from our in-house courses, we also partner with LinkedIn Learning in order to give our employees access to a database of selected courses, from essential digital and software skills in Python programming and BIM modelling, to soft skills like giving presentations, professional writing, time management and business etiquette.

From time to time Arup University invites external guests to give updates on technological trends. In May, we invited Peter Lam, Managing Director of HKT Engineering, to deliver a talk on the implications of 5G for the construction sector. Afterwards, Arup's attendees had a fruitful discussion on the deployment of 5G network and how it accelerates the integration of GIS, BIM and IoTs in building design and city planning.

Externally, Arup experts are constantly invited by professional bodies and industry journals as speakers to provide thought leadership on disruptive trends. For example, Dr Goman Ho, Arup Fellow and East Asia Structural Engineering Skill Leader, shared his perspective on earthquake resilience in a webinar hosted by China's Building Structure magazine in May, which was attended virtually by over 30,000 building professionals from across the country.

HOME

Lessons learnt from COVID-19:

Shaping a resilient future

During the past six months, Arup in East Asia has hosted and co-hosted a series of webinars and published a collection of thought leadership articles to share with the planning and building professionals and the wider public on how the COVID-19 outbreak forces us to rethink the way we plan, design and manage our cities.

In the year to August, we have hosted and co-organised 17 webinars, attracting more than 130,000 participants. The professional bodies Arup partnered with in presenting these webinars include Construction Industry Council, China-Britain Business Council, Urban Land Institute, Construction Innovation and Technology Application Centre, Hong Kong Green Building Council, and The America Institute of Architecture (AIA) Hong Kong.

In a webinar on 'sustainnovation' for green and healthy building design in the big data era, Tony Lam, Arup's East Asia Building Performance and System Skill Leader, talked about how big data can be applied in sustainable and healthy building design to reduce potential health risks and improve the overall environment for health and well-being of the occupants/users.

Click to watch

Future transportation will become more **A**utonomous, **C**onnected, **E**lectrical and increasingly **S**hared. This trend is characterised by the acronym ACES. Carmen Chu, Arup's East Asia Intelligent Mobility Skill Leader and Director of Arup's Transport Consulting team, and Lian Duan, Arup's Senior Engineer in Transport Consulting, were invited by AIA Hong Kong to give an overview of the fast-moving ACES trends and outline their impacts on cities, communities and major developments.

Click to watch

Webinar on mobility trends for a resilient urban system.

They also gave details on how operational strategies, such as mobility-as-a-service, can be implemented and their impacts on a city's transportation policy, adaptiveness and design processes. Other key takeaways included discussions on how an efficient transportation system can be incorporated into city planning and how well-being can be addressed through holistic mobility planning and public transportation redesign in the post-pandemic era.

Meanwhile, our thought leadership articles have been published in various social media channels, media outlets, and the website of Resilience Shift, such as 5 must-do's on urban resilience in a time of COVID, the COVID-SDG connection and the future of transport resilience. Other articles cover themes relevant to infrastructure planning, particularly water and public healthcare, as well as business continuity, healthy buildings and supply chain management.

Vincent Cheng

Leading Arup's winning green team

"Being a leader means we constantly challenge the status quo, envisioning and shaping the future. We see what we do as part of a larger purpose, fostering trust among policymakers and stakeholders."

HOME

© Hong Kong Management Association

■ Vincent was awarded the Sustainability Leader of the Year at the Hong Kong Sustainability Award 2018/19 by the Hong Kong Management Association.

Dr Vincent Cheng, Arup Fellow and East Asia Sustainable Development Leader, is one of Asia's most notable sustainability-focused engineers. During his career spanning over 25 years, he has driven Asia's green building movement, once leading an 80-strong team of multidisciplinary professionals specialised in green building assessments, engineering designs, energy efficiency solutions and strategic partnerships across the region.

His commitment and substantial contribution to sustainability has resulted in myriad awards and recognitions, the latest of which was the Sustainability Leader of the Year at the Hong Kong Sustainability Award 2018/19 from the Hong Kong Management Association.

What is sustainability leadership?

According to Vincent, sustainable development calls for concerted efforts towards building an inclusive, sustainable and resilient future for people and planet.

"To achieve this, it is crucial to harmonise three core elements: economic growth, social inclusion and environmental protection. The COVID-19 pandemic underlines their interconnectedness and the need for a holistic development strategy to bring economies back on track towards inclusive and sustainable growth. For me, sustainability is an evolving, dynamic concept, with increasingly diverse interpretations."

"Being a leader means we constantly challenge the status quo, envisioning and shaping the future. We see what we do as part of a larger purpose, fostering trust among policymakers and stakeholders."

