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BLUEPAPER



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A MESSAGE FROM PROFESSOR TOMMY KOH



Professor Tommy Koh, Chairperson, Singapore International Water Week 2016 – Water Leaders Summit and Ambassador-at-Large, Ministry of Foreign Affairs, Singapore



...we must examine the interconnectivity between cities, water, and the environment to develop innovative solutions which span various sectors and disciplines. This is because in real life, problems do not package themselves neatly in disciplinary silos or ministerial sectors.



Dear Friends,

We are living through a historic transition from a rural to an urban world. It is estimated that by the year 2050, 70% of the world's population will be living in cities. This is especially so in Asia, where the migration of rural people to cities is proceeding on an exponential scale.

While the progress of civilisation has essentially transpired in cities, problems arise when governments are unable to provide adequate facilities and services such as housing, water, sanitation, transport and other urban infrastructure to make these cities liveable. The World Economic Forum's Global Risks 2015 report has identified water shortages as the biggest threat on the planet in the next 10 years, with urbanisation as the critical cause. Global warming and climate change also increases the risk of sudden, intense floods and prolonged droughts, which can further stress water systems.

Governments, industry players, academics, international organisations and communities must all come together to address these issues before they become intractable. Asian countries, in particular, need to be more insistent that their governments step up efforts to provide adequate water services. Solutions, technology and financing are not lacking – what it is lacking are political will and good governance. Sanitation issues, which are inextricably linked to water, must be resolved. Efforts should also go into moulding the public attitude towards water by, among other things, getting the price of water right.

Moreover, we must examine the interconnectivity between cities, water, and the environment, to develop innovative solutions which span various sectors and disciplines. This is because in real life, problems do not package themselves neatly in disciplinary silos or ministerial sectors. Hence, countries will need to strengthen their partnerships, collaborations and mutual learning. Public and private stakeholders, not just from the water but also from the urban planning and environment sectors, should cooperate to identify and develop solutions to our challenges. Furthermore, landmark events and documents, such as the 2030 Agenda for Sustainable Development and the Paris Agreement on climate change, have demonstrated that it is possible to convene representatives of the world, reconcile competing interests, and reach consensus.

Lastly, we need to strive towards greater social inclusivity. Brexit and the recent US Presidential election, for instance, were sobering reminders of what can happen if individuals feel that they have not benefited from economic integration or globalisation. We must provide opportunities for all members of the community to contribute to achieving progress, especially in Asian societies where rapidly ageing and young people are increasingly vocal about their opinions. Youth should also be involved in water-related discussions and decision-making processes, as they will form the next generation of water leaders.

Although the tasks ahead of us are formidable, we can draw courage and inspiration from the fact that, in the last 25 years, we have enabled 2.6 billion people worldwide to gain access to safe drinking water. We should lose no time in building on that accomplishment, to achieve, in particular, Sustainable Development Goal (SDG) 6 on ensuring access to water and sanitation for all, and SDG 11 on making cities inclusive, safe, resilient and sustainable.

This year's Singapore International Water Week (SIWW) was thus once again held alongside the World Cities Summit (WCS) and CleanEnviro Summit Singapore (CESS), to look into the nexus of water, cities and environment, and generate cross-cutting discussions. This enabled participants to explore integrated and innovative solutions, as well as business opportunities and models. The salient points of these discussions and solutions will be expanded upon in the following sections of the Blue Paper. I hope that the lessons learnt will inspire further efforts to work more closely together in overcoming our water challenges.

With best wishes,

Professor Tommy Koh

Chairperson, Singapore International Water Week 2016 –
Water Leaders Summit
Ambassador-at-Large, Ministry of Foreign Affairs, Singapore



Although the tasks ahead of us are formidable, we can draw courage and inspiration from the fact that, in the last 25 years, we have enabled 2.6 billion people worldwide to gain access to safe drinking water. We should lose no time in building on that accomplishment...



EXECUTIVE SUMMARY:

SIWW – DRIVING INNOVATIONS IN BUSINESS, TECHNOLOGIES AND SOLUTIONS

Recent milestones, such as the 2030 Agenda for Sustainable Development and the Paris Agreement on Climate Change, have set the stage for further action. The Singapore International Water Week (SIWW) was thus held from 10 to 14 July 2016, alongside the World Cities Summit (WCS) and CleanEnviro Summit Singapore (CESS). Focusing on efficient water management, advanced technologies and programmes for talent development, the SIWW attracted over 21,000 delegates from 125 countries and regions.

