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Urban Sustainability

THE SINGAPORE EXPERIENCE

**STEERING THE ENERGY
SECTOR TOWARDS
A NET ZERO FUTURE**

06

An interview with
Tengku Muhammad Taufik,
President and Group CEO of PETRONAS

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urban space with
animals and nature



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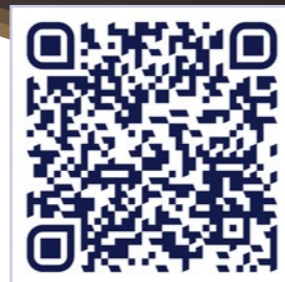


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Allard Nooy is a seasoned executive with extensive experience in the sustainable infrastructure and energy transition space. Serving as the Managing Director of Markland Infrastructure Asia, a leading consultancy firm specialising in energy and infrastructure, Allard offers a profound understanding of industry intricacies and strategic foresight. With a career encompassing leadership positions at reputable organisations.

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The goal of attaining Net Zero is not one borne out of a flight of fancy, neither is it one that is unattainable.

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EXECUTIVE DEVELOPMENT



Cities worldwide already generate a significant amount of solid waste annually, adding to other vexing issues... air pollution, access to public open spaces, urban sprawl, and general sustainability challenges.

– Havovi Joshi, Editor-in-Chief, Asian Management Insights



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The path to greening our future

More than half of humanity currently lives in urban areas, and the United Nations predicts that figure will reach 70 percent by 2050. Cities worldwide already generate a significant amount of solid waste annually, adding to vexing issues that the global community is trying to address—demand for transportation, air pollution, access to public open spaces, urban sprawl, and general sustainability challenges. Throw in global warming and the copious greenhouse gas (GHG) emissions borne of construction activities, and the challenge of creating the necessary urban infrastructure to cope comes into sharp focus.

Lee Chuan Seng, Chairman of Singapore's National Environment Agency, led the development of the internationally-recognised BCA (Building and Construction Authority) Green Mark certification for a building's environmental impact and performance. In this issue of Asian Management Insights (AMI), Lee, also the founding President of the Singapore Green Building Council, shares his insights on the country's goal of greening 80 percent of total gross floor area, achieving a 99-percent recycling rate for construction demolition debris, and developing policy thinking regarding sustainability.

Decarbonisation will be a crucial element in addressing some of those issues, which Tengku Muhammad Taufik has thought long and hard about. The President and Group CEO of PETRONAS expounds on how the Malaysian multinational oil and gas company plans to achieve Net Zero carbon emissions by 2050 by utilising cutting-edge technology and Artificial Intelligence to pave its path forward.

Electric cars or carbon-neutral synthetic fuels? Both help reduce GHG output from the road transport sector, which accounts for 75 percent of global transport emissions. Mark Stevenson and Terry van Gevelt present different solutions. Stevenson proposes promoting electric vehicles (EVs) and micro-mobility, and, just as important, tracking emissions from cars and incentivising driving behaviour that reduces the emissions. In turn, van Gevelt points to the environmental impact of building EV charging infrastructure, and highlights the technological breakthroughs of synthetic e-fuels and their potential to deliver a less disruptive transition to a low-carbon future.

Tree-planting and preservation of nature reserves are another way of greening the urban environment, but wildlife can flourish therein and venture out into human-populated areas. Sayd Randle recounts the Singapore experience of managing the coexistence of wild boars and otters with humankind, and how cities such as Houston and Hong Kong balance urban development with ecological sustainability.

Greening initiatives and the cutting of carbon emissions would help cities manage what Loretta Lees calls the 'triple-H' of Housing, Heat, and Health. Rising temperatures and increasingly unaffordable housing create physical and mental health issues, which necessitate socially and environmentally just policies to address the needs of the vulnerable and marginalised.

All that will be of great interest to cities in Southeast Asia, where massive traffic jams are a longstanding, and seemingly intractable, problem.

But as Shoeb Kagda explains, the recently operational high-speed train between Jakarta and Bandung has sparked a glimmer of hope. While the region's tropical weather cannot be fundamentally changed, Southeast Asia's mega metropolises are set to invest heavily in urban transit systems to solve their gridlock woes.

How do you fit ESG metrics into executive compensation? In Asia, there is still a relative lack of attention paid to the (E)nvironmental factors, and how achievements on the (S)ocial part are often measured, and therefore rewarded, in the short-term. Shai Ganu, Managing Director and Global Leader of the Executive Compensation and Board Advisory business at WTW, explains how companies can design executive compensation to drive climate change objectives and align moral imperatives with business priorities, so as to enable corporate (G)overnance to play its part.

Over in India, a 'perfect storm' comprising heavyweight telecom firms, digital technology innovation, payment systems evolution, and widespread smartphone adoption has changed the digital landscape. Rajendra Srivastava, Vijay Shankar S, and Aman Rajeev Kulkarni recount how India got to where it is now in its digital evolution, as well as the opportunities and challenges that lay ahead as Asia's third largest economy shifts from cost minimisation to technology development.

And in this issue's Case In Point, Geng Xuesong, Andrew Chin, and Thomas Lim tell the story of how the Singaporean multi-dining concept chain JUMBO Group tried, failed, and finally succeeded in digitalising what has largely been a pen-and-paper business. The benefits—better cost control, responsive customer service, and accurate decision-making—are worth all the trouble.

And finally, as part of our continual editorial review, we are excited to introduce Insights as the new umbrella section that covers the erstwhile Industry Watch and Executive Brief sections. We believe Insights would better characterise the thematic content we will be bringing to our readers. Happy reading!

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Steering the Energy Sector towards a Net Zero Future

Balancing traditional operations with emerging sustainability demands.



Tengku Muhammad Taufik, President and Group CEO of PETRONAS, shares how the global energy company is navigating an increasingly volatile energy market even as it pushes ahead with its commitment to a Net Zero future. While striking a delicate balance between delivering energy to those it serves and rising to the expectations of accomplishing an accelerated energy transition, PETRONAS remains steadfast in the strategy it has set out, adopting frontier technology and Artificial Intelligence (AI) to forge its path forward.

You started your career at PETRONAS in 2002, then ventured into entrepreneurship and consultancy before returning as Chief Financial Officer in 2018 and becoming Group CEO in July 2020. In your view, what are the most significant changes you have witnessed in PETRONAS and the energy sector in your second stint with the company?

When I first joined PETRONAS, we were coming off the Asian Financial Crisis. There was a great deal of optimism that Asia would recover from it. Globalisation was almost in full swing at that point in time, so energy consumption was on the rise, but that did not stop the structural corrections that were taking place.

Given the nature of commodities, cyclicity is inevitable. We've seen periods where businesses in the oil and gas industry have had to respond to troughs when the price of a barrel of oil fell to as low as US\$20 in the early 2000s. But the dynamics of the market completely changed with the advent of fracking in the US. What was previously a market guided almost entirely by OPEC (Organization of the Petroleum Exporting Countries), where interventions helped to stabilise production volumes—and thus, prices—has evolved over time to one where influence is more widely distributed among more nations. As this slowly unfolded over the course of a decade, players today are contending with a much more volatile market than in the past.

The swings in dynamics are now characterised by huge shocks. Contrary to popular belief, the expectation that spare capacity can be easily unlocked by the pressing of a button is no longer the case. The reality is that oil and gas are depleting resources. We are approaching the end of what I call 'Big Elephant Oil

Fields', which are large oil fields that hold 500 million barrels of oil or more. Multibillion-barrel discoveries are few and far between these days, and the fields we do find are smaller and more difficult to manage in an efficient and cost-effective manner. They are either in deeper waters with more contaminants, or they are further from sources of demand. Producers extracting the oil are facing challenges in managing the operations, and the recovery rates are not going to be as good as they were in the past.

Coupled with the accelerated energy transition and the greater push for decarbonisation which have come to the fore in recent times, many oil and gas players have had to conduct their business in a different way. This means straddling the fine line between taking positions in 'System A', the 'primary system' that still powers most of the world's energy needs, or 'System B', which focuses on establishing a presence in renewables and hydrogen.

Some have continued to invest in System A, where they contend with the needs of today, even as they put in place the foundations of System B in preparation for the inevitable transition. The other path one could take is to run System A in a markedly different way—sticking to the familiar chemistry and complementing it with solutions such as carbon capture and sequestration, electrification, and zero venting and flaring to deliver much-needed energy in a safe, efficient, and emissions-abated manner.

PETRONAS announced in 2022 its aspiration to achieve Net Zero carbon emissions by 2050. How did this come about, and how does PETRONAS plan to attain this?

Shortly after I made that announcement, I attended a function with oil and gas service providers and marine operators where a member of the audience asked me to take out my business card and read it out loud. If memory serves, he exclaimed something along the lines of, "You're the President and Chief Executive Officer of PETROLIAM Nasional Berhad—'petroleum' is literally in the name of the company!" The implication was that the aspiration to achieve Net Zero by 2050 was unrealistic.

The fact of the matter is, PETRONAS started its sustainability journey even before it came under my watch. I have two predecessors to thank for the

rigorous environmental compliance philosophy and principles that have been put in place. Our sustainability reporting had been proceeding as planned, which gave me the comfort that the building blocks were always there. These building blocks address the removal of carbon dioxide or CO₂, the reduction of flaring, and our push for energy efficiency because the largest culprit is excessive and wasteful processes that consume more energy and cause more combustion.

The target that I eventually presented to the public—capping emissions at 49.5 million tonnes of CO₂ equivalent by this year—was not in the realm of impossibility when we examined the underlying blocks that we had to achieve it. It's admittedly a stretch, but it's not impossible. What we now see as a challenge going into a Net Zero future is deriving the hard metrics that people can embrace and convert the 'what?' to a 'how to?'. We have broken this down to more specific and tangible targets that the Group can work towards together.

Methane is a far more potent GHG (greenhouse gas) emissions agent that worsens global warming. By 2025, we're aiming for a 50-percent reduction in methane emissions from our Group-wide natural gas operations. By 2030, we will amp that up to 70 percent. By that time, according to the roadmap that we have embraced and committed to, we would have reduced Group-wide GHG emissions by 25 percent. I trust that by then, long after I've retired, there will be a reduction map every five years,

and ultimately the aim is to get to Net Zero carbon emissions by 2050.

In my view, the goal of attaining Net Zero is not one borne of a flight of fancy, neither is it one that is unattainable. My mandate still stands—I still have to monetise and maximise the value of hydrocarbons within Malaysia, and offer secure, reliable, affordable, and sustainable energy solutions to our customers and stakeholders. That doesn't change, but the preparation for this new energy system—where we will be compelled to deliver reductions in GHG emissions resulting from our activities—has to be consciously woven into our day-to-day work. This also means seriously pursuing solutions based on hydrogen, green mobility, and renewables.

In your view, does sustainability pay off? And renewable energy has been widely touted as the energy source for the future, but financially, what is the cost-benefit analysis?

I love this question. This always crops up when I engage with staff, regardless of age, experience, or tenure. Thankfully I get a lot of practice by debating with my own daughters!

The nature of the energy business and infrastructure is such that they're long-term. The inherent problem is the conflict between the types of capital and the outcomes that they have subscribed to. For instance, our LNG (liquefied natural gas) ventures were originally intended to last only 20 years, but some of our facilities in Malaysia have now operated north of 41 years.

At their inception, they were such a big capital outlay. Thus, they needed to be seen as being robust and cost-competitive, and now more than ever, sustainably operated over long periods of time. If the capital that is put into these long-term undertakings has a short-term outlook, you are not going to attract investments.

I've had the opportunity to attend many thought leadership conferences, not least of all the World Economic Forum in Davos, where the conversation has always revolved around how we've got the wrong type of capital matched against the kind of investments we need. Power grids are a case in point. Grids are huge undertakings. There is a prevailing misconception that once solar and renewables are in place, eventually the electricity tariffs will come to a point where energy can be made accessible to all, because the source is free. The part of the jigsaw puzzle that's often forgotten is that there's a degree of intermittency in renewables which requires a huge improvement in storage, grids, and connectivity.

That kind of infrastructure spending is not small. Since it is by and large seen as a utility, it's also not going to attract the kind of returns that oil and gas investors are used to. People who are used to seeing IRR (internal rate of return) in the mid-teens to defray the cost of equity will not be attracted at all to enter this space. What some players have decided is that on a portfolio basis, they can commit to their shareholders that they will give them a return of say X percent,

but the shareholders need to allow the management team and the board to take positions in System B solutions. Now these players can choose the more profitable, viable, near-term ventures within their core oil and gas business because that's what they are good at, but they also need to take positions in longer-term portfolio switches, such as what is being done by a few of the well-known oil majors.

Many listed European oil and gas companies have taken a radical step by preparing themselves more for systems of the future. As a result, their near-term returns have suffered, and their shareholders immediately saw that the PEs (price-to-earnings ratio) lagged behind peer groups in the US. This has prompted vociferous debates around why oil and gas companies should take such positions, given that investments are singularly motivated by returns and dividends. This is the dynamic that I think the providers of capital have not fully settled into.

For example, if a pension fund has taken a position in some of the top oil majors, it would want steady dividends. That comes from doing what you're good at, rather than taking a wide capital base and possibly suffering some near-term dips in returns. So, the right investors must be convinced to measure the portfolio performance as a whole, rather than decide based on the short-term positions taken. Companies also need to match the investment horizon accordingly to avoid unnecessarily penalising many NOCs (national oil companies) and oil companies in

The preparation for this new energy system—where we will be compelled to deliver reductions in GHG emissions resulting from our activities—has to be consciously woven into our day-to-day work.

general that are seriously trying to pivot. Some have gone too far and too fast while some have not done enough, depending on which end of the spectrum you sit.

To critics, oil and gas companies remain cast in a negative light. But if these critics can act more responsibly and be more measured in their judgement of what we can and cannot do in the near term, they should hold us accountable today not only for our emissions, but also for delivering energy cleanly, securely, and affordably. They should also measure and judge us on whether we fulfil or deliver what we've committed to, which is taking clear, measurable positions in undertakings that move us towards a decarbonised system.

PETRONAS has invested in AI by establishing an AI Centre of Excellence. What role do you envision AI playing in PETRONAS' business operations and processes?

We'll start with refining operations. A refinery may be understood as a

big distillation column where you crack hydrocarbons at different temperatures to extract various products. In reality, refineries today have grown to be far more complex. There are many modules which extract, refine, hydrogenate, upgrade, and value-add to products, as well as form the start of another value chain into chemicals.

The diversity of modules and pieces of equipment that are assembled in a complex set-up are often challenged when refining margins take a beating. The margins that you make out of cracking a barrel of crude oil can dip to a point where it is difficult for the simpler refineries that can crack and deliver only two or three products to survive. On many occasions, they run at negative margins, so refinery operators need to think about two competing issues: running their business reliably and getting to the right product slate from a given barrel of crude oil.

In a live situation with operating parameters and tons of data being churned, what's the best way to run a refinery so that, from a

maintenance perspective, there is minimum downtime which would keep unit costs low and yet maintain reliability and contain the costs of running operations? In this respect, AI has helped us with predictive maintenance and asset management by identifying the modules that tend to be the ‘bad actors’, to use an industry term. We can then plan their shutdowns and maintenance proactively, so that we know what we’re contending with over an operating period, and it becomes far more predictable.

PETRONAS is one of the world’s largest LNG exporters with a strong reputation for reliability. Among the biggest challenges in running an LNG facility is figuring out how quickly we can liquefy gas after restarting a module. In this aspect, AI has helped us map out the processes and sequences to shorten the time between the module being shut down or being put under maintenance and when it is running again.

AI has also helped in churning petabytes (millions of gigabytes) of subsurface data to enable our drilling to become more accurate. The longer we keep a rig out in the ocean, the higher the costs—with the daily charges reaching exorbitantly high levels. Also, the longer we run our operations out there, the bigger our carbon footprint.

AI also helps us in the office by facilitating customer relationship management, for instance. Additionally, it helps our green mobility initiatives and planning for infrastructure where utilisation rates are better. I think the applications for AI are yet to be fully exhausted.

But the other side of the coin is, “What will happen to jobs?” That’s a question we cannot duck. Yes, it will make some jobs less necessary, but it will also make other jobs far more enriching and multi-dimensional. We need to ask: What do you displace? Is it the roles that can now be AI-enabled? Or are you displacing routines which can be completely taken over by AI or something more automated?

Depending on how mature an organisation is, the embracing and use of AI may be vastly different. As for whether there’s an impact on jobs, there is indeed a real risk for economies, not just companies, where AI is gaining traction faster. The more advanced economies will potentially experience inequity between the employee sets that are AI-ready and those that are not. Despite all the brickbats and the bouquets that are associated with AI, we must be cognisant of the larger gap between those comfortable

working with AI and others who have yet to access AI or fully unleash its capacity. So, the short answer is: Proceed with caution, but the promise is there.

To what extent do you find the energy sector experiencing difficulty hiring talent to replace existing executives who might be retiring soon? One observation is that the skills required to run a 21st century energy company are different from those that make existing energy executives valuable. How is PETRONAS addressing this perceived talent gap?

PETRONAS has already taken some very conscious steps to hire people with different skillsets to complement its natural orientation to hiring engineers. We also need to have people who are familiar with carbon and carbon

markets, and those equipped with environmental sciences expertise. We will further see a larger push for participants in the energy markets who are oriented towards solutions that help current models remain a little more robust.

Some may think that geologists and their jobs are approaching their expiry dates—I’d say it’s the complete opposite. Those who understand geography, geology, and petroleum engineering probably have an extended job lifespan now because if we were to continue production, we would have to also arm ourselves with the solutions to capture and sequester CO₂.

There may be graduates who go into the workplace with a mindset of resignation, thinking, “Wow, this is the economy I’ve inherited. It’s an all-consuming, extractive economy.” To them, I say, “It’s your time now to start thinking how to flip the equation and start thinking about more circularity, more decarbonised systems, more energy efficiency.” The oil and gas space is rich with opportunities and it’s a fertile space for engineers and, to some extent, financiers and businesspeople too to thrive.

We’re looking for solutions that are going to be quite transformative. If we ever get to the degree of penetration into electrification that we envisage, transport systems are going to be completely transformed. For instance, if ride-sharing goes off at a tangent and becomes autonomous later on, then the concept of vehicle ownership gets thrown out the window. We would no longer be talking about engineers having to rethink what they put on the roads

but would instead be discussing the financial models that can complement this. Can financial institutions accept that a car is not owned by any one person but rather by cities or a residential development? We’d be looking at all of these possibilities in a very exciting phase.

Given today’s geopolitical environment, how is the workplace different from when you first started out? What advice would you have for youth today?

This is going to be one of those difficult questions where there is no one right answer, but if I were to lean onto one aspect that has helped a lot of the people I work with, the younger graduates whom I see coming up through the ranks, and members of teams that I enjoy working with, my advice is this: Stay curious.

I think if the youth of today believe that the degree that they walked out of university with is enough to arm them for life, they’re going to discover this belief to be wrong very quickly. If they’re hunting for a job, qualifications may be great—but if they’re hunting for a career, curiosity will be key.

I see in many of our youngsters a degree of not only resignation, but also cynicism, because they think it’s the earlier generations that have brought us to where we are now. We’ve become debt-laden societies leveraged to the hilt, contending with a cost of living that has escalated beyond our means. If they go into the job market thinking that it’s going to be almost always an

uphill battle, they are going to wear themselves out fast.

Instead, the way this next generation should look at it is that this life will be a series of peaks that they’d have to contend with, but the journey to scale each one is well worth it. This may be even more pronounced given the threat of climate change, energy transition, and our economic models being overturned. But on the flip side of the equation, there is also a huge world of opportunities. Educational institutions would do well to spread this message far and wide. [AM](#)

AI has helped us with predictive maintenance and asset management by identifying the modules that tend to be the ‘bad actors’, to use an industry term. We can then plan their shutdowns and maintenance proactively.



URBAN SUSTAINABILITY THE SINGAPORE EXPERIENCE

The importance of green buildings, the circular economy, and zero waste.

Lee Chuan Seng, Chairman of the National Environment Agency (NEA) and the founding President of the Singapore Green Building Council (SGBC), speaks on urban sustainability, including his thoughts on ways to promote reduction and reusing of various components from the built environment.

Where do you believe Singapore's green building strategy has surpassed global benchmarks, and in which areas can the country continue to improve?

We can always improve, but where Singapore has done it differently is right at the beginning. In the early 2000s, we realised that developing green buildings is one way in which Singapore can lower its carbon footprint and achieve net savings from energy savings. In other words, you can save energy and water by making buildings green, and by doing so, you can also save on maintenance and running costs. So we embarked on the green building journey with a much broader national objective than many other countries. Why is there such a difference? Partly because in Singapore, the green building system was set up by a government agency—the Building and Construction Authority (BCA)—and it was looking to achieve national objectives, whereas in most other countries or economies, their green building journey was put forth by an NGO (non-government organisation), a green building committee, or a research organisation vested with a sustainability agenda.