To fulfil this ambitious mission, it is important to drive change in policy, practice and human behaviour, each of which activates and inter-influences each other. 'As long as we can demonstrate the environmental, societal and economic benefits of sustainability in our design, we can have a strong influence on public policies. Meanwhile, if stakeholders appreciate these benefits, it will raise their environmental awareness and pro-environmental behaviour, which will eventually influence future policies and our designs,' he explained.

Shaping policy framework towards sustainability

As an active public policy advocate, Vincent has been driving the formulation of effective green building codes and sustainability policies, providing Asia's policymakers, regulators and the private sector with building design guidelines, energy performance targets and desired comfort and health objectives.

Currently he is serving on the Board of the Hong Kong Green Building Council and Energy Advisory Committee of Environment Bureau of Hong Kong SAR Government to help the local authorities formulate green building codes, develop assessment tools and promote the adoption of green building practices. He has led the inclusion of district cooling systems, lighting and ventilation, green building and life-cycle energy assessment, urban climatic planning and urban heat island assessment.in Hong Kong's planning code.

In Taiwan, he has led the Arup team in developing the Low Carbon Assessment Code for the island's Environmental Protection Agency. The team is also partnering with Taiwan Land Development Corporation on embarking the eco-living projects in Taiwan with the vision of achieving circular economy.

Engaging stakeholders

Apart from advancing green building policies, it is equally important that the needs and concerns of stakeholders are properly addressed. For instance, commercial property owners are more concerned about cost effectiveness and return on investment, thus they must be convinced that the benefits of green buildings outweigh the costs, such as increased rental values and improved employee productivity.

“For homeowners or occupants, if they can personally experience, they will value and appreciate the benefits of living in a green building — physical comfort, indoor air quality, and that their home was designed and built to be as environmentally friendly as possible. Therefore, residential projects are better to be designed to foster a ‘dialogue’ between users and the environment, reinforcing positive experience.”

Realising impactful projects

Throughout his career, Vincent has delivered more than 100 BEAM Plus and LEED projects in East Asia contributing to a long-lasting positive impact on building energy efficiency and carbon reduction. Recent exemplar projects include Construction Industry Council Zero Carbon Park (CIC-ZCP), Hysan Place, Victoria Dockside, Wah Ha Estate, Kai Tak District Cooling System (DCS) , West Kowloon Cultural District (WKCD) DCS in Hong Kong; and Hualien Bay in Taiwan.

Not only do CIC-ZCP and Hysan Place showcase successful zero-carbon emissions strategy and implementation, they also provide practical functions for the office and public spaces, he said. “CIC-ZCP sets a living example of sustainable low-impact lifestyle not just for East Asia but also for the world.” Another green icon, Hysan Place, is Hong Kong’s first LEED Platinum and BEAM Plus Platinum certified building, infusing green building elements into the business community.

A District Cooling System (DCS) is installed across the West Kowloon Cultural District (WKCD).

With more than two decades of experience in designing public housing, Vincent said a more densely built environment does not have to come at the expense of living standards. “For less well-off families living in public housing, they also deserve a good quality of life. Our public housing design involves a careful consideration on residents’ well-being. The process is challenging, yet the results are rewarding and meaningful to us.”

For the Wah Ha Estate project, converted from a 50-year old factory building, Vincent’s team conducted microclimate and Computational Fluid Dynamics (CFD) analyses and tailored a number of green features, including eco-walls, to enhance natural ventilation and introduce daylight into domestic flats. Each residential unit is also carefully oriented to overlook the internal courtyards to optimise ventilation and minimise street noise.

For the Hualien Bay project in Taiwan, the holistic design improves the whole microclimate and boasts plenty of communal green spaces, making it more comfortable for tenants and having a positive effect on the community.

The impact of Vincent’s involvement in the planning, design and implementation of the Kai Tak DCS is even more far-reaching. The first of its kind in Hong Kong, the construction of Kai Tak DCS required fundamental changes to the city’s planning and design codes for energy.

Elsewhere in Asia, Vincent has been leading sustainable projects that address issues of rapid urbanisation and climate change, including eco-cities in mainland China, passive buildings in Japan and smart city in Korea.

Inspiring young Arupians

As an Arup Skill Leader, Vincent devotes selfless efforts to developing our people. “Part of Arup’s success lies in our commitment to creating a learning culture. We have many very talented leaders. We work together to contribute to our learning culture. It has not been always smooth, but we work like partners to make it happen.” The learning culture is more than developing technical skills. It is also about creativity and collaboration — to identify problems and develop solutions and to have control over outcomes. Equally important are the soft skills and mentality like perseverance, communication, and especially empathy, he said.