SIWW also saw a series of high-value and wide-ranging announcements that cemented its value proposition as a leading global platform for business match-making, practical solutions and innovative technologies. A record-breaking S\$15.2 billion worth of projects, tenders, investments and memorandums of understanding were announced. The event also witnessed the launch of PUB's Singapore Water Academy, a leading institute for learning to develop and enhance the capabilities of water professionals in Singapore and around the world.

Furthermore, this year's SIWW saw more discussions on enhancing collaborations between the public and private sectors, elevating the urban water agenda, and using next-generation technologies to address water issues. More details on the event's highlights are captured in the following sections.

A GATHERING OF THOUGHT LEADERS SHARING PERSPECTIVES

The exclusive Water Leaders Summit (WLS) gathered over 500 global water leaders from governments, utilities, international organisations, academia and the private sector, including 14 water-related ministers and chief executive officers of the world's biggest water companies. Distinguished high-level delegates included HE Mohammed bin Abdullah Al-Rumaihi, Minister of Municipality and Environment, Qatar; HE Esben Lunde Larsen, Minister for Environment and Food, Denmark; HE Dr Han Seung-soo, UN Secretary-General's Special Envoy for Disaster Risk Reduction and Water, Special Adviser to the High Level Panel on Water, and Former Prime Minister of the Republic of Korea; Dr Benedito Braga, President of the World Water Council; Peter Brabeck-Letmathe, Chairman of the Board of

Nestlé S.A.; and Charles O. Holliday-Jr, Chairman of Royal Dutch Shell PLC.

The WLS covered key issues about water accessibility, sustainability and supply resilience in cities. Delegates also discussed guiding principles to tackle these challenges, such as the importance of a long-term and forward-looking approach; leadership and governance; multi-stakeholder collaboration; developing a pipeline of talent and expertise; and innovation and technology.

Regional insights emerged from ministers and other senior officials at the ASEAN Plus Three Water Ministers Forum, where they shared their countries' initiatives to enhance sustainability and climate-resilience in water resources management, and how international organisations could facilitate such work.

The Young Water Leaders Summit gathered a select group of 90 young water professionals to gain deeper insights into water-sector careers and how they could scale up innovative projects and partnerships. Participants also had opportunities to network with senior industry experts as part of their programme.

Finally, Aqua Conversations, a flagship leadership and governance programme organised by the Singapore Water Academy, was attended by top executives and senior business leaders, providing macro views on how ASEAN, China, and India fit into Asia's overall growth, and how Asia's needs present both challenges and opportunities for the water industry.

CO-CREATING SOLUTIONS AND FORGING COLLABORATIONS

Groundwater management took centre stage at this year's Lee Kuan Yew Water Prize Lecture, delivered by Professor John Anthony Cherry, a Canadian pioneer in groundwater research. Professor Cherry was awarded this year's Lee Kuan Yew Water Prize for his ground-breaking contributions to the field's science, policies and technologies. Shedding more light on the most pressing issues in groundwater management, he emphasised the need for better education, cooperation, and appropriate technologies to tackle groundwater problems.

The Water Convention also covered the latest technology trends and solutions in pivotal aspects of water management, including supply, treatment, quality, health, wastewater management, increasing liveability and resilience, as well as industrial use. In addition, the inaugural Smart Water Forum highlighted how utilities worldwide are increasingly tapping smart systems to improve their performance, especially in planning, operations and service delivery. On the industrial front, the Industrial Water Solutions Forum continued to examine how industries can boost their water efficiency and sustainability through innovative and cost-effective solutions, with help from both the government and private sector.

To accelerate the commercialisation of technological solutions, TechXchange connected innovators with potential partners and investors to identify ways of boosting funding for promising technologies, such as project financing and multi-stakeholder partnerships. The event also highlighted the latest technological developments in key areas for investors. Aspiring water entrepreneurs were given a chance to shine. After acquiring business skills and water industry knowledge in the intensive 6-month HydroPreneur Programme, short-listed participants pitched their most promising products to the world's top water companies, venture capitalists and business executives during Hydro Pitch Day at SIWW.