A lesser-known aspect of our green building story is that Singapore at that time had just emerged from the Asian Financial Crisis in the late 1990s, and the real estate and construction sectors were still grappling with excess capacity. The industry was looking

for help. The authorities at that time assessed that the best way to help the industry was not in the form of giving handouts, but rather in giving it a leg up to climb the sustainability ladder, so as to acquire better technology and deliver better value. And so the Green Mark certification scheme was set up with this in mind. It was designed to be a calibrated system; we would initially go green with minimum energy efficiency standards for new buildings set to achieve a 30-percent improvement over the 2005 baseline. Every few years, this standard would be further raised. In this way, we help the industry to improve itself.

We then looked at what would be a better way of moving the needle for the whole market. If you look at many green building rating systems in other countries, they are after the development of iconic buildings. After all, when you say that “this building is super energy-efficient”, it grabs headlines. Whereas we were setting up our system as a regulatory process to not only help the industry climb the technology ladder, but also for Singapore as a whole to achieve its national target and manage its carbon emission goals. When

we aim to green 80 percent of our buildings, we are not just looking at the number of buildings. Instead, we are looking at the total GFA (gross floor area)—we aim to green 80 percent of that by 2030, and that is really the litmus test for energy consumption. Today, we have achieved close to 60 percent.

By focusing on performance, we zero in on efficiency—if you can reduce your energy consumption by a certain percentage, you can possibly save millions of dollars a year from reduced operating costs. This translates to a message that developers can understand because it hits their bottom line. In fact, you can save money by going green. For instance, if we are able to design large parts of a building by carefully shaping the openings on its façade, the airflow velocity should be comfortable enough to the extent that people can go without air conditioning. To achieve that, we do a lot of airflow simulation and work with architects to make sure that the sun shading and other design features are suitable. In this manner, one way in which I would say that we have surpassed benchmarks is that we are the ones setting some of the benchmarks now!

I think the way to go for circularity is not to prescribe how we are going to get the whole economy to be circular.

Which recent innovations in green building technologies have caught your attention, especially if you have found them to be promising for Singapore's built environment in the near future?

The aim is to work towards higher energy efficiency using methods that don't contribute more to our carbon footprint and require greater usage of materials.

I find four key areas promising.

The first is to do with photovoltaics (i.e., solar PV panels), which in most of our buildings have only about 16 percent efficiency. In the last five years or so, the efficiency of PV panels has gone up to about 25 percent. One of the most common business models to generate solar power is under a solar leasing model—as the solar panel efficiencies go up, the solar leasing companies could swop their panels for higher

efficiency panels or even part ways through their lifespan. Almost doubling the energy generation will really move the greening needle. Having solar PV will also support buildings that are looking to be Super Low Energy/Zero Energy/Positive Energy.

The second one is smart building controls, which is the ability to put sensors and controls within individual equipment in buildings. The Internet of Things (IoT) is finally coming to the implementation stage. So given the availability of affordable sensors today, smart building controls can integrate many more sensors, providing enhanced personalised control. That means, for instance, individual workstations can sense and even set their own target temperature. There are also lower lighting levels in general and more task lighting. These kinds of controls will give us much better outcomes than what we had been able to achieve about three to five years ago.





The third area is hybrid air conditioning. There has been research done at Singapore's CREATE (Campus for Research Excellence and Technological Enterprise) in collaboration with leading global universities and research institutions. In one of the studies by the Berkeley Education Alliance for Research in Singapore (BEARS), it was found that if a workspace has air movement by virtue of a desk or ceiling fan, then the air conditioning thermostat can be set higher at 26°C or even 27°C (instead of the customary practice of setting it at 24°C) while maintaining or even improving occupants' thermal comfort. Simultaneously, for every 1°C increase in aircon temperature, we can expect about five percent in energy savings and five percent reduction in carbon emissions.

The last area is smart facilities management (FM). In the last five years, there has been a tremendous effort to send FM staff for training on maintaining and monitoring buildings with smart

controls. This would mean that instead of conducting routine scheduled maintenance, one can use sensors to monitor, say, lighting level or chiller performance, and conduct predictive and preventive maintenance instead. We are seeing increased adoption of robotics in FM operations, especially cleaning and security, as well as tapping of smart FM to meet corporates' ESG (environmental, social, and governance) reporting and net-zero ambitions.

What areas does Singapore need to work on when it comes to promoting the circular economy and moving to zero waste?

I think the way to go for circularity is not to prescribe how we are going to get the whole economy to be circular. Rather, we should drill down to the details and work layer by layer, industry

by industry to get it done. Take the construction industry as an example. Some waste types such as ferrous/non-ferrous metals, and construction & demolition debris are 99-percent recycled. The construction industry also uses the spent slag used by the marine industry for sandblasting, thereby recycling 99 percent of it.

We have stopped the dumping of construction waste in a landfill. When you want to demolish a building, you not only get an engineer to give you a plan on how to demolish the structures safely, but the contractor would also need to have a materials management plan on how to reuse or recycle the demolished materials. For instance, the steel bars that are in the concrete are extracted, smelted, and made into new steel bars. Aluminium frames and copper wires are collected, and mostly exported for processing as we do not have smelters for these in Singapore. All these are wonderful, and this part is circular.

But I believe we need to focus more on plastics, since only five percent of them are recycled. The recycling rate for food and textiles/leather too is low at 18 percent and two percent respectively. As for paper/cardboard, its usage has increased tremendously, especially after the COVID-19 pandemic because of the packaging used for deliveries and e-commerce, and only 31 percent of that is recycled.

One of the most serious problems we have with our recycling, especially from the point of collection at residential sites, is that the collected materials are

If you want to be a business leader, you must think through your processes to ensure they are commercially feasible.

typically mixed. But this is not the crux of the challenge, as we can sort them out at one point. The issue is that about half of the recyclables are contaminated by food waste. That makes it very hard for our workers to process everything else due to the smell and hygiene issues. We are nonetheless encouraged to see some improvement in household recycling—according to a recent survey conducted by NEA, 72 percent of households carried out recycling in 2023 compared to 64 percent in 2021. In addition, a higher proportion of survey respondents are aware of common items that can be deposited into recycling bins and chutes. NEA will continue with its outreach

programmes to work with members of the public to not only recycle more but also recycle right.

We also realise that asking the public to sort their waste into different types of recycling bins, just like what is being done in societies such as Japan, Taiwan, and Korea may not be efficient. We would have to send five trucks to collect five different types of materials and likely on different days. So back in 2019 when we launched our slogan of working towards a zero-waste and circular economy, we were actually working towards getting people not to contaminate the recyclables awaiting collection. We are also educating the people across different sectors who are generating waste.

Once we empty out Semakau Landfill, there would be space left there that can be converted into a transit storage and processing hub. We will segregate all the materials that come in based on the stage they may leave the landfill, which would depend on the demand for them. Hence these are very granular, multifaceted solutions that we will have to look at.

We are also still finalising the testing of the treated mixed material that had been dumped in Semakau Landfill. What we have been doing is sending the residues from burning our rubbish to this landfill. If we are able to treat the residues further and convert them to artificial rock for land reclamation, then there will be no more waste left. Perhaps we should call it NEARock! If we succeed, then Singapore can become a truly zero-waste nation.

As an aside, we are really happy with what fellow Singaporeans have accomplished with food tray returns at the hawker centres! The initiative to encourage diners to clear their used trays and crockery began in September 2021, and by April 2024, the average tray and crockery return rate had gone up from 65 percent to 93 per cent. We did not enact new regulations and used only the existing anti-littering ones, and it has been such a success story. We have been so successful on that front that you even hear stories of Singaporeans being spotted returning trays when they travel to other countries!

How does a leader build his or her policy thinking on sustainability? Could you share with us some of the things you have done in developing your strategic mind around this matter?

There is no choice but to read very widely and have a lot of interactions with people to know what is possible and what is not. You need to really pay attention to details, because it is no longer possible for leaders today to set out ideas in broad brush strokes. You need to know your material, your area, the solutions, and be able to see the linkages among different things that could create value and the incentives for people to go that way, since that's what you're trying to lead them towards.

This is especially true in sustainability because it is an area where many have strong counter-

arguments and contrarian views. So you need to be well-informed such that if the counter-arguments presented are false or misleading, you can explain and convince the other person of your thinking. If the counter-argument actually has substance, you should be able to evaluate it so that after you are persuaded by it, you can move to a higher plane of understanding. Do not be afraid of a discussion or a debate.

Besides paying attention to details, you also have to make sure that the commercial model works. You may have the science and the research, but in the end, what drives adoption is the commercial value. There are also a host of social and behavioural factors involved. Hence, the technology may work well, but if it doesn't gel with how people feel about it, it may fail.


At the same time, it helps to involve agencies that are able to move the market. For instance, back in the early 2000s in the private sector, we tried for years to get people to change from using the older fluorescent tubes to the more efficient new fluorescent ones which are thinner. But we couldn't shift the market because Singapore's private residences made up a minority of the total residential market. But when the Housing & Development Board (HDB), which is responsible for public housing in Singapore, said that it was going to use these more efficient lights for all the HDB block corridors, that finally moved the market. Suppliers started importing competing brands, and the price

premium dropped from around 50 percent to about 20 percent. Eventually, nobody bought the old larger diameter fluorescent tubes and new thinner fluorescent tubes became the norm. It is now happening with LED lights too. The same thing happened when HDB decided to adopt solar panels and allowed the market to go into a leasing mode. Immediately, the scale expands dramatically, and projects become very bankable. So if you want to be a business leader, you must think through your processes to ensure they are commercially feasible.

A leader needs to think out of the box by looking at the different aspects of not just technology, but also business models, and have the ability to reorganise and reject potential solutions based on the different marginal costs. To get people to buy into sustainability solutions and green mark buildings and the like, we need to introduce the solutions in steps. If we do so, it challenges the better designers and contractors to design and construct them. And then the leading companies must share their learnings. At the same time, the authorities must ensure that they revise regulations very carefully, so that there is a level playing field. It cannot be just a few who are doing it. Only when everyone is doing it can the market be sustained.^[AM]

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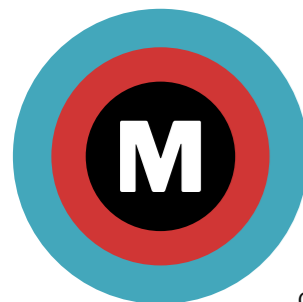


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GETTING ON BOARD WITH INCENTIVISING

ESG

What gets rewarded gets measured and done.



Managing Director and Global Leader of the Executive Compensation and Board Advisory business at WTW, Shai Ganu, speaks about the growing usage of Environmental, Social, and Governance (ESG) metrics in designing executive compensation.

How do you see the role of corporate governance evolving in response to the growing awareness and demand for sustainability, especially the need to address climate change?

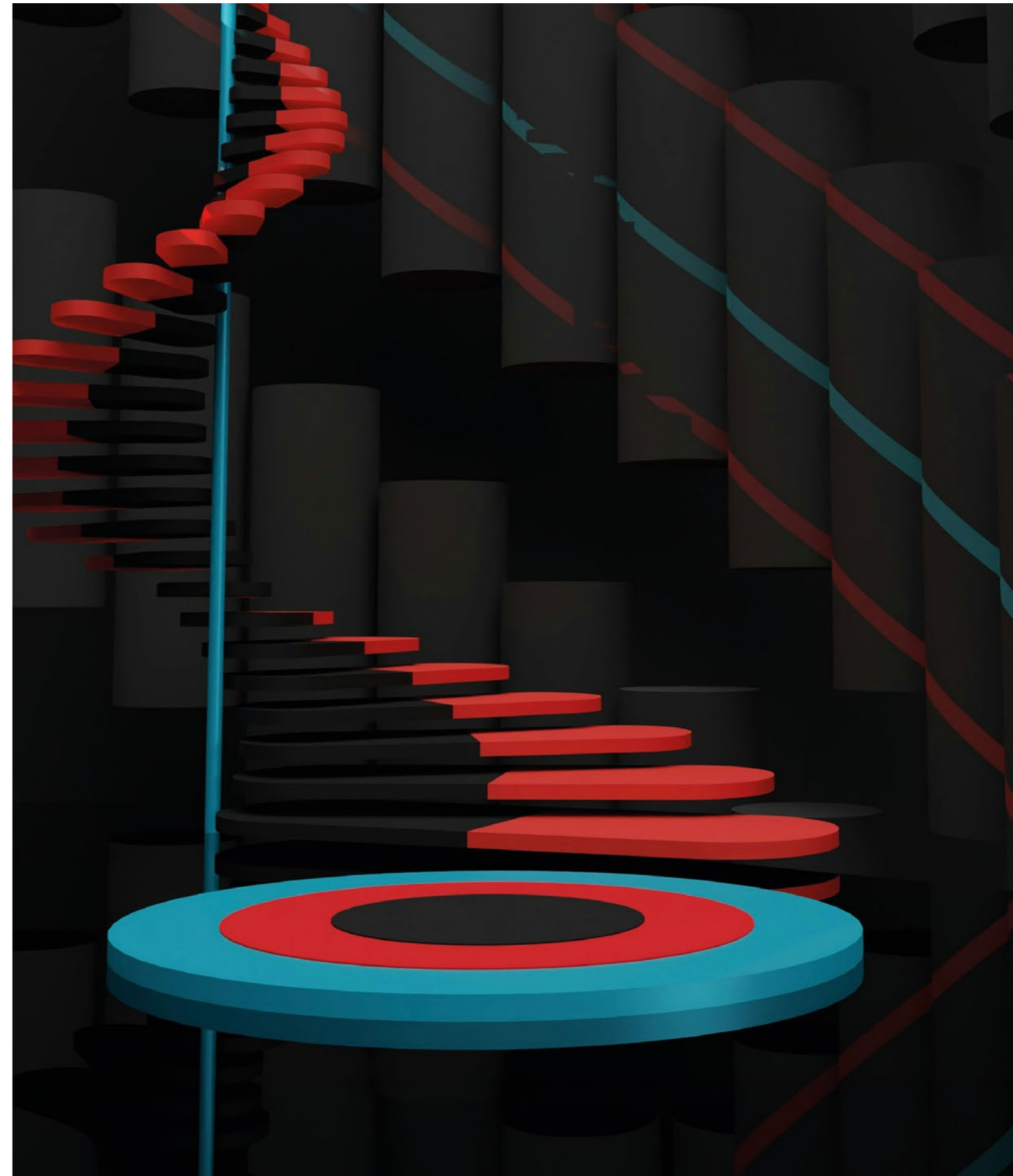
WTW's Executive Compensation and Board Advisory team comprises over 500 consultants across 45 countries who work extensively with boards, compensation committees, nominations and governance committees, and sustainability committees globally.

Across most regions and industries, one of the top five topics in any corporate boardroom is climate. So climate, and particularly climate transition, is becoming an increasingly important priority.

As climate and climate governance move up the agenda of companies and their boards, they need to progress to the next step, which is to align their corporate priorities with their executive compensation plans, because “what gets measured gets done”. I’ll go a step further to say, “What gets rewarded gets measured and gets done”. When it comes to executive pay and climate change, we’re seeing more companies aligning their incentive plans, be they short-term or long-term, with climate transition goals.

Over the last couple of years, we’ve engaged one-on-one with over 1,000 board directors on sustainability and stewardship. One of the issues that repeatedly came up was, “Why should we be paying executives more for doing the right thing?” Some may say that environmental stewardship, climate transition, and diversity, equity and inclusion (DEI) priorities—in other words, doing right for your employees and doing right by the community—should all be part of the job. In fact, that’s what you get your base salary for.

Going back to incentives, the reason we are still proponents of this and why corporate boardrooms consider this an important priority is that when it comes to climate action, it’s becoming clearer that we’re



running out of time. The urgency warrants a stronger connection to executive pay to drive action.

I believe that aligning some of these goals to executive pay can help accelerate the transition, quicken mindset shifts, and catalyse action by management teams to drive the right behaviour.

However, incentives can also drive the wrong behaviour. As board members and compensation committee members, it's our responsibility to encourage the right behaviour and discourage the wrong ones, including greenwashing—or conveying a false impression about how a firm's products are environmentally-sound—and box-checking for the sake of governance or incentive requirements.

How have boards in Asia responded compared to those in other regions that seem to have had a head start in addressing sustainability challenges?

Since 2020, we've been conducting research at WTW on how companies are aligning executive pay with broader ESG priorities by examining their annual report disclosures and proxy statements. When we refer to ESG, 'E' includes climate, nature, biodiversity, and other broader environmental priorities; 'S' refers to social priorities such as employee well-being and equitable career opportunities; while 'G' represents governance priorities such as setting and tracking reasonable ESG goals that are aligned with company strategy.

Our latest research surveyed 1,200 companies globally in 2023.¹

As a specific bespoke KPI for one of my clients in Asia Pacific, 20 percent of the long-term incentive is linked to carbon emission reduction.

We found that 81 percent have at least one metric in either the short-term incentive (STI) or long-term incentive (LTI) plan that's linked to broader ESG goals, as compared to 75 percent in the previous year. Over the last couple of years, we've seen a 10-percent increase in aligning ESG measures and incentive plans.

However, 77 percent of ESG measures are still short-term incentives—usually key performance indicators (KPIs) in their balanced scorecard. Only 27 percent of the companies link the measures to their LTI plans. LTI plans by design tend to have fewer KPIs, and some examples of these include total shareholder returns, capital efficiency measures, and the adoption of climate transition-related goals. One of the more common goals is metric tonnes of carbon dioxide equivalent reduction. But whilst still low in prevalence, the metric is gaining prominence.

If you look at the breakdown among the 'E', 'S', and 'G', the vast majority of companies still focus on measuring 'S' in their incentive plans. Only 53

percent of the companies have environmental goals.

We also found that Europe is the clear market leader, with 93 percent aligning ESG measures to executive incentives. We joke a little within WTW about this—that the 'E' in ESG stands for Europe! In Europe, environmental issues are at the top of every corporate boardroom's list of priorities. In fact, 56 percent of European companies have an ESG measure in their LTI plans. In most of these cases, the measures are specific environmental goals pertaining to carbon emission reduction, carbon intensity, or broader targets related to biodiversity, nature, water, and energy.

ESG issues are also gaining more prominence in North America and Asia Pacific. For American companies, more of them are aligning their short-term incentives, and in most cases, it's social-related or employee-related goals; only nine percent link them to the long-term incentives. So, clearly, there's more work to be done, but across the board, the trend is moving upwards.

In Asia Pacific, 77 percent of companies have some linkage to STI or LTI plans. However, there is room for improvement when it comes to aligning environmental measures with incentive plans. While 27 percent of companies have environmental goals in their STI plans, only 17 percent have such goals in their LTI plans. Asia Pacific companies also tend to take a more balanced approach of rewarding management for both effort and milestones via STI plans, as well as longer-term outcomes via LTI plans.

How should a company design an effective executive compensation plan that aligns with sustainability or climate objectives?

Companies that align their executive pay with sustainability or environmental goals do so not purely as a compliance or check-the-box exercise.

They've identified sustainability as a business imperative because they not only see it as an integral part of their strategy or increasingly as a differentiator against their competitors, but also as a way to gain the hearts and minds of clients, as well as employees.

As we think about embedding ESG measures in incentive plans, we need a game plan, starting with prioritising the spectrum of issues that the company needs to address (refer to Figure 1). The next steps determine the approach and level of oversight required at the board versus committee level, and how to collaborate with management on the strategy and approach to address ESG priorities. Once that's decided, investors and the public must be educated on the issue(s) at hand and why the company has decided on its course of action.

A PRACTICAL APPROACH TO SELECTING THE APPROPRIATE METRICS

1. Prioritise the spectrum of issues the company needs to be addressing
2. Determine approach and level of oversight required at the Board vs. Committee level
3. Collaborate with Management on strategy and plan for addressing ESG priorities
4. Educate investors and the public on the issues—why addressing them is key to ensuring sustainability and long-term value creation, and how the company plans to deliver on its goals
5. Demonstrate commitment to initiatives by incorporating metrics that are specific and measurable, and stretch goals that are achievable and time-bound



FIGURE 1

Source: Adapted from Shai Ganu, "Aligning Executive Compensation with Climate & Sustainability Goals," WTW, page 9.

We find that progressive companies are very good at crafting this shared collective purpose, which is achieved through elements of storytelling. I don't mean storytelling in the sense of greenwashing, but storytelling in the context of creating that shared purpose, that common North Star, and then aligning everybody internally and externally towards that main goal. And thereafter, demonstrate your commitment to the initiatives by incorporating those metrics into your performance appraisal system and incentive plans.

The funnel in Figure 1 helps by steering you away from picking a metric simply because your competitors use it or it appears in research reports. Instead, pick the metrics that are relevant to your business, which you can measure, track and monitor, and are aligned to your incentive plans.