“Empathy means we understand each other and are aware of and are being sensitive to the feelings of others. We identify others’ problems, creatively developing solutions, designing the environment and creating the experience are the skills that enable us to see, understand and feel the world from others’ perspectives.”

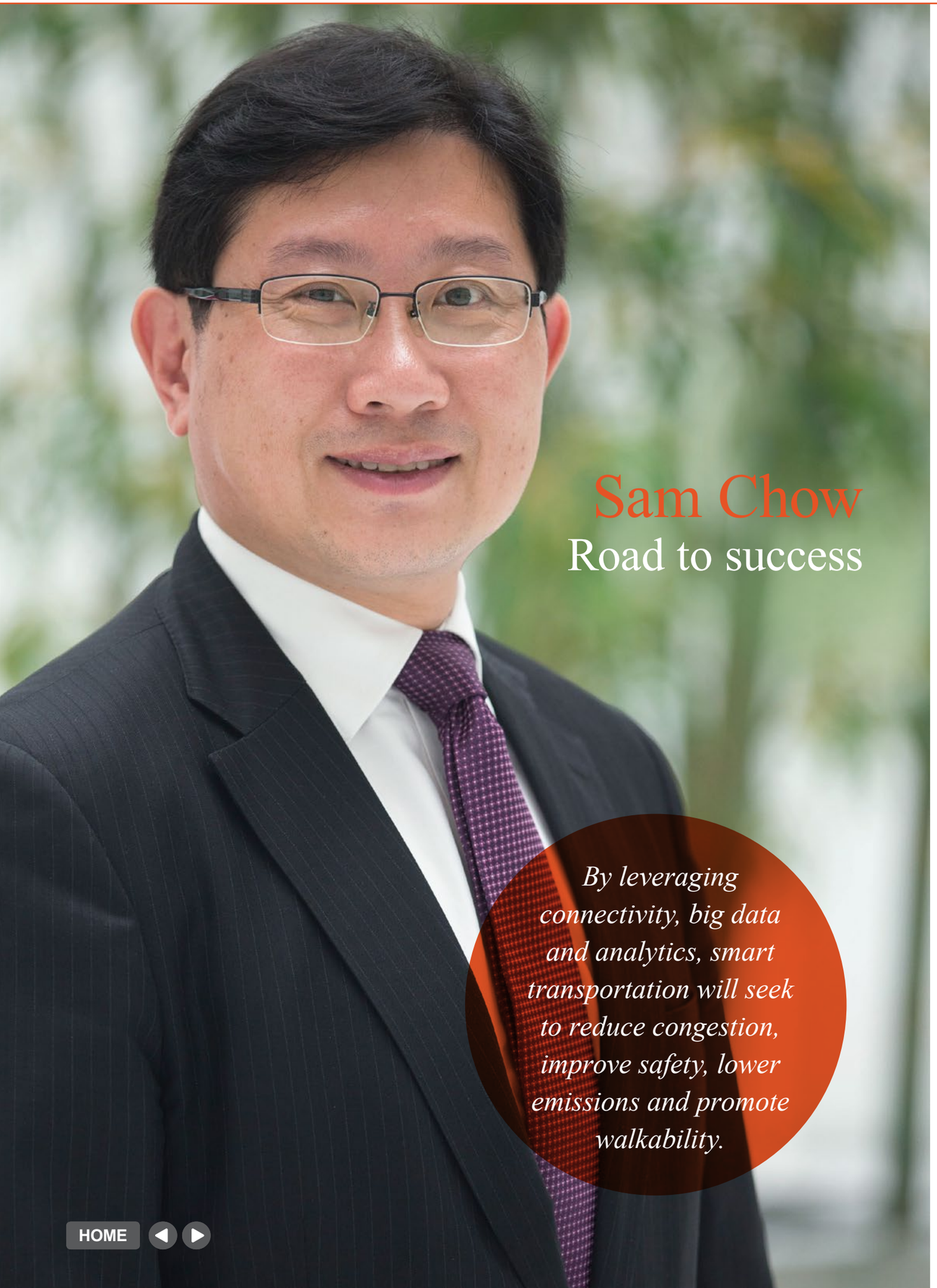
He reminded young engineers to keep a curious, problem-solving mindset. ‘Being able to explore outside the realms of business practice heightens your ability to formulate innovative solutions,’ he said. ‘It’s important to stay curious and find out how things work.’