Tapping the presence of the global water industry, Singapore-based company ZWEEC and the US Environmental Protection Agency announced a research collaboration to develop and implement an online toxicity water monitoring programme. PUB, Singapore's national water agency, and GE Water also embarked on a 5-year agreement to explore new research opportunities, and develop novel water treatment technologies and R&D projects locally.

UNCOVERING BUSINESS OPPORTUNITIES AND MARKET TRENDS

Over 1,000 leading companies and start-ups showcased their innovative solutions in urban development, water and waste and cleaning management at City Solutions Singapore, an integrated component of SIWW, WCS and CESS. 4 country and region pavilions – Turkey, Spain, Scotland and the EU Business Avenues in Southeast Asia Pavilion – made their maiden appearance at SIWW 2016, joining 17 other pavilions to provide a gateway for their companies to enter the growing Asian water market.

The Singapore water industry remains vibrant; the city-state announced a S\$200 million funding boost under the country's Research, Innovation and Enterprise 2020 plan to further R&D in the Singapore water industry over the next 5 years, which will bring the total amount of R&D funding committed by the government to S\$670 million since 2006. PUB also announced the development of a fifth desalination plant on Singapore's Jurong Island that would add 30 million gallons of water per day to Singapore's water supply.

The regional Business Forums distilled insights into trends, challenges and business opportunities not only in China, India, Southeast Asia, but also in Latin America. For instance, there is high investment potential in China's new projects to address its economic rebalancing and sharpened environmental focus, as well as India's drive to harness its urban development by building industrial corridors. South-east Asian and Latin American countries are also implementing policies and measures to encourage greater foreign investment in their economies.

On the thematic front, the Desalination and Reuse Business Forum underscored the strong market potential in cutting-edge R&D for making desalination and water reuse more efficient and sustainable. The first-ever Deep Tunnel Sewerage System Phase 2 and Integrated Waste Management Facility Business Forum also outlined the business opportunities in these 2 projects' key features, processes and technologies, including the water-energy-waste synergies resulting from their colocation.

Other key market opportunities announced during SIWW included an investment of S\$3.5 billion by Korea's Ministry of Environment over the next 12 years to refurbish and build new water infrastructure.

CONTINUING THE FLOW OF OPPORTUNITIES

One major refrain throughout the discussions was that our challenges are opportunities for collaboration. SIWW will continue to facilitate such connections during its next edition from 8 to 12 July 2018.

WATER LEADERS SUMMIT: CHARTING PATHWAYS TO WATER SUSTAINABILITY AND RESILIENCE IN CITIES



[From L-R] Mr Tharman Shanmugaratnam, Deputy Prime Minister and Coordinating Minister for Economic and Social Policies, Singapore; Professor Tommy Koh, Ambassador-at-Large, Ministry of Foreign Affairs, Singapore and Chairperson, Water Leaders Summit

The dramatic speed of urbanisation has been putting countries' urban water management to an increasingly difficult test. Climate change will also heighten the risk of floods and droughts, further challenging cities' ability to provide basic services such as clean water and sanitation. Moreover, cities now have to tackle other growing issues, such as maintaining social inclusion and meeting an aging society's needs.

The convergence of people, however, also offers opportunities for innovation to create liveable and efficient cities with sustainable and resilient water management. The Water Leaders Summit discussed this in the light of key issues about water accessibility, sustainability and supply resilience in cities. The following guiding principles were also developed for the pathway ahead.

ADOPTING LONG-TERM AND FORWARD-LOOKING APPROACHES

Firstly, tackling water-related issues will require patience and commitment. For instance, infrastructural projects to secure water supplies and adapt cities to the risks of climate change often have an implementa-

tion time-frame that exceeds one or two electoral terms. Investments in R&D to generate innovative solutions may also require years to pay off.

To create liveable cities, a long-term approach is thus needed in politics and governance. Governments and the private sector must prepare for the future and invest in projects ahead of time. For example, Singapore is building several desalination plants now to meet its projected increase in demand for water.