What are some of the emerging trends on how Asia Pacific companies are integrating sustainability/ climate-related goals into executive compensation, especially if they are different from other regions?

We use a design spectrum approach to guide this discussion. We start with one end, which includes what is lower impact and easy to put in place, while the other end would be the higher impact, more complex initiatives to implement.

In this design spectrum, the first step is an underpin, which is the easiest to implement. Underpins usually are a low watermark that

says, "Unless this is achieved, unless you pass this gate, all bets are off." Generally, they have a high probability of achievement, so companies are not very stretched. But the reason you put in place these underpins is to send a signal to all employees and stakeholders, internally and externally, that this is really important to the company.

We then look at individual performance rating modifiers. You can have a climate or ESG-related goal, pertaining to individual elements of the STI or LTI plans, to modify the payout percentages. You can also have a company performance modifier like a weighted metric at the overall company level. This again modifies some of the formulaic bonus outcomes. This could be a specific metric in the STI plan, and we would suggest having a quantitative measure, such as the achievement of carbon emission reduction goals. As for weighted measures in the LTI plan, as I mentioned earlier, many companies, particularly in Europe and increasingly in Asia Pacific, are

starting to align carbon emission reduction goals in their LTI KPIs. So as a specific bespoke KPI for one of my clients in Asia Pacific, 20 percent of the LTI is linked to carbon emission reduction.

The final one is my personal favourite. It's a separate stand-alone incentive plan, where typically five-year performance goals are linked to long-term sustainability priorities. One of the really interesting features is that it has a slightly different orientation of what good performance looks like. Most incentives are predicated upon the premise that time is constant and performance is variable. So in the STI, it's a one-year performance period; in the LTI, it's three years. At the end of the one- or three-year performance period, we assess whether you have achieved either your threshold, target, or stretch targets.

The stand-alone incentive plan shifts this paradigm. It says instead that performance is constant and time is variable. So what that means is you could tell executives that

your goal is to achieve a 50-percent reduction in carbon emissions. If you achieve that goal in five years, that's target performance, so you'll get 100 percent of the reward. If you achieve that in four years, that's considered a stretch performance, and we'll give you a kicker. If it takes you six years—which is longer than we'd have wanted—we'll penalise you a bit. Thus time becomes a variable here and this reinforces the sense of urgency, specifically when it comes to climate transition.

What advice would you give to companies that are just starting to design executive compensation that drives climate action?

It's increasingly important for directors to make sure that they're at least climate-literate, if not climate experts, and that they're also placing the same emphasis on it as what they've done for other aspects of governance. Specifically on the question of "What shall we do and not do when it comes to incentive arrangements?", I'll share the following dos and don'ts.

- Do continuously monitor and modify the measurement of your goals. Don't just add an ESG measure to check the box, or because everybody else is doing it.
- Do consider bespoke KPIs that are aligned with your ESG strategy and metrics. Don't just blindly follow market practice and do what your competitors are doing.
- Do measure short-, medium-, and long-term progress. Set

long-term goals and then break them down into short- and medium-term goals, such as milestones. Don't just set annual goals with no long-term vision.

- It's important to "think long and act short". In other words, think long-term, but set these as measurable goals. Also, do select metrics and goals that are quantitative, clear, ambitious, transparent, and consistent. Do not exclusively use qualitative or ambiguous metrics or goals. Shareholders don't like that; proxy advisors don't like that either. It can create a perception that you're using ESG or climate measures just to make management rich without making a real meaningful impact.
- Do tell the story of how KPIs, pay, and incentives drive your sustainability and climate goals, and be transparent about it. For example, companies could at the time of the LTI grant disclose the specific carbon emission reduction targets, and at the time of vesting disclose the actual achievement. Progressive companies are transparent in their target-setting, both at the beginning and at the end of the performance period. Don't manage your annual reports, executive compensation disclosures, and sustainability reporting in silos. It may sound obvious, but we've worked with clients where the three teams managing these functions are just not talking to one another. That's not ideal. We all need to be connected.

What would be one final message you have for companies that are on this journey of climate and sustainability governance?

There's this famous line in the movie *The Godfather*. "It's not personal; it's strictly business." And that very much applies to our discussion. For sustainability priorities to be truly embedded, companies must focus on realising tangible commercial benefits. That's a really important call to action for all board members and corporate directors. The moral imperative may be admirable and very important, but it may not always be sufficient. For truly long-lasting and meaningful change, companies have to align moral imperatives with business priorities, as well as tangible financial and non-financial benefits of sustainability stewardship.

Finally to underline the urgency of the matter, I quote the late John Lewis, a congressman for the State of Georgia's Fifth District: "If not us, then who; if not now, then when?"



SHAI GANU

is Managing Director and Global Leader of the Executive Compensation and Board Advisory business at WTW

For the reference to this article, please visit <https://tinyurl.com/38pufn2v> or scan the QR code below.



Do not exclusively use qualitative or ambiguous metrics or goals. It can create a perception that you're using ESG or climate measures just to make management rich without making a real meaningful impact.

Why isn't Formula 1 Going Electric?

Electric vehicles are not the only sustainable automotive option.

#1 While electric vehicles (EVs) are marketed as 'zero-emission', their overall environmental impact is more nuanced, as factors like electricity sources and battery production all contribute to their lifecycle emissions. In fact, their widespread adoption needs significant infrastructural changes like installing new charging networks and upgrading power grids, which come with substantial environmental and financial costs.

Considering a diverse array of energy alternatives, including synthetic e-fuels, could offer Singapore a smoother transition to low-carbon transportation that is tailored to the specific needs and infrastructural realities of the country and region.

#2

E

very year, I drive my Honda on Singapore's Formula 1 (F1) street circuit. Sure, my Honda is not powered by the same power unit as the one in Max Verstappen's Red Bull RB20, but driving on the inside lane to hit the apex is still thrilling for an F1 enthusiast like me. As I navigate those turns, I cannot help but think about the future of automotive technology. To the average individual, it may come as a surprise to find out that F1

innovations are behind many of the more sustainable automotive technologies we have today.

Take hybrid technology for example. While hybrid engines did not originate from F1, the sport has contributed significantly to the advancement of the technology. In 2014, F1 introduced hybrid power units, combining traditional internal combustion engines with advanced energy recovery systems. F1 further pioneered and perfected regenerative braking, a technology that recovers energy during braking and stores it for later use. Along with systems that recover energy from exhaust heat, F1 hybrids quickly became arguably the most efficient powertrains in the world.

This refined hybrid technology has influenced the development of more efficient hybrid vehicles for everyday use on our roads. F1 has also led the way in the use of lightweight materials like carbon fibre, which improves fuel economy by reducing vehicle weight. Additionally, the aerodynamic designs honed on F1 tracks to reduce drag and increase downforce have influenced road car designs, thereby contributing to lower fuel consumption and emissions.

While F1 is, in many ways, at the vanguard of sustainable technological innovation in the automotive world, it is not going electric. Instead, it is doubling down on the use of internal combustion engines (ICEs) and its hybrid philosophy. This does not mean to say that F1 is not pursuing sustainability. On the contrary, by 2026, the ICE component of F1 cars will be powered completely by sustainable fuels, specifically carbon-neutral synthetic e-fuels. These synthetic e-fuels are produced by capturing carbon dioxide from the atmosphere and combining it with hydrogen sourced from renewable energy. This process creates a fuel that can power traditional engines without adding new carbon to the atmosphere, effectively creating a closed-loop system. Unlike traditional biofuels, which often raise concerns about land use and food production, synthetic e-fuels do not require agricultural land, making them a more sustainable option that does not compete with food production or contribute to deforestation.

F1 aims to prove that through advancements in fuel technology, even the most powerful and high-performance engines can achieve carbon neutrality. By refining and innovating within the realm of ICE technology, F1 not only preserves the essence of motorsport but also paves the way for sustainable automotive solutions that can be adopted globally. This commitment to synthetic e-fuels also underscores the diverse and often overlooked sustainable pathways available to us. While electric vehicles (EVs) are frequently touted as the ultimate solution to our sustainability challenges, F1's strategy offers a compelling reminder that there are multiple pathways towards sustainability, each with its own strengths and potential for impact.

THE MODERN EV

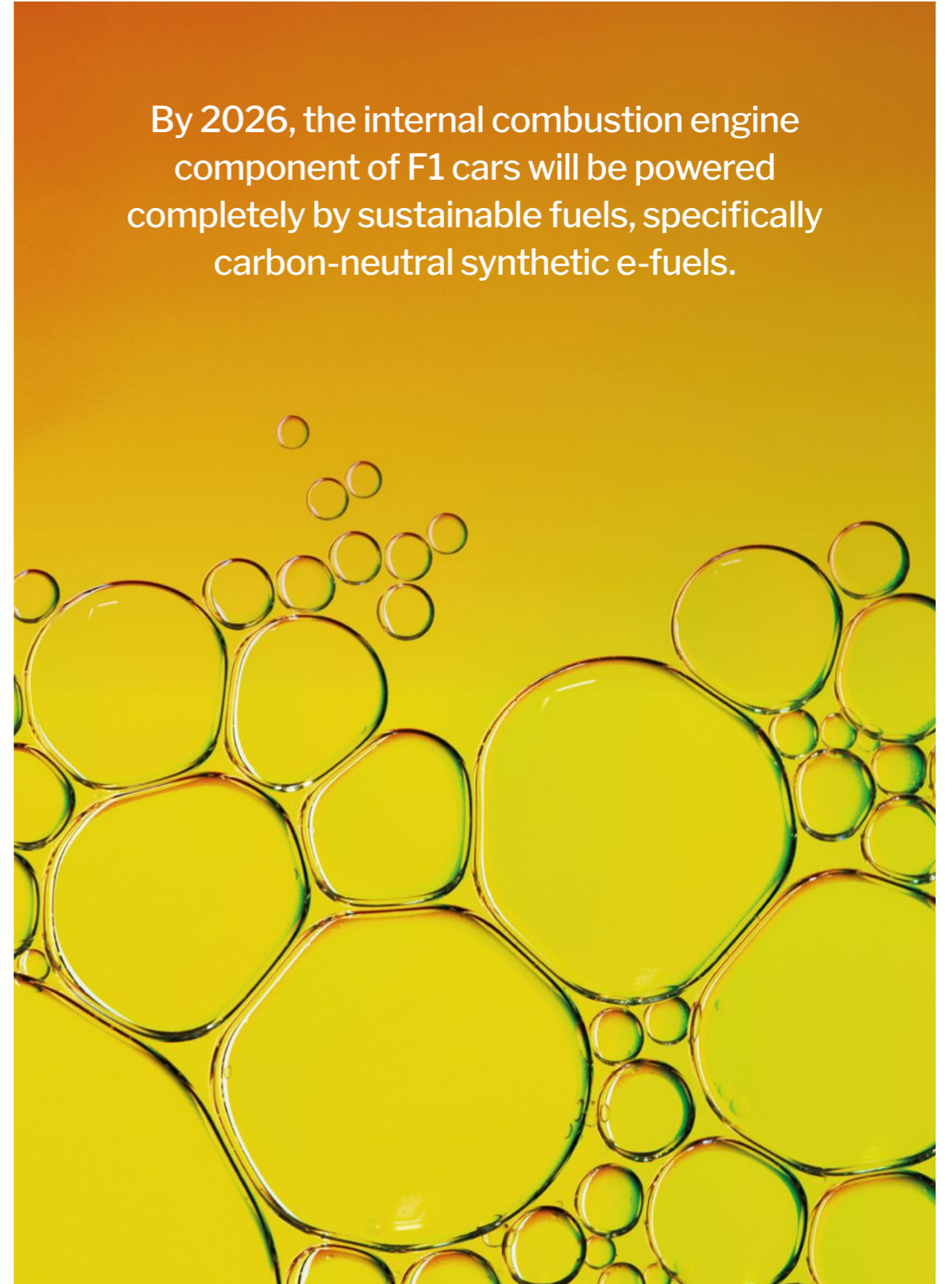
The modern EV can be traced back to a bold move by General Motors (GM) in the early 1990s. Faced with declining market share, GM introduced a fully electric car (the EV1) not out of sustainability considerations, but out of a desperate need for good public relations (PR). And the EV1 was just that: a high-tech showpiece that positioned GM as an innovator. However, because this was largely a marketing stunt rather than a genuine push for sustainable innovation, the EV1 project quickly lost momentum and was eventually discontinued, with most EV1s being famously recalled and destroyed. While the EV1 may have been a PR-driven experiment, it played a crucial role in setting the stage for modern EVs by demonstrating

that electric cars were technologically feasible.

The momentum behind EVs grew significantly when Tesla entered the scene. Tesla was founded in 2003 by Martin Eberhard and Marc Tarpenning, who recognised that lithium-ion battery technology held the key to making EVs more practical and desirable. Unlike lead-acid and nickel-metal-hydrate batteries, lithium-ion batteries were lighter, had a higher energy density, and could provide the kind of range that would make EVs appeal to a broader market. Determined to bring their vision to life, Eberhard and Tarpenning worked tirelessly to develop a vehicle that was not only electric but also high-performance and stylish—something that would make people genuinely excited about driving an EV. Their efforts culminated in the Tesla Roadster launched in 2008, which marked a turning point by shifting the public perception of EVs from utilitarian to aspirational.

So synonymous is Elon Musk with Tesla now that it often comes as a surprise that Musk did not actually found Tesla or lay the technical and conceptual groundwork for Tesla EVs. Instead, Musk—initially as an investor—pushed for his vision for the company, which was based on rapid scaling and expansion. His approach clashed with Eberhard's more measured and engineering-focused leadership style, which led to Musk eventually ousting Eberhard from Tesla, with Tarpenning following suit shortly

By 2026, the internal combustion engine component of F1 cars will be powered completely by sustainable fuels, specifically carbon-neutral synthetic e-fuels.



after. Musk subsequently pushed for mass production, driving Tesla towards the development of the Model S and beyond, thereby giving EVs a scale that would prove crucial in enabling the company to gain a foothold in the car industry.

Tesla's success was not just about the technology; it was also about timing and marketing. The early 2000s saw growing concerns about climate change and oil dependency, creating a favourable environment for EVs. Tesla positioned itself as a forward-thinking company, aligned with the environmental and technological aspirations of a new generation of consumers. The narrative of a 'clean' and 'sustainable' vehicle, free from the emissions of traditional cars, resonated deeply and helped Tesla build a passionate customer base.

Developing extensive charging networks, upgrading power grids, and reconfiguring urban spaces to accommodate new energy demands all contribute to the broader environmental footprint of EVs.

However, despite the popularity of EVs, there remains significant debate over their true environmental impact. The lifecycle emissions of EVs are complex and vary, depending on the source of electricity used for charging, the materials used in battery production, and the vehicle's overall energy efficiency. While EVs produce zero tailpipe emissions, their production involves

the extraction of lithium, cobalt, and nickel for their batteries, which incur significant environmental and social costs. Besides, end-of-life management of EV batteries poses challenges, including environmental contamination and energy-intensive recycling processes. Furthermore, EVs tend to be highly data-intensive, generating and processing vast amounts of information through



onboard systems, telematics, and connected services. This data is often transmitted to data centres, which require significant amounts of energy to operate. Data centres, depending on their location and energy sources, can contribute further to the carbon footprint of EVs.

Perhaps most significantly, the widespread adoption of EVs would necessitate a significant overhaul of existing infrastructure, which comes with tremendous costs, both financially and environmentally. Developing extensive charging networks, upgrading power grids, and reconfiguring urban spaces to accommodate new energy demands all contribute to the broader environmental footprint of EVs. The production and installation of charging stations, the materials required for grid upgrades, and the land use changes needed to support this new infrastructure carry their own environmental impacts, further complicating the sustainability narrative surrounding EVs.

SIMPLE OPTICS, COMPLEX REALITY

The full sustainability implications of EVs are often not fully engaged with in public discourse. Much of this is due to the powerful optics surrounding EVs. The simplicity of the message 'zero emissions' makes EVs an attractive option for consumers and policymakers alike. This straightforward narrative has created a mental shortcut or heuristic where EVs are equated with environmental responsibility. The image of a 'clean' car, free from the emissions of traditional ICEs, resonates deeply with a public

increasingly concerned about climate change.

Governments have capitalised on this perception by offering incentives, tax breaks, and subsidies to accelerate the adoption of EVs. However, the reasons behind these policies go beyond just a strategic push to reduce carbon emissions. The favourable optics of EVs make them an easy and politically advantageous choice for policymakers. Promoting EVs allows governments to align with public sentiment and be seen as taking decisive action on climate change. This is not to say that governments do not act with genuine sustainability objectives. Indeed, many countries have made significant strides in renewable energy adoption and environmental stewardship, and their commitment to EVs is part of a broader, long-term strategy to reduce their carbon footprint and achieve climate goals.

Nevertheless, the political narratives put forward by governments (no matter their motivations) oversimplify the complex realities of EV sustainability. For example, the rise of EVs is not a product of market forces. Instead, it is the outcome of industrial policy. Nowhere is this more evident than in China. Recognising that it would be difficult to compete with established ICE vehicle manufacturers in Europe, Japan, and the US, China pivoted towards EVs as a strategic move. The Chinese government implemented a series of policies to support the development of China's EV industry,

including subsidies for EV buyers, significant investment in battery technology, and stringent emission regulations that favour EVs. China further set ambitious targets for EV adoption, aiming to become a global leader in the EV market.

These policies have had a profound impact on the global automotive industry. Automakers with significant exposure to the Chinese market, mostly German, American, and Korean manufacturers, have accelerated their shift toward EVs to maintain their competitiveness in China. Companies like Volkswagen, General Motors, and Hyundai have all made substantial investments in EV technology, driven in large part by the need to comply with Chinese regulations and capitalise on the growing demand for EVs in China.

A compelling argument can be made that the push for EVs is driven less by definitive scientific evidence of their sustainability and more by a complex interplay of factors. This nuanced reality is often overshadowed by the powerful and appealing optics of EVs as a 'zero-emission' solution, leading to a simplified discourse that positions EVs as the definitive (and only) pathway forward.

SUSTAINABILITY IS NOT A ONE-TRACK ROAD

In contrast, Japanese automakers, which are less dependent on the Chinese market, have taken a different approach. Japan's automotive industry has been less aggressive in its shift towards EVs, partly due to its strong legacy in ICEs and hybrid technology. Recognising

the challenges they would face in the EV market, Japanese car manufacturers are instead exploring a variety of alternative pathways to sustainability.

For example, Toyota has been a pioneer in the development of hydrogen fuel cells, with its Mirai model leading the way for hydrogen-powered vehicles. The company is heavily invested in researching liquid hydrogen, particularly for motorsport applications, which could push the boundaries of this technology even further. Similarly, Honda is set to begin production of a hydrogen fuel cell version of the popular CR-V model, which combines the benefits of fuel cell technology with plug-in hybrid capability.

Most promisingly, Japanese manufacturers are making significant strides in the development of synthetic e-fuels as an innovative alternative to fully electric powertrains. Much like in F1, these synthetic e-fuels are designed to power traditional ICEs (or hybrids) while dramatically reducing their carbon footprint. In addition to developing these advanced fuels, Japanese automakers are also focused on designing a new generation of ICEs optimised for maximum efficiency with synthetic e-fuels. For instance, Mazda is leveraging its expertise in rotary engine technology—a design known for its compact size and high-power output—to develop ICEs that work seamlessly with synthetic e-fuels. Subaru is similarly exploring the potential of synthetic e-fuels in conjunction with a new generation of its iconic Boxer engine.

Most promisingly, Japanese manufacturers are making significant strides in the development of synthetic e-fuels as an innovative alternative to fully electric powertrains.



What makes the synthetic e-fuels approach particularly promising is that it allows for a sustainable future without the need to overhaul existing infrastructure to accommodate EVs. Instead of requiring extensive investment in new charging networks and grid upgrades, synthetic e-fuels can be used within the current framework of fuel distribution and ICE vehicles, enabling a smoother and potentially less disruptive transition to low-carbon transportation. Synthetic e-fuels therefore represent a promising and versatile solution for reducing carbon emissions across the automotive industry, all while utilising existing infrastructure.

RETHINKING THE ROAD AHEAD

It is worth questioning whether EVs are truly a done deal as the definitive route forward in our pursuit of sustainable transportation in Singapore and elsewhere. The powerful optics of EVs—marketed as ‘zero-emission’ vehicles—have undeniably captured the public and political imagination, leading to their rapid adoption and the widespread belief that they are the solution to the sustainability issues the car industry is facing. However, this narrative oversimplifies the complex realities of EV sustainability.

Additionally, the narrative tends to characterise the rise of EVs as a market-driven phenomenon. This is not the case, as the EV industry has been heavily shaped by Chinese industrial policy, which has significantly influenced the global automotive landscape.