Vincent’s mentorship with the firm’s established learning culture has inspired young Arupians to come up with innovative solutions. His group has delivered the highest number of patented projects across Arup.

Throughout his career, Vincent has delivered more than 100 BEAM Plus and LEED projects in Asia, including Construction Industry Council Zero Carbon Park (CIC-ZCP) (above) and West Kowloon Cultural District District Cooling System (WKCD DCS) (top right) in Hong Kong.

© Cheung Tsun

As an Arup Skill Leader, Vincent supports young engineers’ creativity and innovation through training and mentorship.



Sam Chow
Road to success

By leveraging connectivity, big data and analytics, smart transportation will seek to reduce congestion, improve safety, lower emissions and promote walkability.

Sam Chow, an Arup Fellow, Global Skill Leader of Transport Planning and a Director in charge of East Asia's transport consulting business, has contributed to the successful planning of many regional urban transport projects in East Asia over the course of his career.

Sam is now an internationally recognised expert in transport planning, engineering, forecasts, research and development studies. He has led a multidisciplinary team of planners and engineers from Arup in contributing to the regional infrastructure development in the past ten years.

Transport planning chosen as life-long career

After completing high school in Hong Kong in the early 1980s, he went on to study civil engineering in Australia. He pursued his childhood interest in transport planning by selecting traffic infrastructure engineering, modelling and management elective courses on top of discipline core courses.

Upon graduation, Sam returned to Hong Kong in 1986. He was landed a job as transport modeller with a US-based international transport consultancy. During his six-year stint, he had many opportunities to work on transport infrastructure projects in Hong Kong.

Sam left Hong Kong for Australia again in late 1991. He joined an Australia-based transport consultancy, where he gained plenty of experience in international projects.

While working in Australia, an old colleague in Hong Kong introduced him to a job at the Hong Kong company as a senior transport planner, a role required to be willing to travel to mainland China frequently and be able to communicate with Chinese clients. Apparently, Sam was the right candidate.

He was officially back to Hong Kong in the mid-1990s to pursue his career journey as transport planner. Hong Kong's and later China's rapid economic development opened him doors to exciting opportunities.

Hong Kong's 'golden age'

Hong Kong experienced strong economic and population growth in the 1980s and 1990s. The then Hong Kong government invested heavily in infrastructure facilities including ports, railways, highways, new towns and other strategic works to keep Hong Kong a competitive world-class city.

Among the first few projects he worked on in Hong Kong were planning studies on the extension of the metro and railway networks. He then conducted a lot of traffic forecasting for major highway projects, such as West Kowloon Highway, West Harbour Crossing, North Lantau Highway and Tsing Ma Bridge.

Amidst the city's trade boom, Sam was also involved in the planning and design of multiple port development projects and a comprehensive study on the expansion of the then Kai Tak Airport.

With rapidly increasing disposable income and growing tourists and business travellers flocking into the city, numerous upmarket hotels and shopping facilities were built, expanded and renovated including Pacific Place in Admiralty and Harbour City on the harbourfront of Tsim Sha Tsui. Sam was engaged in these iconic mixed-use projects as transport planner.

'The experiences I gained from these projects are so valuable for my later career at Arup that paved the way for us to capture tremendous opportunities arising from China's growth story that began in the 1990s.'

A ride on China's rise

Since the 1990s, the initial stage of China's growth has been its infrastructure development, particularly transport. All modes of transport saw their networks expanded rapidly, aiming to provide the infrastructure needed to support the broader development goals. 'I was very lucky that I could ride on the wave of China's economic development.'
Sam spent nine years with the US-based consultancy in Hong Kong. He was already a managing director in charge of the company's East Asia operations by 1999.

His track record included numerous infrastructure projects, such as toll roads, bridges, subway systems and tunnels. Many of these projects were public-private partnerships with various sorts of funding, guarantees and other items from the government.

Building Arup's transport team

He joined Arup as Director in 2011 on the invitation of Wilfred Lau, an Arup Fellow, who set up the firm's transport consulting practice in East Asia.

Contract signing ceremony for an urban transport planning strategic partnership with the Zhuhai Municipality in 2012.

■ Traffic consultancy for Shenzhen Qianhai COFCO Asia-Pacific headquarters.

■ Speaking at the Transit-Oriented Development Asia Conference held in Shenzhen in 2013.

■ Sam's team has conducted various feasibility studies of developing transit-oriented development (TOD) projects in mainland cities, including the Shanghai Xujiahui ITC TOD project.

'Over the years, we've built a 90-strong transport planning team in the East Asia Region, with key members in Hong Kong, Shanghai and Shenzhen. That compares with a humble team of 30-plus people when I came on board.'