Long-term thinking also means ensuring that initiatives are self-sustaining and flexible enough to accommodate changes, and do not mortgage the future to meet short-term needs. Groundwater extraction might help meet immediate water demands, for instance, but it must be accompanied by measures to recharge the water, as is done in Denmark and Western Australia. Moreover, with the impact of climate change, Rotterdam is developing its public spaces to be part of its flexible urban water system. This includes a public square which is used for recreation during dry weather, and stores rainwater during storms to reduce flood risks. Such risk management to secure water

sources, especially against the vagaries of climate change, should be viewed as an investment, not as a cost.

In fact, scenario-planning is also more important than ever, as climate change has rendered the past an inadequate predictor of the future. Hence, scientific, economic and social uncertainties should also be factored into decisions about projects to build cities' long-term resilience, and help us better manage our future water challenges.

IMPROVING LEADERSHIP AND GOVERNANCE

To build sustainable and resilient cities, governments must also lead with policies, such as water-pricing, to encourage water conservation and funding for infrastructure which can enhance water provision and wastewater collection. Cities can also attract more investments by using new economic development models. With integrated and strategic investments, a project can yield multiple benefits. For instance, Singapore built the Marina Barrage to create a source of water supply, reduce flood risks, and serve as a recreational spot.

Countries could also consider enhancing their urban water governance in the following ways: streamlining processes by centralising responsibility for water issues under one agency or taskforce; improving accountability within the government through sharing of best practices with the public; and making it easier for firms to partner the government in tackling water issues.

Indeed, rather than relying solely on the government to drive change in the water sector, other key players in the sector can lead in different areas. For example, multinational corporation Nestlé introduced internal, differentiated pricing to better reflect its products' true water cost and encourage water-efficiency. It also prices one cubic metre of water at US\$1 in water-abundant countries and at US\$5 in water-scarce countries, to help it justify investments in innovation for greater water efficiency.

Major breakthroughs can also come from behavioural economists and behavioural psychologists, who can provide deeper insights into why some people consume water excessively, and how to encourage water conservation.

STRENGTHENING MULTI-STAKEHOLDER COLLABORATION

Given water challenges' competing demands and cross-cutting issues, the future will require stronger cooperation among the public, private and people sectors. Such collaboration increases all stakeholders' chances of discovering and implementing innovative water solutions and best practices.

For example, the Danish government actively engages companies on how they can reuse water, and introduced full cost recovery for groundwater extraction and wastewater treatment. Hence, although Denmark's economy has expanded by 80% since the 1980s, its daily water consumption has fallen by one-third to an average of 105 litres per person.

The private sector can also help develop water and sanitation infrastructure and provide water services. For instance, since the Manila Water Company took over Manila's water services from the government 19 years ago, it has delivered affordable and safe drinking water to most of the city's population, including 1.7 million people who were previously not connected to the water network.

Moreover, governments need to help citizens better understand the key aspects of water management, including the need to pay for and reduce their water consumption, as well as consider recycled water as a source of good drinking water. For example, after the Water Corporation of Western Australia built a visitor centre to educate school children and their mothers about recycled wastewater's potential as a drinkable water source, there was widespread acceptance of it.



[From L-R] Dr Joan Clos, Secretary-General of the UN Conference on Housing and Sustainable Urban Development; HE Park Won-soon, Mayor of Seoul, South Korea; Dr Judith Rodin, President, Rockefeller Foundation; Professor Tommy Koh, Ambassador-at-Large, Ministry of Foreign Affairs, Singapore; Ms Isabelle Kocher, Chairman and Chief Executive Officer, Engie; HE Mrs Laurence Tubiana, French Ambassador for Climate Change Negotiations; Mr Charles O. Holliday-Jr, Chairman, Royal Dutch Shell PLC



[From L-R] Professor Chan Heng Chee, Ambassador-at-Large, Ministry of Foreign Affairs, Singapore; HE Dr Han Seung-soo, UN Secretary-General's Special Envoy for Disaster Risk Reduction and Water; HE Mohammed bin Abdullah Al-Rumaihi, Minister of Municipality and Environment, Qatar; HE Esben Lunde Larsen, Minister for Environment and Food, Denmark; Mr Peter Brabeck-Letmathe, Chairman of the Board, Nestlé

New, innovative collaborations can also unlock original ideas, projects and technologies, secure financing to implement them, and create networks to help them scale. This is well illustrated by the Rockefeller Foundation's efforts to prevent wildfires, which are increasingly frequent in many countries due to drought. The Foundation has facilitated partnerships between non-governmental organisations (NGOs) specialising in forest restoration and private investors, to fund the NGO's mitigation work through the Forest Resilience Impact Bond. The bond raises capital from the investors to finance forest restoration. Investors are then repaid by the water and electric companies who benefit from fewer fires and a more reliable flow of water.