Singapore, a city-state known for its forward-thinking policies and commitment to sustainability, has embraced the EV narrative, promoting its adoption through incentives, infrastructural development, and ambitious targets like phasing out ICEs by 2040. However, this singular focus on electrification risks overshadowing other viable pathways to sustainability. A more nuanced approach for Singapore might be to consider alternative technologies such as synthetic e-fuels. Synthetic e-fuels can be integrated into existing fuel distribution infrastructure, reducing the need for massive overhauls and allowing for a smoother transition to low-carbon transportation. This approach could be particularly beneficial in the context of Singapore, where space is limited and the demands on its infrastructure are already high. Furthermore, as Singapore positions itself as a leader in sustainability within Southeast Asia, considering a broader range of technologies could provide it with a more inclusive and regionally appropriate strategy, given the significant economic and logistical barriers that many of our neighbouring countries face in transitioning to EVs.

The road to a greener future is unlikely to be as straightforward as it seems. Rather than committing absolutely to EVs at this juncture, Singapore and our Southeast Asian neighbours might benefit from considering a more diverse array of technologies. By exploring and potentially integrating solutions like synthetic e-fuels, we can ensure that our approach to sustainability

is both resilient and adaptable to our unique challenges and opportunities. This flexibility could allow for a smoother transition to low-carbon transportation that is tailored to the specific needs and infrastructural realities of each country without the risks associated with putting all of our resources in a single technology. [AM](#)



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Our Roads Are Choking

WIS

Re-imagining transport systems to cut carbon emissions and drive climate change.



The global transport sector, particularly road transport, contributes significantly to global greenhouse gas (GHG) emissions and air pollution, causing serious health issues like respiratory and cardiovascular diseases, especially in highly urbanised areas.



Transitioning to electric vehicles and micro-mobility solutions, with the support of proper infrastructure and regulations, is crucial for reducing carbon emissions and improving the urban transport system.

M

ore than half of the world's GHG emissions have risen in the period after the United Nations Framework Convention for Climate Change (UNFCCC) was signed in 1992. The transport sector is one of the most significant contributors to these emissions, accounting for 25 percent of global carbon dioxide (CO₂) emissions. In 2021, over 7.8 billion tonnes of CO₂ were emitted globally by the sector, which happens to be the third largest emitting industry behind energy and electricity.

Within the transport sector, road transport is the highest contributor

In-vehicle telematics and smartphone apps that provide emission feedback can help incentivise drivers to adopt sustainable driving habits. A global carbon credit market can help achieve the same goal by letting individuals and companies monetise their emission reduction.



at 75 percent of global transport emissions. In Singapore, for example, its road transport system accounts for 14 percent of total GHG emissions and related air pollution.¹ To contribute to the 2016 Paris Agreement goal of limiting global warming to 1.5°C, Singapore is targeting an 80-percent reduction in road transport emissions by 2050.² This is a laudable target for a country that sits in a region where air pollution is rising from the overwhelming and exponential increase in the use of internal combustion engine (ICE) vehicles. Throughout Southeast Asia, road transport emissions have grown more than any other sector. In

Vietnam for instance, in tandem with its economic progress, emissions have nearly doubled since 1980, with road transport accounting for the bulk of it.³

Road transport-related air pollution arising from the burning of fossil fuels creates an array of negative environmental and health impacts. In fact, fine particulate matter (PM_{2.5} and PM₁₀) arising from road transport emissions is associated with premature mortality⁴, with their cumulative effects reported to increase the risk of cardio-respiratory morbidity and mortality.⁵ There is an urgency therefore to implement strategies that transition to a low-emission transport system. The urgency is

paramount for populations living in highly urbanised areas such as Singapore, Kuala Lumpur, and the numerous cities in the low- and middle-income countries across the region that are disproportionately exposed to the burden of climate change, particularly urban heat and air pollution.

Every effort is needed to mitigate rising road transport-related emissions. The role of in-vehicle telematics providing feedback to drivers on their personal emissions alongside dynamic financial incentives can play a significant role in driving the necessary emission reductions to achieve important climate change targets. Similarly,

transitioning to electric vehicles, particularly electric micro-mobility, will play an important part in this journey to achieve net-zero emissions.

DRIVING CHANGE: ADDRESSING THE CAR*-BON ISSUE

The societal challenge to mitigate GHG emissions by 2030 and attain net-zero emissions by 2050^{6,7} is a significant one, highlighting the urgency to deliver pragmatic solutions. At the University of Melbourne's Transport, Health, and Urban Systems Research Lab (THUS), we have established a number of responses to drive the needed change.

The first response is to tackle the 'low-hanging fruit', such as the emissions/air pollution arising from drivers on the road transport system. In collaboration with industry and government partners, THUS is implementing an intervention trial which is the first, globally, to deliver vehicle emission feedback to drivers using a smartphone app. The technology integrates vehicle emissions alongside a financial incentive, which we know from our earlier research is the key to observing changes in driver behaviour (refer to box story).

The information on vehicle emissions is fed into a sophisticated model that calculates emission reductions accurately and in real time, which is then delivered to the driver. The driver or end-user is therefore kept updated of his or her net emission reductions on a quarterly and yearly basis, furnished with a concrete metric (e.g., how many trees need to be planted to mitigate their vehicle emissions) with which to measure and modify driving behaviour. At the population level, drivers will be able to monitor the impact of their adoption of the technology in terms of their own contribution to emission reductions and fuel savings.

In the longer term, we propose to establish the sustainability and other UN Sustainable Development Goal (SDG) credentials of the technology. This is likely to occur by developing an advanced methodology for publication by Gold Standard (GS), which is the international voluntary carbon emissions certifier. This is one

tangible mitigation strategy that has the potential of capturing and monetising vehicle emissions, if disseminated across road users throughout Southeast Asia. It represents a significant opportunity for cities to re-invest in sustainable healthy transport futures.

Carbon credits: Circulating funds and clean air

Another solution is to create pathways for the monetisation of voluntary and regulatory carbon credits. In this regard, Singapore has made significant progress, and is considered a leader globally, in setting regulatory pricing thresholds for carbon credits that will rise to between S\$50 and S\$80 by 2030, to establish a carbon tax regime that will gradually push large emitters and their supply chain to reduce emissions by the same year.⁸ A limited number of countries globally have followed the same pathway to build carbon taxation and pricing into their respective 2030 and 2050 strategies.

Singapore also operates a carbon exchange, the CIX, which is a subsidiary of Singapore Exchange.⁹ In parallel with establishing government-to-government agreements for the procurement of voluntary carbon credits under Article 6 of the Paris Agreement, Singapore also leads the way in establishing a model to allow for voluntary carbon credits to be used to offset carbon taxation for large emitters, to a limit of five percent of their carbon emission tax liability.¹⁰

Under these frameworks, the defined and measurable carbon emission reductions from individual

car drivers can be certified under international standards including ISO 14064, and the certification protocols of the Geneva-based GS, thereby generating a Singapore-based pipeline of voluntary emission reduction certificates to meet the growing demand for such credits on both the CIX and under the direct offset threshold for large emitters.

In this manner, sustainable transport solutions and technologies can assist countries in moving away from fossil-fuelled propulsion over time by reducing direct transport emissions from private vehicles and potentially even heavy goods vehicles. This supports large transport emitters like airlines to navigate the challenges of transitioning to a lower emitting impact. In the future, such voluntary carbon credits could also be transferred under bilateral agreements established between the Singapore authorities and other governments.

MICRO-MOBILITY: BIG PROMISE FOR SUSTAINABLE FUTURE TRANSPORT

Importantly, the vision of sustainable future transport relies on a widespread mode shift from using private hydrocarbon-fuelled motor vehicles such as ICE ones to adopting public transport, walking, cycling, and electric micro-mobility (hereafter referred to as micro-mobility) devices such as electric bicycles (e-bikes) and scooters (e-scooters). Sustainable mobility technologies are a key part of such a shift, and there is a significant and growing body of academic literature on the role

Within the transport sector, road transport is the highest contributor at 75 percent of global transport emissions.



and sustainable impacts of electric micro-mobility. Important aspects researched since the inception of shared e-scooter operations in 2017 (starting with Telepod in Singapore) include the carbon emission reduction potential^{11,12}, safety aspects¹³, contribution to public transport uptake based on first- and last-mile accessibility resolution¹⁴, and the replacement of ICE vehicles. Increasingly, questions around the governance of operating models¹⁵ as well as distributive justice have also been raised, which further requires striking a balance between the benefits and burdens of micro-mobility to stakeholders.¹⁶

There are also significant challenges in transitioning to a future transport system that is built on clean fuels. We still need to find out much more about micro-mobility. For example, on urban utility, work is required to understand the effects of introducing micro-mobility not only with respect to transport, but more so in the broader urban ecosystem including its impact on employment, education, and equity (where peri-urban dwellers can also enjoy access to public transit). Other knowledge gaps include building a better understanding of the relationship between micro-mobility and the circular economy, identifying micro-mobility's role in the context of cost effectiveness per kilometre travelled and carbon emission reduction, and last but not least, the issue of safety when operating e-bikes and e-scooters in a transport system that has been primarily designed for private motor vehicle use.

As a mode of transport, micro-mobility reduces emissions by creating a mode switch from a higher emitting transport mode, such as a car, to a lower emitting mode of transport such as an e-scooter. The same applies to other shared transport modes such as public trains and buses. The emission reductions are rooted in the ability to create a mode shift during selected journeys or trips. The more mode shifts that occur, the more we reduce our emissions over time. This seems simple, but there are multiple challenges to carrying this out.

Paving the path for micro-mobility's success

First, the development of new transport infrastructure requires capital investment. One way to finance the switch is via carbon credits which higher emitters can purchase to offset their emissions, thus financing more development in sustainable transport solutions (STS). The second challenge is ensuring that the existing urban and transport infrastructure is adapted to the introduction of micro-mobility vehicles in a planned and organised manner.

A third challenge, which is growing, is that of regulation and recognising that micro-mobility vehicles bring benefits, as well as issues. In the initial phase, e-scooters and e-bikes have often been deployed and operated in grey legislative and regulatory frameworks that have not considered the negative externalities that they can introduce to the transport system with their

growing adoption. It is essential that the negative aspects are recognised in the planning stage before deploying micro-mobility vehicles, thereby avoiding the negativity that emerges without consistent and workable regulations prior to their deployment. This is why stakeholder involvement in the planning for micro-mobility is so critical.

Fourth, as a result of regulation, traffic and urban data feedback systems need to be adapted and adjusted to ensure any new deployment can be monitored. This would ensure that the systems are calibrated to meet new regulations, such as when sending as well as receiving updated sustainability data points. In fact, without sufficient data, micro-mobility initiatives may result in public disenchantment. This, in turn, reduces the success of micro-mobility programmes and their ongoing deployment.

We observed such an occurrence in Paris in 2023, which resulted in the existing micro-mobility infrastructure being dismantled. This unfortunate outcome was largely due to a weakness in regulatory definitions of vehicles that had only recently come into existence. For instance, rentable mobility devices that made their Parisian debut in 2020 shared the same 'private vehicle' classification that came into being in the early 20th century to address parking issues. This classification resulted in a lack of requirement for fleet management and designated parking spaces, leading to e-scooters strewn willy-nilly and souring



public sentiment on micro-mobility. What happened in Paris would be akin to the Land Transport Authority in Singapore or the Department of Motor Vehicles in the US classifying rentable e-scooters as private vehicles, which would likely result in similar outcomes as what transpired in Paris.

Determining the carbon value of e-scooters

While significant, the challenges discussed are not insurmountable, especially considering the potential long-term revenues from certification in micro-mobility projects which can be re-invested in research and urban infrastructure to develop safer and more sustainable

transport. To highlight an example, an initiative by the Mobility Research Partnership that not only supports the integration of micro-mobility within the transport system, but has also led to an amendment to AMS-III.BM, is a UN Clean Development Mechanism-approved methodology that recognises two- and three-wheeled transport modes such as e-scooters and e-bikes, and their contribution to emission reductions.¹⁷ The amendments specifically allowed for the inclusion of e-scooters as a certifiable project activity under GS rules. E-scooter operators can thus begin generating GS Voluntary Emission Reductions for micro-mobility modes of transport.

These are then tradeable on a variety of global carbon exchanges as carbon credits.


To enable the inclusion of e-scooters by GS into the amended version of AMS-III.BM, new formulae have to be developed to determine the emissions reductions from combining lower emitting transport modes. To demonstrate this, the new formulae calculate the uptake of public transport such as buses and trains as a result of micro-mobility trips made. This is a critical point as micro-mobility provides last-mile solutions that connect public transport infrastructures, thus facilitating the use of public transport. In addition to the uptake of public transport, the new formulae should also calculate the reduction in private ICE vehicle ownership as a result of micro-mobility trips made.

CONCLUSION

The significance of delivering an intervention that delivers reductions in transport-related air pollution cannot be underestimated. Implementing smart financial incentives—such as smart apps that can be tailored to individual behaviour—can deliver net reductions at a low cost. The intervention has significant scalability and can therefore be delivered across urban settings, particularly low- and middle-income countries in Southeast Asia. It has the potential for a global scale-up of an intervention that leads to reductions in greenhouse gas and particulate emissions, thus representing an important opportunity for cities

to invest in sustainable healthy transport futures.

Similarly, micro-mobility, as a new industry and technology sector launched globally in 2017, also has enormous potential to reduce carbon emissions with micro-mobility trips found to have no carbon footprint when compared to the same distance trips made by other modes of fossil fuel transport. Micro-mobility is also delivering on social and economic factors, thereby meeting many of the UN SDGs. Emerging technological developments suggest that micro-mobility is at the beginning of an exponential innovation and growth curve, with significant improvement in micro-vehicle durability, as well as innovation in micro-vehicle design and sharing models to come.¹⁸ The integration of micro-mobility into future transport systems is likely to be a necessity if cities wish to embrace a zero-emission transport future.

Highlighting these applications provides city leaders with examples of technology that can be delivered across Singapore, Kuala Lumpur, and other urban agglomerations in Southeast Asia. Importantly, the potential to establish the sustainability and other UN SDG credentials of the technologies, including international voluntary carbon emissions certification, could lead to opportunities for new income from trading carbon credits, thereby ensuring ongoing investment in strategies, which contribute to the mitigation of climate change. 

REDUCING VEHICLE EMISSIONS: THE SMART TRIAL

The SMART trial, supported by the NSW State Insurance Regulatory Authority, delivers a combination of safety and emission feedback to road users via a smartphone app. The trial uses in-vehicle telematics (technology that captures a vehicle's braking, acceleration, and speed relative to posted speed limits) alongside unique algorithms and financial incentives to modify a driver's behaviour in relation to safety and vehicle emissions.

The SMART trial is a two-year field experiment where drivers are randomly allocated to one of three groups where they will receive: i) safety feedback and financial incentives, ii) safety and emission feedback and financial incentives, or iii) no feedback or incentives (this would act as a control). Figure 1 highlights the smartphone app used in the trial.

Financial incentives to encourage changes in driving behaviour and therefore reduce emissions are based on research from the THUS lab that highlights providing feedback to drivers alone may be insufficient to motivate behavioural change.¹⁹ Rather, combining feedback with financial incentives can deliver potentially important and statistically significant changes in driving behaviour.

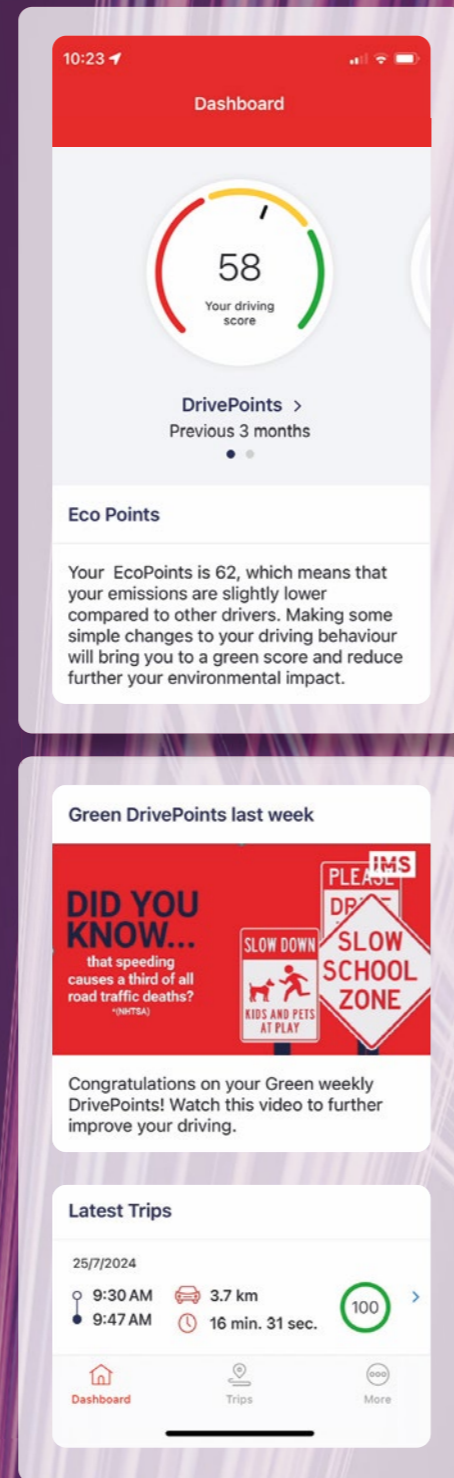


FIGURE 1

The availability of this unique technology that continuously monitors individual behaviour raises the potential for personalised and *adaptive design of incentives* (including emission feedback) as implemented in this trial.

The incentive is structured as penalties for increased emissions—for example, levied as monthly \$25 deductions from an endowment of \$125 deposited into a virtual driving account. Importantly, the penalties are used to leverage ‘loss aversion’ and maximise reductions in driving behaviours that increase vehicle emissions or unsafe driving. The personalised financial incentive is tailored weekly to their risk and emission profile, thereby acting as a ‘SMART incentive’.



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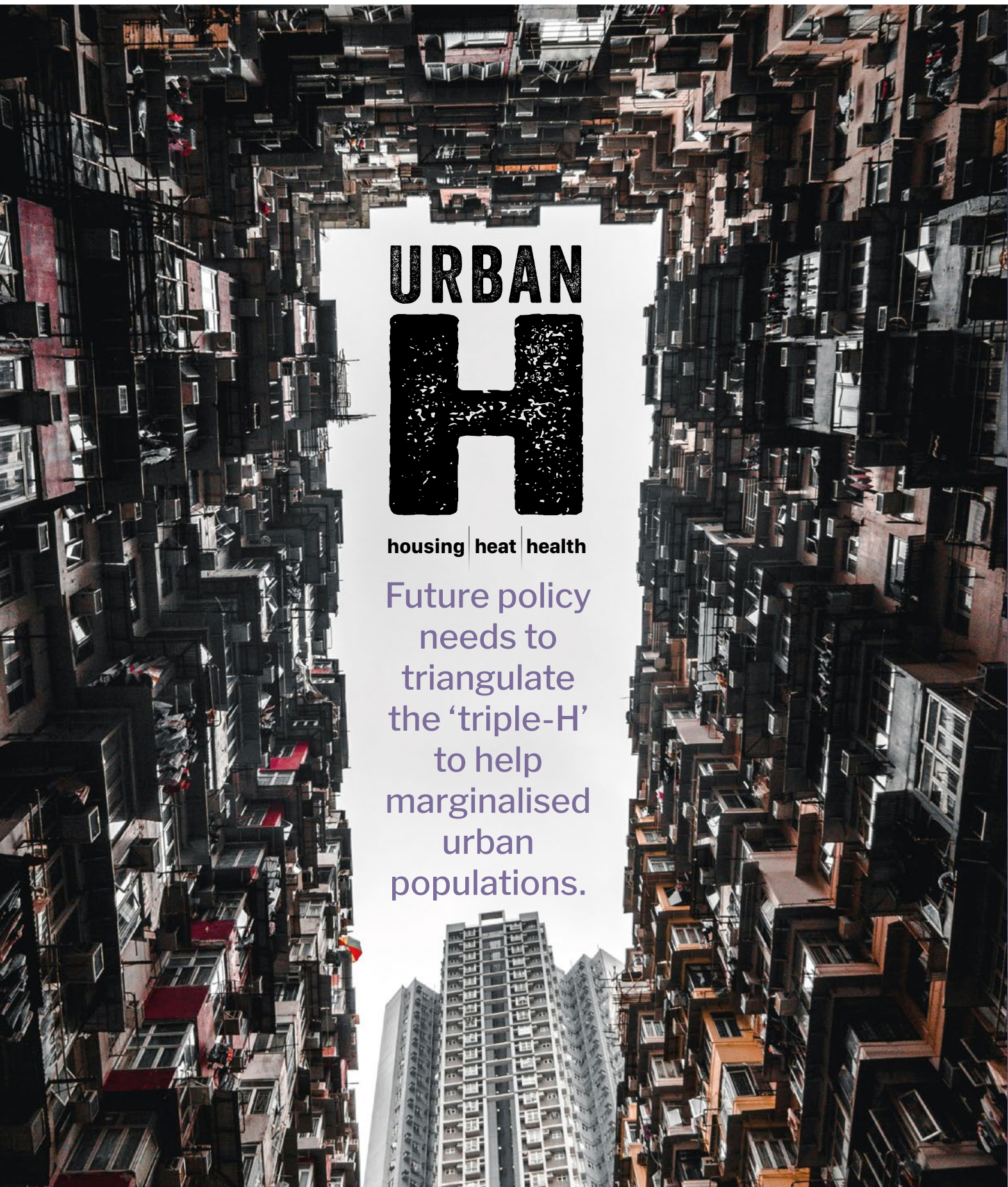
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For a list of endnotes to this article, please visit <https://tinyurl.com/38pufn2v> or scan the QR code below.