The Chinese government has demonstrated a strong political will to drive through many transport projects over the past decade. Today, Arup's transport planning projects in mainland China account for nearly half of its transport consulting business in East Asia.

'After joining Arup, I've travelled extensively across the country, having made my footprint in all provinces in the country, from tier-one cities to as far as Qinghai and Tibet. For example, we worked on the Lhasa airport project with the aviation team before.'

In 2018, the team was awarded a consulting contract to conduct a feasibility study of developing a transit-oriented development (TOD) for the Hangzhou West railway station, which is a planned new station intended as part of the infrastructure preparations for the 2022 Asian Games. The team made field trips to South Korea and Japan to study the success factors of TOD overseas.

■ Meeting Thailand's Ministry of Transport officials in 2019.

'Our team was also involved in a planning project that aimed to develop southern Pazhou, Guangzhou into a new Central Business District (CBD) as the city government wanted to accommodate an additional population of 3.5 million by 2035.'

Not only that, the team has worked on numerous transport planning projects for a wide range of integrated mixed-use urban complexes and prime office developments across China. Recently, China Resources has commissioned the team as term consultant for the group's pipeline of projects in both southern and northern China.

By the western standard, China's urbanisation took place at a stupendous speed in the past decade. The process was quick and dirty. But the benefits outweigh the difficulties. Policymakers have also vowed that they would make 'liveable' cities a central goal of China's urban planning as well, he said.

'We are seeing an emerging market in Southeast Asia, especially due to rising urbanisation and the growth of a sizeable middle class in the region who are keen to travel. Countries such as Thailand, Vietnam, the Philippines and Indonesia will be a key growth engine for us over the next few years, while our experience in China in the last decade would be a very good experience that can be drawn on to help us develop best possible strategies for the region.'

Smart transportation for sustainable future

The deployment of 5G networks will be transformative for transport planning. While connected autonomous vehicles (CAVs) may take some time to mature into reality due to complex legal and safety reasons, connected vehicles (CVs) are within reach. Connected vehicles are those that can communicate with other vehicles and roadway infrastructure using 5G networks.

'When all vehicles become CVs, there will be far less accidents caused by human error. Congestion could be improved, too. If cars could communicate with stop lights, for instance, the flow of traffic could be streamlined. By leveraging connectivity, big data and analytics, smart transportation will seek to reduce congestion, improve safety, lower emissions and promote walkability.'

Therefore, smart and sustainable transportation not only will help reduce the carbon footprints or the negative impacts of environmental effects (Goal 13: climate action), the efforts also address Goal 3 (good health and well-being), Goal 15 (life on land), Goal 11 (sustainable cities and communities), and Goal 9 (industry, innovation and infrastructure), according to Sam.

At a glance. . .

Future of offices in a post-pandemic world

COVID-19 is reshaping the office landscape and accelerating growth in the deployment of smart buildings, according to **Future of offices in a post-pandemic world** published by Arup. Sustainability, smart buildings and the digitally oriented workplace are an integral part of this transformation, reshaping what will be the office space of the future.

For investors and developers alike, the huge uncertainty caused by the pandemic is a critical factor in determining building design and floorspace. Smaller satellite offices in multiple locations allow tenants greater flexibility and choice, allowing them to build organisational resilience through diversification. The pandemic has also significantly raised the awareness of the importance of hygiene and wellness in office settings, driving innovation in smart buildings for improved indoor quality and ventilation.

Click to download the report

Five city resilience lessons from the coronavirus

From healthcare to high street retail, transport to food and medical supply chains, the COVID-19 outbreak has exposed the limited resilience of our cities. Beyond the immediate priority of everyone's health and livelihoods, the crisis is an opportunity to rethink the way we plan, design, develop and manage our cities to make sure we are better prepared when the next emergency arises.

So, how do we improve our response? Bruce Chong, Arup's Director of Urban Sustainability, explores what the current crisis is teaching us – from understanding the connections between multiple hazards and taking a proactive response, to using 'big data' and identifying the inter-connectedness of cities' many systems.

Click to read the full article

Fulfilling Asia's offshore wind potential

Blessed with long coastlines and favourable government policies, Asia looks set to grow its offshore wind significantly over the next decade and beyond. As the region makes the most of its opportunities, this promises to be a very busy time – both for developers and for design teams with the local expertise to meet these regional needs.

According to Peter Thompson, Arup's East Asia Energy Business Leader, Asia is becoming the focus of growth in global offshore wind and has the opportunity to fast-track its development by exporting long-established expertise from the established European market.

Click to read the full article

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