Moreover, multilateral financial institutions can work with governments and utilities to finance projects that help build operational capacity through technological innovation, as well as financial sustainability for enhanced water services. For example, as non-revenue water (NRW) is a serious issue in Asia, the Asian Development Bank (ADB) works with its clients to incorporate NRW-reduction methods, such as real-time monitoring for leak detection, into the design of ADB-funded projects.

DEVELOPING A PIPELINE OF TALENT AND EXPERTISE

With water challenges becoming more acute, the demand for water engineers and other professionals will rise. There is much scope within the water industry for creativity and entrepreneurial spirit to achieve greater advances in water management. It is thus also necessary to invest in developing and maintaining their capabilities and talent.

For example, Singapore's national water agency PUB has set up the Singapore Water Academy, which aims to be a leading institution for learning and building expertise for the specialised programs needed to grow the country's water sector.

In addition, more opportunities should be created for youth to interact with, learn from and share their ideas with more senior and experienced decision-makers. Young leaders, in particular, are critical to the world's future, as we can harness their energy and innovations to go beyond business-as-usual approaches. The younger generation is more comfortable with innovation and using networks as a tool to develop technologies. By organising themselves, they can urge their societies to prioritise the water agenda.

FOSTERING INNOVATION AND TECHNOLOGY FOR BETTER GROWTH

Furthermore, both the public and private sectors should invest in R&D to yield a wide range of technologies which can reshape the future and improve people's lives. Innovations should include those that can expand countries' water supply and are weather-independent, as well as those that can help individuals, companies and cities to use less water.

For instance, by investing in desalination and water-recycling technologies, Singapore has diversified its water sources to help overcome its challenge of water scarcity and ensure a robust water supply. As desalination and water-recycling require more energy compared to conventional water treatment, PUB is looking into ways to improve the energy efficiency of its processes.

Some multinational firms are also leading the way in innovation. These include Coca-Cola, which is exemplary for using less than 2 litres of water to produce one litre of finished beverage in India. Nestlé, for its part, pioneered technologies to extract water from milk to manufacture dairy products, so that its milk factories can be water-neutral.

Countries must also continue to pilot technologies which can reduce waste and turn wastewater into a resource. More resources can be extracted from wastewater, including plastic, paper, sulphur, phosphorus and energy.



[From L-R] Professor Asit K. Biswas, Distinguished Visiting Professor, Lee Kuan Yew School of Public Policy; Dr Cecilia Tortajada, Senior Research Fellow, Lee Kuan Yew School of Public Policy; Mr Ng Joo Hee, Chief Executive, PUB, Singapore; Mr Peter Brabeck-Letmathe, Chairman of the Board, Nestlé; Mr Venkatesh Kini, President, India and South West Asia, Coca-Cola; Dr David Molden, Director General, International Centre for Integrated Mountain Development

At the household level, smart home systems can enable individuals to monitor their water usage, so that they can find ways to conserve water.

Investing in technology, however, is not just about creating new ones. We must make existing and future technologies easier to use and simpler to fix, without further straining limited resources. This is crucial as small nations may lack the expertise and resources to build and maintain complicated systems. Moreover, utilities will have to grapple with the challenges of ageing workforces and loss of expertise when employees retire. Companies must thus design for service in mind, simplify their technologies and allow for training and remote distance learning opportunities, so that users are self-sufficient.

Furthermore, we need to examine the impact of regulations on innovation. Regulations often spur technological innovations, as people and firms strive to meet regulatory requirements at the least possible cost. However, regulations can hinder technology and innovation if they are applied too rigidly. Hence, regulators must identify potential barriers and how to overcome them, for example, in providing the space for smart sewer technologies and water collection, monitoring and distribution systems.



Given water challenges' competing demands and cross-cutting issues, the future will also require stronger cooperation among the public, private and people sectors. ...New, innovative collaborations can also unlock original ideas, projects and technologies, secure financing to implement them, and create networks to help them scale.