URBAN H

housing | heat | health

Future policy
needs to
triangulate
the 'triple-H'
to help
marginalised
urban
populations.

The urban heat island effect generates disproportionately high temperatures in urban settlements compared to non-urban ones, leading to increased heat-related illnesses and mental health issues, especially among vulnerable and marginalised populations living in poorly-planned or -resourced areas.

The Urban-H research agenda by Boston University's Initiative on Cities focuses on the interconnected effects of housing, heat, and health (triple-H) to develop a resilience index for cities.

The proposed global Urban-H Index could help cities worldwide address the triple-H crisis by guiding policymakers to craft equitable, as well as socially and environmentally just policies for their most vulnerable and marginalised populations.

In 2023, heat records were broken on all continents and the world saw the highest global temperatures in over 100,000 years.¹ With buildings and roads retaining heat and creating urban heat islands, warmer cities have not only become increasingly uncomfortable but are also posing health risks such as heat exhaustion and respiratory disorders to their inhabitants. In the US, the 175 largest cities—which account for 65 percent of the total population—have seen a disproportionate number of heat-related deaths in the past 15 years.²

Studies have also shown that exposure to extreme heat, especially during heatwaves, can have detrimental effects on mental health.³ Such exposure can increase stress, anxiety, and irritability, while high temperatures can disrupt sleep patterns and exacerbate existing mental health conditions, such as depression and bipolar disorder.^{4,5,6} Quality housing is key to mitigating the worst physical and mental effects of scorching weather, but it is sometimes unaffordable or even unavailable, thereby contributing further to a vicious cycle of stress, anxiety, and even depression.

This triumvirate of Housing/Heat/Health is what we call the 'triple-H' and it has been incorporated into a research agenda called Urban-H (refer to Figure 1) at Boston University's Initiative on Cities (IoC). Our review of research to date has found numerous studies establishing causal links between housing and heat, housing and health, heat and health, but little to no studies on them as a tripartite. By studying triple-H issues in cities at the same time, we hope to mitigate and even solve the different social justice and other issues. The IoC hopes to develop a global 'Urban-H Index' for cities based on the triple-H that measures the resilience of cities in relation to these three global threats.

WHY TRIANGULATING TRIPLE-H IS IMPORTANT

As average temperatures continue to rise, the frequency, duration, and intensity of heatwaves are expected to increase.⁷ 'Urban heat islands' describe how cities experience higher temperatures compared to their non-urban counterparts, mainly due to infrastructure

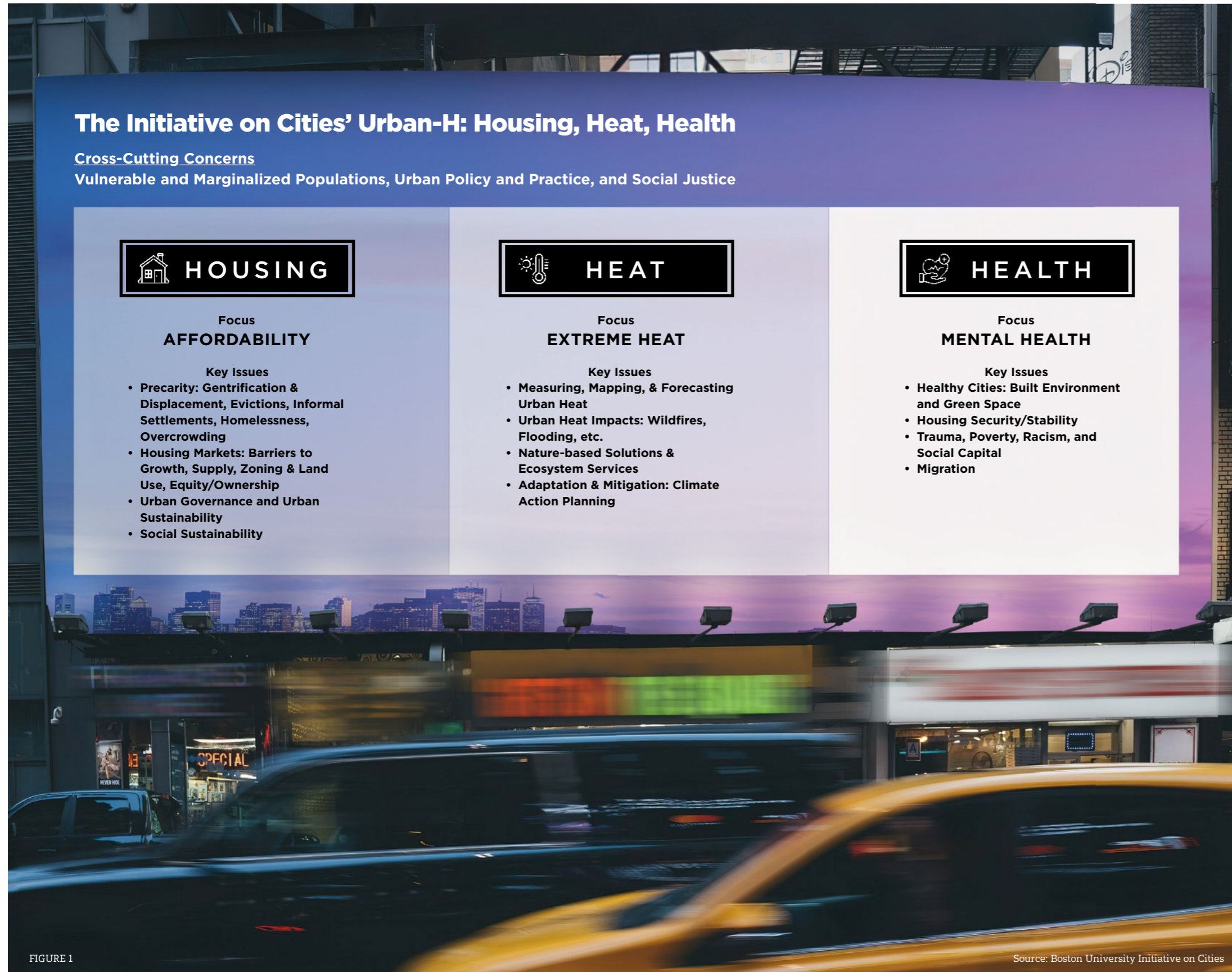


FIGURE 1

Source: Boston University Initiative on Cities

(e.g., roads and buildings) that retain heat within the area. In the US, urban areas are already 10 degrees warmer than surrounding suburban or rural areas.⁸ Individuals living within urban heat islands in and around downtown areas are more vulnerable to heat than those residing further out. High temperatures can exacerbate negative health effects that are already present, especially for vulnerable groups. Urban heat-related deaths surpass those from any other US weather-related event and disproportionately occur among marginalised populations.^{9,10} According to a study conducted in Europe, overheating due to living in hotter environments can increase the risk of cardiovascular disorders, respiratory disorders, heat stroke, heat exhaustion, and mental illness.¹¹ In a study conducted in Adelaide, Australia, it was found that hospital admissions for mental and behavioural disorders increased by 7.3 percent during heatwaves.¹²

The quality and stability of housing plays a crucial role in mitigating or worsening the effects of extreme heat on mental health, and the literature highlights the importance of considering both the physical and social aspects of housing in order to understand its impact on health. Living in substandard housing can contribute to stress, anxiety, and depression. Residing in unaffordable housing is directly linked to poorer health outcomes such as worse self-rated health, hypertension, and mental health.¹³ Socioeconomic stressors associated with housing displacement and insecurity, such as financial strain, social isolation, and disruption in access to healthcare, can compound the impact of extreme heat on mental well-being.

Some people are better able to adapt to extreme heat than others due to the characteristics of their built and socioeconomic environments. The physical and social conditions of homes and neighbourhoods can support or harm individual and community health in many ways and across different health outcomes. To measure how heat impacts residential areas, researchers have developed the Heat Vulnerability Index (HVI), which has been widely used as an indicator for researchers and local governments to determine which neighbourhoods and communities are most affected by heat.¹⁴

In metropolitan areas such as New York City, there were higher HVI scores in boroughs or districts such as the Bronx and Brooklyn which are predominantly

non-white.¹⁵ A study of over 100 urban areas in the US revealed that 94 percent of cities with the highest temperatures were in previously redlined areas, reflecting the legacy of past planning policies.¹⁶ Historically, racist urban planning practices that redlined black neighbourhoods have left a lasting impact on marginalised communities, leaving them more vulnerable to health problems from heat than wealthier neighbourhoods within the same city.¹⁷ This discriminatory practice, typically in areas with predominantly minority residents, has led to the systematic disinvestment and socioeconomic decline of such neighbourhoods.

Poorly designed urban environments with limited green spaces and high concentrations of heat-absorbing surfaces can intensify heat exposure and contribute to thermal discomfort, particularly for residents in densely populated

neighbourhoods with inadequate infrastructure. Unaffordable, insecure, or substandard housing also significantly exacerbates an individual's vulnerability to extreme heat. Understanding housing conditions, such as housing age, crowding ratio, and roof conditions, can help predict the risk of heat-related illness. Poorly insulated or ventilated housing can trap heat indoors, leading to higher indoor temperatures during heatwaves. Inadequate access to air conditioning or cooling systems can increase heat exposure and discomfort, particularly for vulnerable populations such as the elderly, children, and low-income individuals.

The connection between heat and housing underscores the importance of addressing both environmental and social determinants of health to promote resilience and well-being in the face of climate change. Research and

policy coordination will increasingly be needed as the impacts of climate change and the housing affordability crisis worsen around the world.

IoC research triangulating urban triple-H

The IoC recognises the importance of conducting interdisciplinary, transdisciplinary, and translational Urban-H research (refer to box story). It has just co-authored a paper with the Barcelona Urban Lab in Spain on heat racism, heat gentrification, and urban heat justice that is under review. We argue that extreme and prolonged heat has recently gained traction not only as an 'invisible killer', but also as a visible amplifier of unequal vulnerability and adaptive capacity. In our paper, we call for urban climate researchers to move beyond heat exposure studies, and individual or environmental biophysical factors, and not to treat human populations as homogenous groups. Instead, they ought to distil the relations between unequal heat impacts and the legacy of exclusionary urban planning, to point out how injustice is (re)produced through heat-response measures and heat gentrification, and propose new research priorities, and policy and planning takeaways that are grounded in heat justice.

Specifically, we argue that no heat abatement strategies can be climate justice-driven if the core focus is on heat management as an apolitical heat response strategy that does not account for, nor address, concurrent patterns of heat racism,¹⁸ and emerging trends of what we term 'heat gentrification'

as some of the most acute and structural forms of heat injustice. 'Heat gentrification' occurs when lower income populations are displaced from urban heat islands because they cannot afford to keep cool, and are replaced by wealthier in-movers who can, or when lower income populations are displaced out of parts of the city that are less hot, which become more desirable to higher income groups as extreme heat escalates.

Our takeaway is that the trends of heat racism and heat gentrification require new research on the interactions among heat, its health impacts, infrastructure for heat resilience, and the social factors of vulnerability. From a practice standpoint, we argue that planning for urban heat in

an equity-driven manner requires a variety of tools and innovative practices as detailed in Figure 2.

The IoC has also seed-funded three new Urban-H projects which are being undertaken by interdisciplinary research teams at Boston University this year.¹⁹

Project 1, *Building Resilience after Redlining: Understanding the Cumulative Impact of Heat Vulnerability Factors in Massachusetts*, argues that to implement effective interventions against extreme heat exposure in urban areas, we need a better and more granular understanding of how the built environment, as well as social, demographic, and individual vulnerability factors combine to exacerbate or reduce health risks. The team responsible

for this project noted that decades of racial and economic residential segregation and disinvestment have produced redlined neighbourhoods characterised by poor housing stock, and residents with few resources available for adaptation to the impacts of extreme heat. Using high-resolution geographic, demographic, and healthcare utilisation data from across Massachusetts, including all-cause, acute heat-related, and mental health-related hospital visits, they will examine the influence of historical redlining on the risk of emergency room visits on hot days, and the increased risk of hospital visits on hot days associated with the combined risk of multiple intersecting built environments and sociodemographic vulnerability factors.

Our review of research to date has found numerous studies establishing causal links between housing and heat, housing and health, heat and health, but little to no studies on them as a tripartite.

THE IMPORTANCE OF INTERDISCIPLINARY, TRANSDISCIPLINARY, AND TRANSLATIONAL URBAN-H RESEARCH

The IoC has appointed three Urban-H leads. Each one is a Boston University faculty specialising in political science, earth and environment, and public health, respectively. They are leaders in their fields who have a commitment to interdisciplinary, transdisciplinary, and translational urban research, and are working with cities and communities. These leads are working separately and together to undertake and catalyse Urban-H research. Briefly, interdisciplinary research bridges, integrates, and harmonises the knowledge between disciplines, while transdisciplinary studies are a result of different disciplines working together to create new conceptual, theoretical, and methodological knowledge beyond discipline-specific approaches. As for translational efforts, these involve converting scientific discoveries from research to directly benefit humans through means such as policy interventions and medical treatments.

The IoC, as also Singapore Management University's (SMU's) Urban Institute, are somewhat unique in that they are both university initiatives that are not tied to any particular discipline or department. This is important for it allows and enables them to be properly inter- and trans-disciplinary as they do not have to answer to or situate themselves in a particular discipline, be it urban planning or another. This makes for a more open research team that is able to think outside the box and be nimbler in its research and actions. Translational Urban-H research that is for the public good, and which has real-life impact in terms of policy and practice, has to be the way forward in terms of mitigating and managing the coming together of these three global crises—housing, heat, and health.

Project 2, *Coping with Extreme Heat: Intersecting Vulnerabilities Related to Urban Heat Islands, Homelessness, and Serious Mental Illness*, seeks to better understand how homeless adults with serious mental illness manage during periods of extreme heat, and the unique barriers they face in adapting to this increasingly common aspect of climate change. For example, they may not have consistent access to reliable shelter, air-conditioned spaces, cool showers, or other common methods for adapting to heat. The unhoused population is at heightened risk of the negative effects of extreme heat, and they already have higher rates of serious mental illness than the general population. Drawing on qualitative interviews with homeless adults who are receiving psychiatric emergency services in a community crisis stabilisation centre that serves Boston neighbourhoods identified as urban heat islands, the results will directly inform the development of novel interventions and policies which address the needs of those most vulnerable to the health impacts of climate change.

Project 3, *Housing and Neighbourhood Determinants of Sleep and Mental Health in Low-Income Toddlers and Their Parents*, is using geocoding to assess neighbourhood-level factors, including housing and heat island severity, and spatial analyses to examine these factors in relation to actigraphs (wearable devices that measure rest/activity) and parent-reported indices of toddler sleep and mental health in Denver



FIGURE 2

Source: Isabelle Anguelovski et al., "From Heat Racism and Heat Gentrification to Urban Heat Justice". (In review)

and Boston. The main aim is to understand the contributions of poverty-related disparities in the neighbourhood and housing to sleep and mental health problems in early childhood. The researchers are drawing on data from an ongoing randomised controlled trial, the Parent and Toddler Health (PATH) project, which focuses on low-income families with toddlers experiencing co-morbid sleep and mental health problems, and interviews with the participants to assess family-level rent burden, housing stability, and overcrowding.

Effects of triple-H on Southeast Asian cities: Singapore and Jakarta as examples

Singapore seems to be ahead of its regional neighbours in terms of climate resilience. Experiencing increased urban heat, it has established its National Climate Change Secretariat (NCCS) which ensures that the country's climate resilience strategies remain up to date. The NCCS sits in the Prime Minister's Office, the pinnacle of policymaking in the country. That said, there may yet be issues for the marginalised populations in Singapore, and mental health has received less attention than physical health to date.

A triple-H issue that may deserve attention is the emergence of Singapore as a climate haven, given its ambitious climate change policies. Climate refugees may well be the new normal and a significant challenge for the country. Fleeing extreme heat that is not managed well elsewhere,

they will no doubt put pressures on housing and health services in Singapore. Such an existential threat underlines the importance of not only cooperating with other cities and states beyond Singapore's borders, but also taking the interplay of triple-H seriously.

Jakarta, Indonesia, like other Southeast Asian cities, has also started developing and implementing its climate mitigation strategies. For example, low-income neighbourhoods in Jakarta, which have limited green spaces, have become heat islands that disproportionately affect the health of people living and working in them because of higher temperatures than surrounding areas and the lack of access to cooling devices. The Indonesian capital has regulations that highlight the importance of equal distribution of green spaces across the city, but studies have found the city is still far from reaching its goal of providing adequate and fair access to open green spaces for all its residents.²⁰

Meanwhile, Jakarta has built a number of child-friendly public places (RPTRA), which have the potential to be used as cooling spaces, but they have been criticised for being exclusionary to low-income populations.²¹ Like in many cities around the world, green spaces in Jakarta are more likely to be found in high-income neighbourhoods, both old and new. New-build developments are often branded/advertised with plush green spaces (called 'green gentrification' in Euro-America and 'bourgeois environmentalism' in India).²² Many cities, especially dense and poorer ones, posit limited space and budget as the reason for not building more green spaces in their urban environs. But limited space is not always a barrier if you are up to the challenge as Singapore appears to be.

DEVELOPING AN URBAN-H INDEX

The IoC and the SMU Urban Institute are currently in discussion on developing an Urban-H Index.

There are already numerous urban and city-related indexes—from global city indexes to creative city indexes to sustainable city indexes, and so on. We have looked at the history of such indexes and their links to competitive city rankings, in relation to what we are planning for our Urban-H Index.

There has always been an interest in ranking and comparing cities, but the city rankings we are familiar with today date back to the 1970s. As Euro-American cities moved into a new post-industrial phase and new forms of globalisation based on new technology emerged, models and indexes were developed to guide investment decisions in cities. For example, Swiss bank UBS released its first Prices and Earnings Survey in 1970 that compared the consumption power of citizens in 72 cities globally. Interest in city rankings increased throughout the 1980s and 1990s and they were more often developed to support the newly globalising, neoliberal economy. Examples include those produced by the Economist Intelligence Unit and Mercer for multinational companies.

In 2008, the *Foreign Policy* journal noted that "the world's biggest, most interconnected cities help set global agendas, weather transnational dangers, and serve as the hubs of global integration. They are the engines of growth for their countries and the gateways to the resources of their regions".²³ It published a ranking of global cities based on consultation with urban sociologist Saskia Sassen and urbanist Witold Rybczynski.²⁴


The ranking was based on 27 metrics across five dimensions: business activity, human capital, information exchange, cultural experience, and political engagement. Universities have also increasingly weighed in on the global ranking of cities. For example, UK-based Loughborough University's Globalisation and World Cities Research Network is known for organising cities into alpha, beta, and gamma tiers based on their integration into the global network.²⁵

Over time, city indexes and rankings became of interest not just to businesses, but also city and national governments. Consulting firms, think tanks, and universities have all got in on the act. An example would be American urban studies theorist Richard Florida's Creative City Index. Meanwhile, new city indexes using different data, methodologies, and with increasing levels of sophistication are being developed and these are evolving all the time.

Our Urban-H Index will be different from other urban indexes as it will be the first socially and environmentally just index for cities globally that has been developed. It will measure the complex interplay of triple-H in 3D space using World Health Organization (WHO) and other national health data, global climate remote sensing data, UN Habitat, and national and city-wide housing data. We will use cloud computing and machine learning to map 'actual liveability' at the neighbourhood and city level. The goal of the Urban-H Index rankings is to identify cities, large and/or

small, that could serve as havens in the face of a triple-H crisis, so as to inform policy and promote intercity learning globally.

MOVING FORWARD ON THE TRIPLE-H CRISIS

In developing mitigations, if not solutions, for the triple-H crisis, global, national, and local governments, policymakers, and practitioners need to triangulate research and evidence that intersects housing, heat, and health. Given that marginalised urban populations are the most overexposed to the triple-H crisis, they deserve particular attention. The development of an Urban-H Index that ranks cities globally in terms of how well they do in dealing with the intersection of housing, heat, and health would be the icing on the cake. 



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For a list of endnotes to this article, please visit <https://tinyurl.com/38pufn2v> or scan the QR code below.



Like in many cities around the world, green spaces in Jakarta are more likely to be found in high-income neighbourhoods, both old and new.

DIGITAL INDIA

Promises, perils, and inspiration for the Global South.

At the heart of India's ongoing digital transformation lies a 'perfect storm' of pivotal elements: a robust telecom industry, groundbreaking digital technologies, an evolving payments ecosystem, and widespread smartphone adoption. Together, these elements have redefined connectivity, communication, and financial transactions, positioning India as a leader in the digital age.

This dramatic change in India's digital landscape has not only democratized access to digital services but also fostered a competitive environment that spurs innovation and economic inclusion in the country.

As India's digital ecosystem matures, potential consolidations in sectors like digital payments and ride-hailing could occur. Continued investment in infrastructure, digital literacy, and sustainable practices will be essential to sustain the country's current digital growth trajectory.



There has been a very positive perfect storm taking place in India's digital stack—

a digital revolution that is testament to the remarkable confluence of four pivotal elements: the telecom giants, groundbreaking digital technologies, a thriving payments ecosystem, and affordable smartphones. Each of these elements plays a defining role in redefining connectivity, communication, online transactions, and digital interactions.

The telecom industry has ushered in an era of widespread accessibility to high-speed Internet. In tandem with this advancement, impressive digital technologies such as the Unified Payments Interface (UPI), which streamlines online transactions by offering convenience and security, have been developed. This has boosted e-commerce and other digital payment-driven services, creating a booming payments

ecosystem. Finally, smartphones have become all-pervasive gateways to this digital realm, empowering users with limitless access to information and services.



The ingredients are all set in place to build India's digital stack. What else is needed to orchestrate this perfect convergence of elements that will continue to grow and offer opportunities?

THE FOUR PIVOTAL ELEMENTS OF INDIA'S DIGITAL STACK

The digital disruption, whether initiated by the Indian government or other entities, presents numerous social challenges. Despite this, India has embraced and expedited digital disruption to maximise its economic and social inclusion benefits, rather than slowing down to address these challenges.

Telecom industry: Reaching every corner

The telecom sector has revolutionised the way people in India live, work, and communicate. Today, India is the world's second largest telecom market, worth almost US\$49 billion, and projected to exceed US\$76 billion by 2029.¹ A joint report by Google, Temasek, and Bain & Company states that the value of India's Internet economy, in the range of US\$155-US\$175 billion in 2022, is expected to register six-fold growth and reach US\$1 trillion by 2030. The expansion has mainly been driven by e-commerce. The report adds that B2C (Business-to-Consumer) e-commerce is expected to grow at least five times to US\$350-US\$380 billion by 2030 from US\$60-US\$65 billion in 2022, while B2B (Business-to-Business) e-commerce is expected to grow 13 to 14 times from around

US\$8-US\$9 billion in 2022 to at least US\$105 billion over the same period.²

As of February 2024, there were about 636 million urban and 529 million rural mobile subscribers in India.³ Rural subscriber growth has also outpaced that of urban subscribers with a 43-percent increase since 2014, compared to the 19-percent rise for urban subscribers for the same period.⁴ This trend highlights a quicker expansion in rural areas, where subscription levels are inching closer to those of urban areas.

Several key factors have driven the expansion of the Indian mobile network. To begin with, in contrast to Western countries, fixed line or cordless phones are less prevalent in India, making mobile phones the primary communication tool for many people. Second, while mobile phones were relatively expensive to begin with, they rapidly became affordable for middle-income individuals—particularly post-2016, when telecom giant Reliance's entry with its highly economical Jio product truly disrupted the Indian mobile network market. Jio's aggressive pricing strategy, including free outgoing voice calls and cheaper data plans, led to a steep decline in mobile data prices and average prices per GB of data dropped from INR 152 (US\$1.80) to INR 10 (US\$0.12).⁵ Jio thus made data accessible and affordable, expanding the reach of the Internet to entirely new segments of society for the first time. It onboarded 108 million customers

in just 170 days in an entirely paper-free manner, relying solely on mobile technology.⁶ Such a streamlined approach reduced customer acquisition costs to less than US\$1 per customer from the previous industry average of US\$25.⁷ This level of affordability likely drove increased smartphone adoption for Internet access. Today, India enjoys some of the most affordable data tariffs globally. For instance, Jio offers data and voice services at US\$0.04 per day.

The growth in subscribers also reflects the country's insatiable appetite for data. Mobile data traffic per device in India is skyrocketing. Average usage per device was 21.4 GB in 2022, and is expected to reach nearly 50 GB per month by 2027.⁸ The growing popularity of online streaming and gaming along with the adoption of the latest fifth-generation (5G) mobile network technology have contributed to this. 5G offers faster download and upload speeds, encouraging data-intensive activities like HD (High Definition) streaming and online gaming. Online streaming services like Netflix and Amazon Prime Video are further driving increased data use, while popular mobile games like PUBG Mobile and Call of Duty require significant data for downloads and online play.

In 2024, Reliance Jio remains the leader of India's telecom market, with a strong presence in both rural and urban areas. It has the highest market share of rural subscribers due to its aggressive pricing strategy and wide network coverage.



Today, India enjoys some of the most affordable data tariffs globally.

Innovative digital technologies: Facilitating financial inclusion

In 2008, India's central bank, the Reserve Bank of India (RBI), and the Indian Banks' Association (IBA) set up National Payments Corporation of India (NPCI),⁹ a non-profit company promoted by 10 major banks, to establish a strong and secure electronic payment and settlement ecosystem in the country. In 2010, NPCI further introduced the Immediate Payment Service (IMPS), which offered an instant, round-the-clock interbank electronic fund transfer service between mobile phone users.

Aadhaar: The national digital ID programme

In 2010, the government also issued the 'Aadhaar' card, a universal digital form of identification that captured personal details, including biometric and iris scans, and stored it digitally. Aadhaar was a groundbreaking initiative for India as it significantly facilitated digital inclusion. Companies used to spend considerable time and resources to collect basic customer details. Now, with data available on the Aadhaar Portal, they were able to access personal information through Aadhaar authentication using the registered mobile numbers. Aadhaar was also a great facilitator of financial inclusion and economic growth, enabling instant, secure, and accessible transactions. In 2014, the Pradhan Mantri Jan-Dhan Yojana (PMJDY) was launched by the Indian government. Considered the world's largest financial inclusion initiative, it offered basic savings

bank accounts that could be opened with zero balance. As of June 2024, there were about 525 million PMJDY accounts with about 67 percent of these account holders living in rural and semi-urban areas.¹⁰

Enter UPI

The introduction of UPI in 2016 was another game changer. An instant payment system and a protocol developed by the NPCI, UPI facilitates interbank peer-to-peer (P2P) and person-to-merchant (P2M) transactions. Regulated by the RBI, it is used on mobile devices to instantly transfer funds between two bank accounts, and runs as an open-source application programming interface (API) on top of the IMPS. With UPI, India has maintained its position as the global leader in instant payments, accounting for 46 percent of all global instant payment transactions in 2022.¹¹ The platform had over 300 million monthly active users in India as of October 2023,¹² and had enabled over 2,300 transactions every second in 2022.¹³ According to data from the NPCI,

12.2 billion UPI transactions worth US\$222 billion were processed in January 2024, representing a 42-percent increase in transaction value compared to that for January 2023.¹⁴ As of 2024, UPI transactions accounted for 75 percent of all digital payments.¹⁵

The surge in trust and adoption of digital transactions in India can be attributed to their secure nature and traceability.

The exponential growth of UPI can be attributed to several factors. One significant reason is the prevalent savings culture in India, which has resulted in a higher number of debit card holders compared to credit card users. Consequently, the transition to UPI transactions, which are similar to debit card transactions, encountered less resistance and substitution effects than say countries in the West, where credit card usage is more common.

In 2024, the UPI ecosystem comprised 605 banks,¹⁶ and a large number of UPI-supporting apps such as PhonePe, Paytm, Google Pay (GPay), MobiKwik, Uber and SBI Pay, besides bank account holders and merchants.

Payments ecosystem: Users, merchants, and banks

The way Indians pay for their shopping has changed over the years. In 2017, cash accounted for 72 percent of POS ('point-of-sale', typically retail) transactions, followed by debit cards (11 percent), credit/charge cards (nine percent), and other payment methods (eight percent). However, by 2022, the proportion of cash payments had declined to 27 percent, while that for digital payments (e-wallets, prepaid cards, etc.) had grown to 37 percent. The proportion of credit and debit card payments meanwhile remained relatively stable, accounting for about 18 percent of POS transactions over the past five years.¹⁷

Meanwhile, the volume of UPI payments to merchants (P2M) has surpassed that of person-to-person (P2P) transactions in India, accounting for a remarkable 56 percent of all UPI transactions in 2023.¹⁸ This shift is being driven by several factors, including the Indian government's mandate for merchants to accept UPI payments and the inherent convenience of the platform. With a few taps on their smartphones, customers can make payments without having to carry cash or cards.

The surging popularity of free UPI P2M transactions is beneficial for consumers, merchants, and banks. For consumers, it provides a convenient and secure way to pay for goods and services, with features such as two-factor authentication and biometric authentication providing extra security. For merchants, it opens up a broader customer base and boosts sales. An instant transfer of funds and clear acknowledgement of the status of the transaction encourage merchants to adopt the technology. Banks, meanwhile, benefit from increased transaction volumes and enhanced customer engagement, which can lead to greater retention and cross-selling opportunities. Additionally, the widespread use of UPI reduces cash handling costs and associated risks, further improving operational efficiency for banks. Overall, the surge in UPI P2M transactions is a positive development for India's economy, making it easier for businesses to operate and for consumers to shop, while also promoting financial inclusion by



making digital payments accessible to everyone.

In addition to UPI, other payment systems like Real-Time Gross Settlement (RTGS) and National Electronic Funds Transfer (NEFT) contribute to the diversity of India's financial ecosystem. RTGS is a high-value payment system that processes fund transfers individually on a real-time basis, ensuring immediate transfer of funds. NEFT is a country-wide payment system enabling one-to-one fund transfers. It facilitates transactions from individuals, firms, and corporates from one bank branch to another across participating branches in India. NEFT can be used for transferring any amount without a minimum or maximum limit. Transactions exceeding INR 200,000 are typically processed through RTGS, while smaller transactions, which are primarily for salary payments, are handled by NEFT. As a result, the value of RTGS and NEFT transactions has exhibited steady growth.

Digital payments have also increased the government's efficiency by allowing for the likes of electronic toll payments on highways through the National Electronic Toll Collection system and easily accessible bill payment services through the Bharat Bill Payment System (BBPS). The multiple authentication layers further ensure essential safety.

In another initiative, in 2012, NPCI introduced RuPay (the name is a blend of 'Rupee' and 'Payment'), a first-of-its-kind domestic card payment network in India, with wide

acceptance at ATMs (Automated Teller Machines), POS devices, and e-commerce websites across the country.¹⁹ RuPay offers debit cards, credit cards, prepaid cards, and government scheme cards. It was meant as an alternative to Mastercard and Visa cards, and the government mandated that all merchants in India accept RuPay cards. As of February 2021, there were 628 million RuPay cards across all the categories. These have been issued by more than 1,000 banks, and the cards account for nearly 35 percent of the card market in India.²⁰

Furthermore, to lay the foundation for a strong and inclusive digital economy that can propel the nation's digital transformation, India has devised its Digital Public Infrastructure, which consists of five key layers. They are the Identity Layer with Aadhaar, the Consent Layer with Data Empowerment and Protection Architecture (DEPA) that allows individuals to share their data with service providers securely, the Paperless Layer with DigiLocker and eSign, the Payment Layer with UPI and RuPay, and the Transaction Layer with BBPS and Goods and Services Tax (GST) Network.²¹ These five layers are designed to work together seamlessly to ensure smooth integration across services. The focus on data security, user consent, and privacy protection promotes financial and digital inclusion, reduces transaction costs, and improves service delivery.

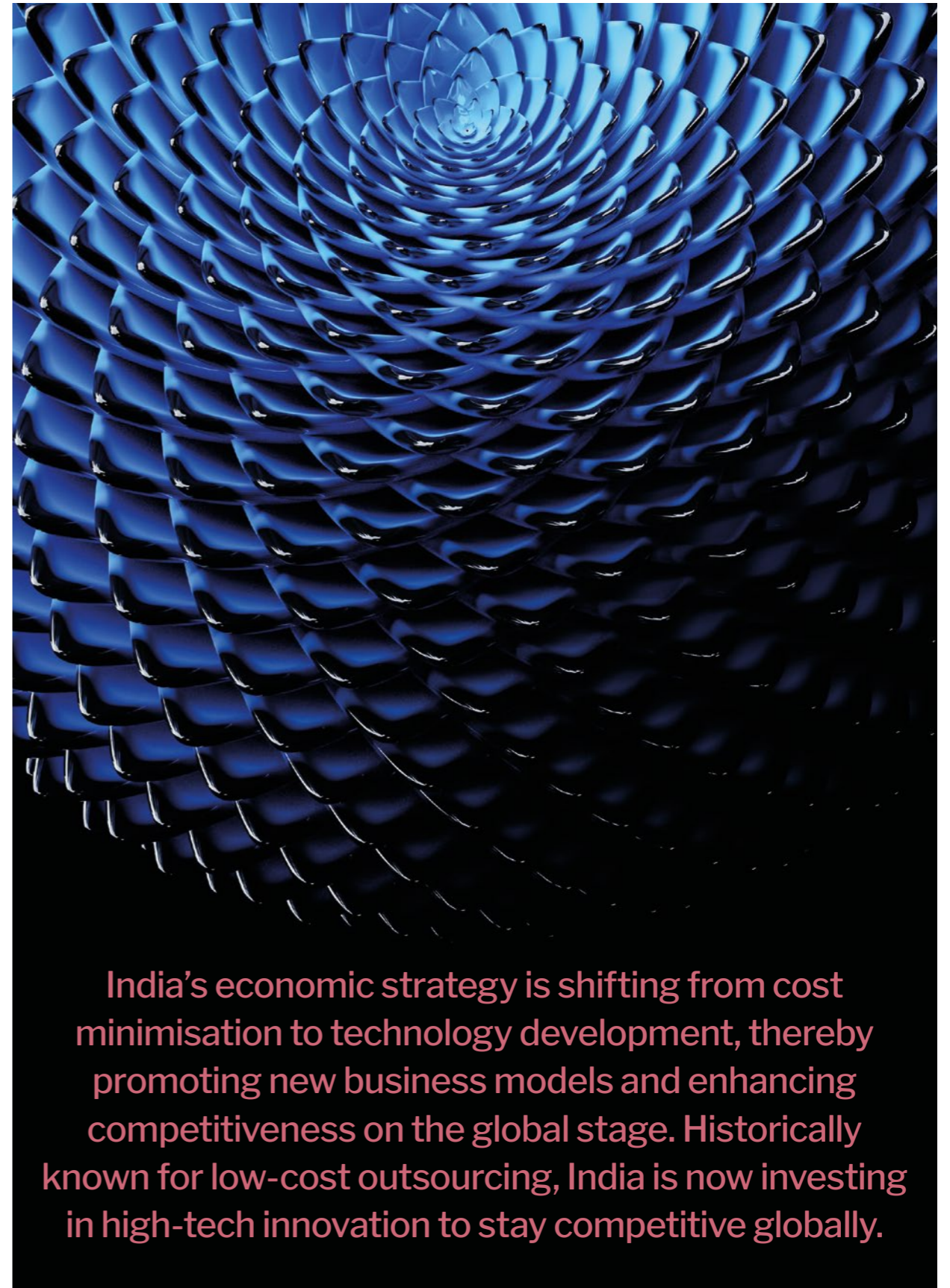
Overall, the surge in trust and adoption of digital transactions in India can be attributed to their secure nature and traceability. Unlike cash transactions, digital

transactions leave a digital footprint, making them easier to track and reducing the incidence of fraud. This transparency fosters trust in the system, thereby encouraging the widespread adoption of digital payment methods. Besides, the government's focus on digital infrastructure, including Aadhaar for identity verification and electronic Know Your Customer (e-KYC) processes, has significantly contributed to strengthening this trust.

Smartphones: Offering affordability and improved connectivity

The growth of smartphone usage in India is remarkable. Just a decade ago, only 34 million people in India had smartphones; by 2024, that number has grown to over one billion. This expansion is expected to continue, with estimates suggesting there will be 1.55 billion smartphone users in India by 2040.²²

The proliferation is driven by several factors. As disposable incomes increase, more people in India have been able to afford smartphones. The Indian government has also made significant investments in improving Internet connectivity. Some key initiatives under its Digital India Programme include the BharatNet Project, which aims to provide high-speed Internet to rural areas; the Jan Dhan-Aadhaar-Mobile (JAM) initiative for improving Internet usage; and the electronic delivery of public services to make them more accessible. These efforts have not only increased Internet accessibility



India's economic strategy is shifting from cost minimisation to technology development, thereby promoting new business models and enhancing competitiveness on the global stage. Historically known for low-cost outsourcing, India is now investing in high-tech innovation to stay competitive globally.

and improved the quality of Internet access across the country, but also made it easier for people to use their smartphones to access online content and services. Moreover, smartphone manufacturers are now offering a wide range of affordable smartphones that are well-suited to the needs of Indian consumers.

RAGING AHEAD: PROMISES AND CHALLENGES

India's digital transformation has created an environment where technological innovations can thrive. Digital infrastructural investments have multiplier effects across nearly all sectors of the economy. For instance, in finance, digital payments enhance efficiency and reduce operational costs, while in the transport sector, simplified fare transactions lead to better operational transparency. Moreover, such investments foster the creation of sustainable and efficient digital ecosystems in infrastructure and the environment. The government and society must together set the stage through policies and the promotion of digital channels to increase financial inclusion. There is a need for policies that are stable and conducive for businesses to ensure that digital financial services are accessible to nearly all individuals, thus bridging the financial gap and rapidly fostering economic growth.

The Indian government has substantially expanded its Digital Infrastructure Investment, which goes beyond the area of payment systems and fintech, to innovation across numerous areas such as

tax systems (for example, GST), public services (like healthcare and insurance), logistics, and food delivery. All these sectors have interoperability in their payment systems due to common frameworks like e-KYC and Aadhaar, which help reduce costs and enhance efficiency. This inclusive growth will allow the benefits of digital advancements to seep down to all strata of society.

India's digital journey has seen explosive growth in smartphone usage as the main tool for accessing digital services. The telecom industry's robust infrastructure, including the expansion of fourth-generation (4G) networks and the 5G rollout, ensures that digital services reach even the most remote regions, leading to a digitised nation. UPI has been a game changer for the financial sector, and India's market model, which focuses on lower prices aimed at higher quantities, aligns perfectly with the digital revolution. This approach is evident in the pricing strategy of mobile data and UPI transactions. By keeping prices low and affordable, the adoption rate increases, leading to higher transaction volumes. The government's support in subsidising digital infrastructure costs ensures that the fixed costs of maintaining systems like UPI are manageable, allowing the benefits to be passed on to consumers.

For UPI to go global, maintaining an open ecosystem is critical, as it will allow seamless integration with international financial institutions through open APIs. Looking ahead, perhaps monetising UPI through transaction charges can create the necessary revenue for continuous

improvements and technological advancements within the system. This revenue can help UPI remain at the forefront of global technology, security, and user experience. Another crucial aspect of UPI's future preparedness is recognising the potential impact of tech giants on the financial landscape. UPI's user-friendly interface has inspired tech giants like Google and Amazon to develop their products on top of the UPI framework. This trend is likely to continue and could enable these tech giants to replicate their successes in the global West, posing a substantial challenge to traditional financial giants like Mastercard and Visa.

We also note that India's economic strategy is shifting from cost minimisation to technology development, thereby promoting new business models and enhancing competitiveness on the global stage. Historically known for low-cost outsourcing, India is now investing in high-tech innovation to stay competitive globally. This shift necessitates new educational policies to create tech talent, with updated curricula in Artificial Intelligence, Machine Learning, and the Internet of Things, ensuring the future workforce is prepared for a tech-powered world. Financial innovation, particularly through digital payment modes like UPI, has significantly impacted the bottom of the pyramid by bringing financial services to the unbanked and promoting economic inclusion. The large number of unicorns in the fintech and e-commerce space is a testament to the huge potential and continued impact that digital

innovation is going to have on India. To sustain and enhance this growth trajectory, it is imperative to strengthen infrastructure, improve digital literacy, and focus on skills development. This momentum needs to be maintained through continued investment, regulatory support, and a commitment to evolving digital ecosystems. Emphasising sustainable practices will ensure that this growth is not only robust but also responsible, with innovation and sustainability going hand in hand into the future.

Finally, innovation in India, driven by intense competition, has led to significant advancements across various sectors. However, as markets mature, sustainability becomes more nuanced, with early signs of potential consolidation in sectors like ride-hailing. Similarly, the success of GPay and PhonePe in establishing dominance over the digital payments market in India indicates competition dynamics and the possibility of consolidation within the UPI ecosystem. Backed by Google and Walmart, these firms have captured early-mover advantages in the country through their user-friendly interfaces and can create less frictional payment processes. As the market matures, a more competitive and fragmented market will possibly result in strategic consolidations driven by the need for sustainable business models, regulatory challenges, and market saturation. Such consolidations can benefit from operational efficiencies, reduce duplicate competition, and direct resources to fuel technological advances and service enhancements, instead of stifling innovation. ¹⁰



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Catching the

DIGITAL WAVE

JUMBO Group shows how digital transformation and its seafood business can go together.

S

ingapore-based JUMBO Seafood restaurant was founded in 1987 by Ang Hon Nam and his nine friends, who shared “a passion for eating and seafood”. Since joining the business in 1993, his son and current CEO Ang Kiam Meng has not only expanded JUMBO to span 46 outlets across 14 Asian cities but has also made it one of the city-state’s leading multi-dining concept food and beverage (F&B) establishments.

EARLY MOVES TO DIGITALISE OPERATIONS

Restaurants are typically labour-intensive businesses that traditionally rely heavily on paper-based operations. For example, to fulfil an order for even a glass of water requires considerable paper coordination across different units in a restaurant. The order taker will pass the order to the kitchen manager, who appoints a staff to check the inventory for a glass and prepare the water. Subsequently, a waiter would take the glass of water from the kitchen and serve it to the guest. The order fulfilment information would then be recorded by the order taker, who would inform the cashier so that the payment could be received.

Order takers thus had to move around several units to register the order. Multiple data entries were

also necessary (such as on the guest order and payment system), all of which were done manually. This made the process error-prone. For example, the order taker might submit the order slip to the cashier but forget to pass it to the kitchen, making the guests wait a long time for their food. Substantial effort was hence wasted in correcting these unproductive mistakes. One way to manage this issue was to make the process paperless, enabling seamless information flow across units.

It was with this objective in mind that Ang’s project to use PDAs (personal digital assistants¹) in the 1990s for order-taking was initiated. In fact, JUMBO was one of the first Chinese restaurants in Singapore to use PDAs to manage food orders and launch an online customer loyalty programme.² Ang also automated the restaurant’s payroll function, and JUMBO became the first F&B business in Singapore to implement a fully integrated point of sale (POS) system.

Besides order-taking, monitoring and controlling backend operations (e.g., kitchen and procurement) were also difficult with the traditional paper-based approach. For a seafood restaurant chain like JUMBO, fresh seafood could account for about half the cost of operations. Yet it was almost impossible to calculate the average price of some of these stock-keeping units (SKUs), as there were multiple suppliers every day, with most simply handing over a list of items printed on a sheet of paper. If too much

seafood was ordered, the excess stock would have to be discarded. This made inventory management particularly challenging. Managers could only spot the problems, such as raw material price increases or too much seafood being discarded, in the consolidated report many days after the actual transactions. This meant that attempts at cost control were based on outdated information.

According to Ang, an ideal digital system would address these challenges. It would help to capture information accurately in real time so that managers could monitor what was happening and consequently impose tighter control over the cost of goods and sources of revenue. With every food or material item captured in the system, it would be easy to extract the relevant information and generate business intelligence. For example, examining the daily change in the average price of raw meat or the average size of live crabs would enable immediate recognition of any abnormality, alerting and enabling the managers to make necessary adjustments.

THE SECOND TIME IS THE CHARM

Buoyed by his initial successful implementation of PDAs and the POS system, the CEO, who was nicknamed “System Ang” by his staff on account of the systematic approach he adopted to run JUMBO, went on to implement an Enterprise Resource Planning (ERP) project for the company to further increase operational efficiency and productivity. Ang also obtained

financial and advisory support from Enterprise Singapore, a government agency dedicated to assisting traditional businesses leverage digital technologies for operational enhancements.

At that time, big data analytics and ERP systems were not yet commonplace.³ As JUMBO had been quoted astronomical sums for implementing a customised ERP system, the Group decided to select a vendor who quoted a more reasonable figure. Unfortunately, that did not work out, and for several years, JUMBO struggled with the implementation of its first ERP system. It had to modify its system flow and set-up considerably to cater to the ERP system, thus affecting other business processes.⁴ Besides, the methodology used then was focused on solving problems in parts. For example, procurement data only needed to show *x* number of cartons had been purchased, but in another part of the system, the data was more detailed, and the staff had to key in the exact amount of ingredients used in grammes and kilogrammes. As a result, different parts of the system yielded varying data, which resulted in data inconsistencies and a need to verify which set of data was accurate. Such problems cropped up repeatedly because the system was not sufficiently integrative.

Things eventually came to a head when Ang found that despite the best efforts of his team, the ERP system was a lemon through and through. Ang commented, “The more we tried to fix it, the more errors we introduced. The data was

inconsistent, so it was impossible to generate any useful business intelligence. It was so tiring that in the end we decided to abandon it.”

He then decided to start all over again. This time round, he and his team would have to be even more cautious and rigorous when selecting a new vendor. The optimal choice would be a system that had a solid track record. This would not be cheap, but it was a must for systematic transformation. In 2021, the Group appointed German multinational software company SAP SE to help it implement the second iteration of its ERP system. This time, Ang also paid attention to building a strong in-house team to work with the vendor and prepare for the implementation.

The project took less than nine months to complete, and the early results after implementation were encouraging. For instance, the finance department, one of the first beneficiaries of the second ERP implementation, used to struggle with completing month-end closing financial reports on time but now found that the process was much smoother. In addition, the duration for processes like stock-taking and inventory reconciliation had not only shortened significantly from one week to just a day, but important information such as inventory balance and the expiry date of stocks could also now be retrieved directly from the system.⁵ According to SAP Singapore Managing Director Eileen Chua, other benefits that had materialised included the ability to track procurement journeys and intervene ad hoc when necessary,

the cutting of revenue losses because of seasonal goods arriving late, and improved inventory accuracy due to a unified, single journal for stock information.⁶

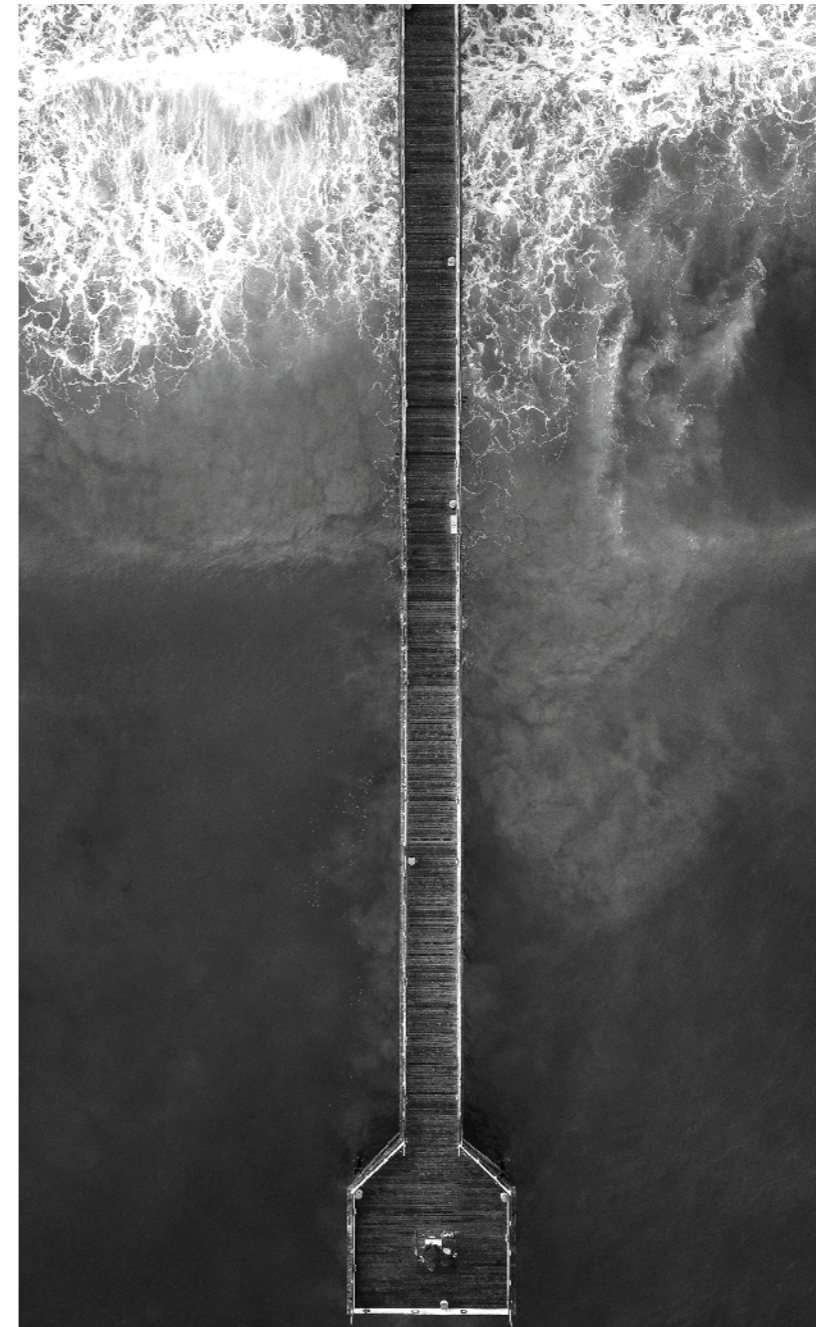
Ang added, “The use of SAP also cleared blind spots that were present when we were still using paper. Previously, staff could sometimes end up ordering materials beyond their authority level. Then when the goods arrived, we would start asking each other who ordered it and who authorised the order. But with this new system, we can instruct the suppliers that unless they receive an official purchase order, they need not act on the order. This way, we have better checks and balances.”

LESSONS GLEANED FROM THE IMPLEMENTATION

Reflecting on the outcomes of its two digitalisation initiatives, Ang believed that the methodology of the project management made the difference. Like software development, digitalisation projects should follow a four-step process model of analysis, planning, design, and implementation.

Based on his experience, Ang realised that companies had to know the tasks they needed to complete, the software that was required to conduct those tasks, and then demonstrate commitment to finishing these tasks.

First, all digital transformation had to begin with a good analysis of the ‘jobs to be done’. Any digital transformation should result in better service quality for customers. “We were lagging behind our goals of driving customer satisfaction



By 2022, JUMBO was a digitalisation leader in the Singapore F&B industry.

and delighting our customers,” said Ang.⁷ The transformation therefore had to be consumer-centric, as well as alleviate the pain points for customers, and raise customer satisfaction. This meant that the project team had to spend sufficient time upfront analysing the pain points and customer needs before moving to the next stage of system design. According to Ang, such diagnosis should take up at least one third of the total project time. In his experience, the most challenging part was when the project team exited, and the implementation stage started. If the project team had not done its analysis and design well, the debugging and troubleshooting process at the point of implementation could be very painful, like what JUMBO had experienced during its first project.

Second, the software needed to meet the company’s business needs. In its first digitalisation experiment, while a proprietary app had been developed to meet JUMBO’s unique needs, the restaurant staff found that it took too much time and resources to maintain and use the software. Quipped Ang, “I define efficiency by the number of clicks needed. If you have to click 10 times to complete a job, it’s inefficient, and that was exactly what my staff had to do when they used the app. It’s not user-friendly at all. How can my staff be productive like that?” Moreover, in Singapore, many elderly restaurant staff were, in general, not tech-savvy and afraid of new technology. Hence, for successful digitalisation to take place, the systems implemented

had to be easy for the staff to use. Otherwise, they would lack the commitment to try and use them.

Third, the entire organisation, especially top management, needed to be strongly committed to the project. Digital transformation involved a transformation of mindsets and the acceptance of different ways of doing things, which meant that many people had to get out of their comfort zone. The family-like culture in JUMBO and Ang’s lead-by-example leadership style had built a solid foundation for this. Chefs usually do not wish to share their recipes with restaurant owners as the recipes are considered their unique competencies. However, JUMBO chefs trusted the management to the extent that they were willing to share their recipes to contribute

to the restaurant’s digitalisation journey. As recipes revealed the wide range of types and amounts of fresh ingredients needed for different dishes, JUMBO could input this data into the ERP system to monitor usage and variance, preventing stockout situations and waste. This data-driven approach enabled JUMBO to better control its business costs and improve its operational excellence.

Modular yet integrated system

By 2022, JUMBO was a digitalisation leader in the Singapore F&B industry. It had digitalised its front-office operations, including reservation, meal order, table service, customer payment, and feedback collection. Ang believed that digitalising the POS function should be the first

step of digital transformation in a customer-facing business, as it stood at the intersection of other key functions and departments. JUMBO had also digitalised much of its back-office operations, including human resources (HR), accounting, and finance. The new system enabled the company to work out the bottom line far more accurately and easily as it captured the procurement, labour, and marketing costs, along with the revenues.

However, to generate useful business intelligence for management’s decision-making, these modules needed to be better integrated. Ang expected this to happen over another two to three years. The plan was to create heterogenous, best-in-class modular subsystems to digitalise

various aspects of its operational needs (POS, Customer Relationship Management, HR, procurement, finance, etc.) and deploy customised connecting software such as APIs (Application Programming Interfaces) to integrate all such modular subsystems.

Another key element in the digital system was building a data warehouse with data integrity. Accurate data, especially valuable ones like sales figures and procurement costs, would be key for decision-making. But building a data warehouse could be challenging and time-consuming as it was essentially a manual process in which employees needed to take care and commit to inputting data correctly. Besides, the system needed to have checkpoints to ensure data integrity.

Like software development, digitalisation projects should follow a four-step process model of analysis, planning, design, and implementation.

Digitalisation could enable a better understanding of customer needs, better business intelligence concerning cost control, and therefore better decision-making.

The ideal digital system would be an integrated system in which all modules were connected to the data warehouse. All stakeholders—including managers and employees—would have access to the data warehouse for different pieces of information depending on their authority and actual needs. Multiple entries of data would be eliminated and any change in data would be reflected across the entire system in real time. As a case in point, in the past, if guests were to change their order, the order taker needed to tell the chef and then update the cashier to revise the bill. In the ideal scenario, the order taker could simply change the order on a mobile app, and the chef, kitchen manager, and cashiers would be immediately informed of the update. Therefore, the information would become transparent, and transactions would become traceable.

Returns on investment for digital transformation

Ang observed that organisations hesitated to initiate digital transformation because it was capital-intensive, and the outcome could be hard to quantify. The benefit of digitalisation, he believed, was that it could enable a better understanding of customer needs, better business intelligence concerning cost control, and therefore better decision-making. As such, it was more of an investment in the company's capability for the future. For example, the system was able to inform the management how effective their online promotion (i.e., click-through rate) was and whether they should continue. It could also streamline the company's operations by predicting consumer demand accurately, enabling minimal wastage of resources while also capturing business opportunities. The HR function could enable the company to plan for the optimal number of part-time employees to supplement the workforce, which was important as there was typically a shortage of service staff in Singapore. The system also allowed relevant employees to access critical information through their mobile phones anywhere, anytime, and make decisions without delay.


Nevertheless, businesses needed to be pragmatic about digital transformation and stop at the point when diminishing returns occur. As Ang explained, if it became increasingly difficult and costly to improve another one percent in productivity or reduce another percentage point in outcome variance, it might be time to stop.

Initially, Ang hoped to implement a system that could do everything, but he came to realise that some subsystems were not as mature or cost-effective as others. In addition, forcing everyone to get onto the system was difficult. Therefore, he turned his attention to designing the system to be modular and open-ended, so that later subsystems could be integrated via APIs.

MAKING JUMBO EVEN SMARTER

JUMBO had already adopted several strategies to work its way around many of the pressing issues that plagued its business. A prominent one was its choice to use data collected through the new ERP system in a more intelligent way, giving it a stronger footing to devise how it could run its business more optimally. Ang believed that it would still take several years for the ERP system to fully yield its long-term benefits. Could the Group truly leverage the system to create data-driven operations and scale its business even further? Ultimately, he believed, JUMBO would become a smart business.

Could it eventually deploy new digital technologies like blockchains to improve efficiency at its outlets and central kitchen operations, which would be smart enough to adjust according to different scenarios? Could it perhaps leverage AI to help create more personalised JUMBO customer experiences? For example, could the system identify customers when they entered the restaurant using facial recognition technology and then prepare their preferred drinks even

before they placed their order? In addition, how could digital assets and skills enable JUMBO to expand internationally? Might it even be able to monetise its investment in the system and create spin-offs, perhaps in a tech-related field? The possibilities seemed endless. 



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For a list of endnotes to this article, please visit <https://tinyurl.com/38pufn2v> or scan the QR code below.



Riding Southeast Asia's first high-speed train between Jakarta and Bandung is a breeze. A journey of 143 kilometres (km) which used to take three to four hours by conventional railway and up to six hours by road has been cut to just 30 minutes. Built with Chinese investments and technology, Whoosh, which can reach speeds up to 300 km an hour, has been a game changer for mobility in Indonesia.

Coined by former President Joko Widodo following a nation-wide competition, Whoosh stands for "Waktu Hemat, Operasi Optimal, Sistem Hebat" (literally translated as time-saving, optimal operation, reliable system). The project, which cost US\$7.3 billion, took more than seven years to complete.

While the final costs overran the initial budget of US\$5 billion, Indonesians have taken a huge liking to the high-speed train. According to Eva Chairunisa, the general manager corporate secretary of PT Kereta Cepat Indonesia China (KCIC), Whoosh recorded 9,000 passengers per day when it began operations in October 2022 and to date has sold over four million tickets.

Daily passenger traffic has since grown by twofold to over 22,000, with 44 percent of passengers travelling between the two cities for leisure and family visits.

FROM CONGESTION TO CONNECTIVITY

Southeast Asia is betting on new urban transit systems to solve its urban gridlock problems.

"This figure underlines the important role of Whoosh in supporting and promoting the tourism sector in Indonesia," she noted in an official statement.¹

Whoosh is part of a larger Indonesian railway masterplan as the country aims to extend its railway network to over 10,000 km by 2030, an increase from just 4,814 km recorded in 2014. The increase includes over 3,000 km of urban railway and an estimated US\$52 billion will be required to accomplish the masterplan.

Such accelerated development of the country's rail network is deemed crucial for promoting economic growth, ensuring nationwide connectivity, and reducing logistics costs, which are the highest in the region.²

Other ASEAN countries are also spending big on rail networks, both between cities as well as metro lines within cities, so as to improve mobility and economic productivity.

Hanoi's Cat Linh-Ha Dong metro line, Vietnam's first and only mass rapid transit (MRT) system, has also proved to be popular, with 60 percent of its passengers noting that they used the rail instead of riding motorbikes, while 18 percent said they ride it instead of using cars.

Vu Hong Truong, general director of Hanoi Metro Company, added that after three years of operation, the metro line has served around 35,000 passengers a day, with 45 percent of them commuting to work and another 45 percent to school.³

MRT TO UNCLOG CITY ROADS

Cities such as Jakarta, Hanoi, and Manila are infamous for their traffic congestion. With little space to build new roads and highways, the MRT is thus viewed as the most viable solution to improve mobility for its residents.

Every day, more than one million cars move in and out of Jakarta as residents commute between the suburbs and central Jakarta. Such a large number of cars is one of the key contributors to the infamous traffic that clogs Jakarta's roads and contributes to its pervasive air pollution.

Many of the residents living in the greater Jakarta area, which is the second largest Asian metropolitan area after Tokyo-Yokohama with a population of 35.4 million, have little choice but to drive between their homes and workplaces, given the lack of adequate public transport.

Jakarta is not alone amongst Asian cities in facing this challenge. Public transport infrastructure has not kept up with the explosion in population growth and urban built-up areas in cities across Southeast Asia. However, that may be changing as governments accelerate the pace of their investments in public transport infrastructure.

According to Statista.com, Southeast Asia is expected to witness a significant growth in the public transportation market. Countries such as Indonesia, Malaysia, Vietnam, and Thailand are all investing significantly in railways.

Such investments will bear long-term returns. Revenue is expected

to reach US\$7 billion by the end of this year and is projected to grow annually at a rate of 2.6 percent until 2029, resulting in a projected market volume of US\$8 billion.⁴

Indeed, urban rail transit, which includes various modes of railways, is seen as the best solution to alleviate the chronic traffic congestion that plagues the roads of many Southeast Asian cities. For example, the transport system for Greater Kuala Lumpur includes an MRT, light rail transit (LRT), monorail, commuter railway, and a dedicated airport expressway.

In Jakarta, the local government has also spent heavily on the Bus Rapid Transit (BRT) system which now reaches most parts of the city. Transjakarta was the first BRT system in Southeast Asia and is today the largest of its kind in the world, supporting 11 million people who crisscross the megapolis every day.

Supported by a grant from United States Agency for International Development (USAID), Transjakarta is a showcase of the benefits of BRT for other Southeast Asian cities. Since it first opened in 2004, the Indonesian government has continued expanding Transjakarta into an enormous transit system covering 244 km across the city.⁵

Apart from investing in physical infrastructure, government policies also have a huge impact on mobility trends.

Allan Tandiono, project manager and business development director for PT KCIC, commented that improving mobility in cities such as Jakarta must involve more

than just building metro lines and improving the bus system. He noted that the government's fuel subsidies, for example, encourage people to drive while the country's large auto industry is also keen to sell more cars.

"Public transportation will continue to grow and expand as demand is greater than supply," he said. "But there are challenges such as integrating the various public transport systems as people often do not live close to stations and bus stops." He added that while fuel subsidies were critical for supporting low-income families and boosting economic growth by keeping energy costs low, such policies also encourage middle-class families to travel by car instead of using public transport. The Indonesian government spends around US\$5 billion a year on fuel and gas subsidies.

In recognition of the impact of such subsidies on both the environment as well as the state budget, the government has announced plans to reduce fuel subsidies in 2025, which could save the country US\$4 billion a year.

TRANSIT-ORIENTED DEVELOPMENTS

Given the complexity of improving mobility in large metropolitan cities such as Jakarta and the need to meet the demand for more landed housing and better living conditions, Indonesian private property players have started to build new townships which are designed around the concept of transit-oriented developments (TODs).

TODs typically include a central transit stop such as a train station surrounded by high-density mixed use areas, with lower-density housing spreading out from the centre. These developments are also more walkable, so that residents can rely less on cars.

One of the first TODs in Indonesia is BSD City, a joint venture between Mitbana (a consortium comprising Mitsubishi Corporation and Surbana Jurong) and Sinar Mas Land. Located about 30 km southwest of Jakarta, BSD is a fast-growing tech and education hub with more than 450,000 residents.

Capitalising on existing facilities, the TOD will offer access to multiple public transportation options including road, rail, and park-and-ride facilities to enhance last-mile connectivity and reduce congestion from BSD to Central Jakarta.⁶

TODs can be an effective measure to help cities solve issues that arise from growth strategies that were previously carried out. The COVID-19 pandemic has also compelled more people to forsake high-rise living in densely populated areas and opt for more landed housing in suburban areas, even if it means additional commuting time.

With many Southeast Asian cities experiencing rapid economic growth, motorisation, and socio-economic progress, new solutions will be needed to improve public mobility and lower emissions which often lead to air pollution.

Governments and the private sector are responding to these challenges by investing heavily in public transport infrastructure such as urban transit systems and innovative urban townships that are centred around green spaces and walkability, rather than being car-centric.^{AMU}



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Pigs and the City

Urban greening requires a re-look at sharing space with animals and nature.

- 1 There are several challenges when balancing urban development with ecological sustainability, as seen in Singapore's struggles with human-wildlife interactions like wild boars entering populated areas.
- 2 Opinions on managing wildlife diverge between calls for stricter population control and concerns over habitat loss. This shows the need for balanced approaches that cater to both humans and ecology alike.
- 3 Cities like Houston, Barcelona, and Hong Kong offer different models for human-wildlife management, showing that local contexts shape approaches to achieving peaceful coexistence with urban wildlife.

In the early evening of March 9, 2022, a wild boar entered Housing & Development Board (HDB) Block 846, located in the Yishun area of north-central Singapore. Things did not go particularly well during the animal's short sojourn in the housing estate. Per eyewitnesses speaking to Singapore daily *The Straits Times*, the boar was about the size of a dog. It spent a brief period meandering through a crowded pedestrian area near a cluster of ground-floor shops before colliding forcefully with a woman, who fell to the ground and was knocked unconscious. Sprinting

away, the pig rammed into a nearby shop's glass window before absconding to a patch of forest in a local nature park.

Covered extensively in local English and Chinese-language media outlets, this incident is representative of a genre of human-boar encounter that has come to figure prominently in the island's public discourse. In short: pigs find their way into spaces inhabited by humans, then injuries and mayhem ensue. An expected coda often surfaces in the news a few days or weeks afterwards, as it did in this case: the pig is reported as "humanely euthanised" by

state agents, following a period of confinement in a nearby park.

Such incidents have been invoked to make divergent arguments about Singapore's landscape and the wild animals that inhabit it. Some claim that they signal a need for more aggressive animal population control tactics, to ensure the safety of the island's human residents. Others contend that they represent compelling evidence of excessive habitat encroachment caused by relentless development. While both positions have merit, a third, more open-ended assessment is perhaps most helpful in making sense of these encounters: they (and the heated conversations around them) illustrate some of the challenges and contradictions emerging from attempts to manage cities as urban ecosystems.

BUILDING NATURE: AN OXYMORON?

The phrase "urban ecosystem" may initially read like a contradictory label. Ecology, the scientific field dedicated to the study of ecosystems, is popularly associated with verdant, undeveloped landscapes, rather than spaces dominated by the glass of skyscrapers or the concrete of HDB blocks. To many, "city" and "nature" are understood as obvious opposites.

Yet despite the common sense of these two categories standing in binary opposition, there have long been attempts at a synthesis. In the world of urban design and planning, these took on a new visibility around the turn of the

20th century with the publication of Ebenezer Howard's *Garden Cities of To-morrow* (1902). Howard's utopian vision called for a rejection of the cramped, unhealthy urban form characteristic of Industrial Revolution-era England in favour of cities organised around parks and open spaces, all accessible to the working class and wealthy residents alike.

While perhaps unfamiliar with Howard's articulation of the concept, most Singaporeans likely know the term "garden city" from their national history classes in school. In 1967, the nation's founding Prime Minister Lee Kuan Yew declared his vision of developing Singapore into a "garden city", weaving greenery into the fabric of a rapidly urbanising landscape. At his behest, the nation invested in sustained programmes of tree planting and park development throughout the ensuing decades. The aesthetic and functional effects of these efforts are readily observable, visually reducing the height of the ubiquitous concrete high-rises and providing shade for pedestrians. Indeed, they have helped make Singapore a much-touted model of so-called green urbanisation, spawning explicit imitation in cities within and beyond Asia.

Notably, the Singaporean state has officially moved two re-brandings past Lee's much-touted "garden city" approach. In 1998, the National Parks Board (NParks) reframed its goal as developing a "City in a Garden", a phrase meant to signal the state's desire to incorporate nature directly into the lives of all Singaporeans.

With the release of the Singapore Green Plan 2030 in 2021, the agency shifted its goals once again, announcing the desire to transform the island into a "City in Nature". Reviewing that plan reveals many familiar goals and methods, among them tree planting and the expansion of land area dedicated to urban parks. But its language also signals a change in emphasis, highlighting its pursuit of greenery that serves functions beyond the visual and experiential.

In this sense, the plan reflects a rising tide of interest in urban landscapes. Grounded in a growing body of research that explores the complex ecological relations characteristic of such densely developed terrain, a growing number of urban planners see cities as environments that, with careful planning, can be managed to provide a wide range of valuable ecosystem services. These include purer air, cleaner streams, reduced flooding, enhanced biodiversity, and even carbon sequestration. In such a view, strategically cultivated urban nature emerges as foundational for a thriving metropolis.

For the past two decades, cities around the globe have been adopting plans intended to maximise the ecological benefits that urban nature might provide. China's widely touted "Sponge Cities" initiative—which proposes an approach to flood management that relies on nature-based infrastructures to direct storm runoff within urban areas—is among the most prominent examples of this tendency. In both popular discourse and urban planning scholarship,

such natural infrastructure projects are frequently framed as "win-win" undertakings that support both human and environmental flourishing.

But such efforts can enable unintentionally robust forms of flourishing—that is, they support the rapid expansion of wild animal populations within the urban fabric. Natural infrastructure projects at multiple scales have been shown to provide patches of habitat for species ranging from snakes to mosquitoes to macaques. Whether loved, loathed, or feared by their human neighbours, growing populations of such non-domesticated animals are thriving in metropolitan settings, thanks in part to urban greening initiatives. The growing recognition that many such species play valuable roles in the ecological fabric of urban environments further complicates questions of how best to pursue interspecies coexistence in these settings.

MANAGING WILDLIFE'S WILD LIVES

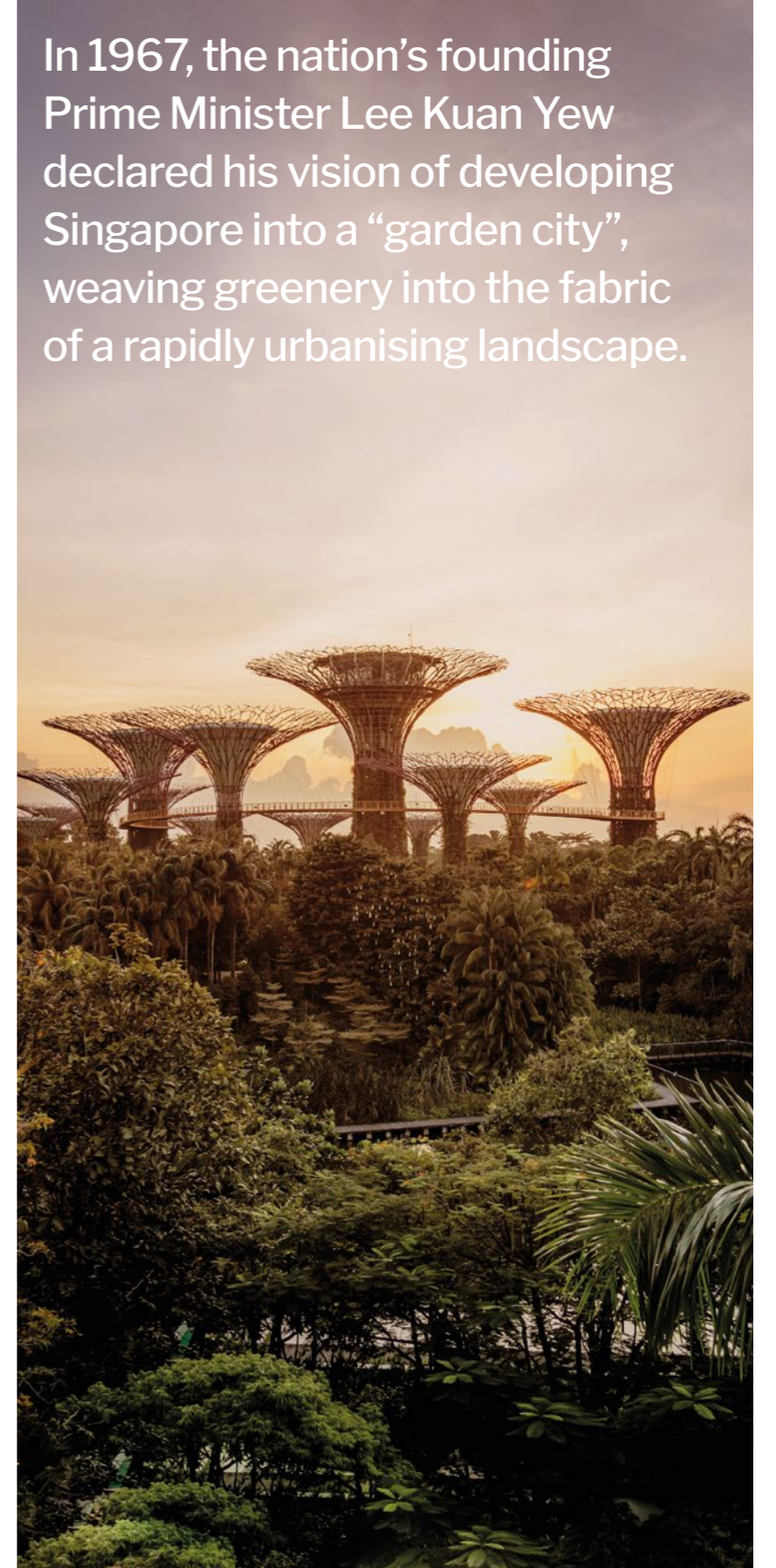
As the residents of HDB Block 846 can attest, nature—rural or urban, strategically planned or otherwise—is not always docile or predictable. And indeed, Singaporeans are familiar with many examples of unruly other-than-human co-residents across their island home. Visitors are regularly warned that local otters may be adorable but can attack viciously. Likewise, anyone who has hiked in the forests around MacRitchie Reservoir has likely been instructed to avoid eye contact with monkeys encountered

along the trails, which have no compunctions about stealing phones or food.

But wild boars (*sus scrofa*), a species native to the island, offer a particularly vivid case to consider the range of human-wildlife interactions emerging in tandem with government-led efforts to cultivate a "City in Nature". While thought to be extinct here for a period—primarily due to biodiversity surveys conducted in the Central Catchment Area in the 1990s that revealed no pig presence—by the 2000s, residents and ecologists alike were reporting boar sightings within the city's major nature reserves. The 2010s and early 2020s saw a growing number of human-pig encounters, the details of which were often breathlessly reported by local media outlets. A 2023 ecological study predicted that the species would fully "recolonise" the island within a few years.

Per ecologists, this isn't all bad news. A healthy population of wild boars can play a useful role in improving soil health and maintaining biodiversity. Their characteristic rooting practices help to break apart soil layers, enabling a wider range of plant species to thrive and create supportive environments for ground-nesting birds. But ecological problems can emerge when population of boars become too concentrated in a small land area, a common trajectory in cases where the species lack a natural predator—as in Singapore. Much of the popular concern around the species, however, focuses on the boars' complicated relationship with their human neighbours.

In 1967, the nation's founding Prime Minister Lee Kuan Yew declared his vision of developing Singapore into a "garden city", weaving greenery into the fabric of a rapidly urbanising landscape.



Incidents like the 2022 Yishun encounter discussed above serve as a reminder of both the boars' undeniable agency, and officials' efforts to manage those capacities in the name of limiting violent run-ins and bodily harm to people. Notably, NParks officials frequently state that eliminating wild boars from the island is not possible, due to the animals' prolific breeding capacity and ability to enter Singapore by swimming from nearby islands. But the officials also detail ongoing efforts to better contain the animals within naturalised terrain, to prevent them from entering crowded areas like HDB blocks. For instance, in 2023 the agency reported the construction of exclusion fencing, cattle grids, and CCTV cameras in areas around Zhenghua Nature Park, following a pair of roadside boar attacks near the park's perimeter.

Furthermore, the agency has been conducting a protracted programme of culling oil palms, a favourite food source for boars, across the island, in the interest of limiting their population. In theory, eliminating the plants will mean boars must dedicate more time to foraging, leaving less time for mating.

Despite these efforts, it is likely that the most formidable force in limiting the number of boars on the island will not come from NParks. African swine fever (ASF), first reported in pigs in Singapore in early 2023, is predicted to cause a substantial dip in the local pig population. Even so, the agency's boar containment efforts continue apace, seeking to constrain the animals' capacity to venture into the parking lots, subway stations, and sidewalks where human-hog encounters have turned bloody.

Cities across the globe are actively grappling with the human-wildlife encounters that pursuing strategic programmes of urban greening can produce.



Yet while such incidents have garnered considerable press coverage and public discussion, a close examination of the media record reveals that physical danger, fear, and attempts at containment are not the whole story of human-hog relations. Singaporean human residents have also displayed notable forms of agentive unruliness around wild boars in recent years—gestures grounded, in most cases, in a staunch sense of affection and concern for the animals.

FEEDING TROUBLE

In January 2021, four Singaporeans pleaded guilty to a crime that carries a fine of up to S\$5,000 for a first offence: feeding wild boars. The members of the quartet were among a group of eight residents charged for offering food to pigs in Lorong Halus in the final months of 2020 under the recently tightened Wildlife Act. The four who submitted pleas in January each paid S\$2,500 to the state for their illegal offerings of bread and dog food.

These much-publicised charges—which were published in *The Straits Times* alongside photos of the individuals pleading—were not the first round of punishments doled out for feeding boars. In April 2020, which was during the COVID-19 circuit breaker period, a group of residents was fined after one posted a video of feeding a herd of roughly 20 boars; the footage subsequently went viral. Notably, many of the comments left on the video were encouraging, praising the “kind-hearted” men offering the food. In a similar vein,

a 2017 *The Straits Times* article recounts the reporter observing a middle-aged woman stopping her car near the Pasir Ris bus interchange to dump a large portion of rice and canned dog food on a nearby slope. Observing the gaggle of boars that appeared to consume the offering, the woman told the reporter that she had been feeding the pigs regularly for nearly a year. “All animals have the right to live,” she stated, suggesting that her motivation was grounded in a sustained concern for the boars' well-being.

To be clear, beyond its status as a forbidden activity under Singaporean law, feeding the wild boars is discouraged on the grounds of its effects on the boars' behaviour. NParks literature states repeatedly that feeding boars draws the animals into human-dominated spaces to seek more sustenance. In effect, the agency frames the act as one that pulls pigs from naturalised spaces into more obviously urbanised ones, seeding the violent encounters that many fear. Seeking to control such feeding practices, the agency reportedly ramped up its surveillance efforts following the viral videos from early 2020. Through fines, surveillance, and aggressive public messaging, NParks seeks to cultivate a particular sort of human-boar relationship: respectful, but distant.

WILD BOARS: HOGGING THE LIMELIGHT

The ongoing struggle to realise these desired outcomes signals a challenge inherent to managing urban nature as a service-providing

ecosystem. Namely, uncertainty lingers regarding how best to achieve such relatively peaceful coexistence with fellow valued inhabitants of an urban ecosystem. Scanning the globe reveals that Singapore is far from being the only city working through this issue in relation to a wild pig population. It also shows that approaches to human-hog urban coexistence vary wildly.

For instance, the swampy US city of Houston, Texas has struggled with a pig presence for decades. In stark contrast to Singapore, gun ownership is common there, and residents are allowed (even encouraged) to shoot feral hogs in many settings (hunting in nature parks, however, is far more restricted). Such an acceptance of vigilante culling seems to have done little to limit the population, however, as the local media has reported a steady stream of attacks and property damage within and beyond city borders. Recognising the species' ubiquity, in the 2010s some city leaders pushed for a programme that transformed the animals into a nutritional resource: the meat from trapped pigs was processed and donated to local food banks. The programme is now dormant, however, due to lingering concerns about spreading disease via hog meat.

Barcelona, Spain takes a substantively different approach to its urban boars, many of whom reside in a sprawling nature reserve directly adjacent to the city. In 2013, the city hired a team of veterinary researchers from the Autonomous University of Barcelona to assist

with managing the pig population. Strategic culling is involved: the scientists conduct targeted killings, focusing on female pigs of reproductive age. But the team also works to defuse potentially tense human-hog encounters, sending representatives to the scene when alerted that a boar is entering a crowded area. By encouraging bystanders to notice and avoid the animal in their midst, the researchers help to cultivate a more peaceful coexistence.

Within Asia, Hong Kong is perhaps the city most notorious for its boar management struggles, following high-profile incidents involving pigs entering its airport complex. The stakes for pig containment there are particularly high due to the presence of pig farming on the island, and the growing fears of disease transmission between wild and domesticated hog populations, given the presence of ASF that has been detected among the former. Following a rash of pig collisions within the urban fabric, in the fall of 2021 the Hong Kong government announced a new, aggressive approach to culling the population, a programme that has been fiercely criticised by animal rights groups.

Since 2018, when wildlife management was fully folded into the portfolio of NParks, Singapore has charted something of a middle path. Agency representatives conduct occasional boar culling, particularly following violent human-hog encounters. But the organisation coordinates its responses with those of the Animal Concerns Research and Education

Society (ACRES), an animal welfare group that seeks to facilitate peaceful coexistence between humans and wildlife on the island. While concerning incidents have not entirely disappeared, far more common are benign encounters, as when weekend park-goers share grassy knolls with grazing pigs, always keeping several metres of distance between them.

Furthermore, recognising that motor vehicles pose major risks to boars and other wildlife, the city has begun to invest in 'eco-link' infrastructures, which are planted overpasses that offer animals a safer route across busy motorways. While such installations have not halted pig deaths via cars, they serve as a promising example of how the project of strategically expanding green spaces can coexist with other vital land uses, helping to sustain a range of species in the process.

CONCLUSION

As such trajectories attest, cities across the globe are actively grappling with the human-wildlife encounters that pursuing strategic programmes of urban greening can produce. The range of approaches suggests that local regulations, cultural norms, and neighbouring industries are likely to shape the effectiveness of management techniques in a given setting. But while some may feel anxiety upon reviewing such variable, imperfect playbooks for coexistence, such experimentation can also be viewed through a more hopeful lens. Creating a "City in Nature" – a goal rooted in recent advances in ecological, engineering, and

planning research – is undoubtedly a valuable and cutting-edge objective. Figuring out the complications and contradictions that such a complex environment entails would be an opportunity to demonstrate a new sort of urban leadership. ^{AMU}



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