YOUNG WATER LEADERS SUMMIT: STRENGTHENING THE ROLE OF YOUTH IN THE WATER INDUSTRY



Discussion at the Young Water Leaders Summit

The huge number of young people in big cities – with around 10 billion aged 18 to 24 years – offers immense potential to transform the future. How, then, can young people help drive innovation and collaboration more effectively, to solve complex water issues? The Young Water Leaders Summit (YWLS) provided deeper insights into the latest challenges and careers in the water sector; identified innovative water projects from different regions; brainstormed ideas for scaling up innovation and partnerships; and facilitated networking between young water professionals and senior industry experts.

NOT TOO YOUNG TO BE AGENTS OF CHANGE

It is vital to include everybody on-board in tackling water challenges in order to achieve lasting innovation and impact. The 8-year-old niece Rosa of Mr Henk Ovink, Special Envoy for International Water Affairs for the Netherlands, is herself already a water ambassador in the Netherlands, which illustrates the potential of this inclusive approach. The successes in Singapore's water story were likewise not attributed only to the visionary leader, but also the innovators, planners and young engineers rallying behind the vision. Young water leaders should thus be proactive in tackling

water issues on a global scale, for example, by participating in high-level initiatives, and they had the opportunity to do so at the Water Leaders Summit.

MANY DIFFERENT PATHS IN WATER

YWLS participants also learnt about the various fields in today's diverse water sector, where they could make a difference.

Mr Booky Oren joined the water industry relatively late in his 40s. He gained varied experiences in the water industry, including Business Development in Netafim, a drip and micro-irrigation solutions provider, and as Executive Chairman of Mekorot, Israel's National Water Company. He also set up Booky Oren Global Water Technologies, pioneering the Global Water Partnership Hub which uses the "izi" (innovation to implementation) approach to promote collaboration between utilities, consulting and engineering companies, and technology vendors in order to overcome global water challenges.

Ms Zhang Lei, whose background is in law, is now the chief executive of Aquapoten, which specialises in water filtration membranes. She shared the considerations she had as she transitioned into the water sector and underlined the importance



Dr Amy Khor, Senior Minister of State, Ministry of the Environment and Water Resources and Ministry of Health, Singapore

of focus, continual training and persistence in achieving her goals. Ms Diane d'Arras, President-elect of the International Water Association (IWA), had also made a successful career shift; but within the water sector, from operations to R&D. She remarked that although change can initially appear threatening, it is often the catalyst for new and better experiences.

3 young water leaders from different backgrounds also recounted their experiences. Mr David Pong from Singapore founded WaterROAM, a water start-up that develops simple, portable, durable and affordable water filtration systems for communities in disaster-hit and rural areas. The firm has brought safe drinking water to over 15,000 people, filling the gap between existing solutions which are too bulky and slow or require constant resupply.

Ms Karmina Alejandro, Head of Social Media at Maynilad Water Services, the Philippines' largest private water solutions provider, explained how customer engagement through social media has led to high service quality and cost-efficiency. In just 3 years, she had helped halve the dropped-call rates, reduce the company's response time, and boost the acceptance rate for Maynilad's sanitation services from 30% to 50%.

Mr Adam Purvis from Scotland represented yet another path in the vast water arena. He co-founded the Metta Network and Power of Youth (POY) organisation, which seeks to introduce the world's leading water technology entrepreneurs to Indian entrepreneurs to build, mainstream and advance innovative technologies. POY's work is supported by impact investors, service providers and senior government leaders.



Mr Henk Ovink, Special Envoy for International Water Affairs, the Netherlands

EMPOWERING YOUNG LEADERS

Through the various roundtable discussions, YWLS participants distilled additional salient observations which could help them make greater contributions in the water sector:

Mindset

- Since youth are the water users of the future, they should not hesitate to become involved at all levels of policy-making for water-related plans, programmes and projects.
- If the environment is not favourable, the young should not be disheartened but should take up the leadership instead, relying on global platforms to collaborate and learn best practices.

Approach

- A successful approach would include a long-term comprehensive plan that is connected to short-term intervention, projects and investments in a process that is inclusive to all.
- An interdisciplinary methodology is critical, and complex issues should be separated into smaller ones to facilitate problem-solving.

- The Sustainable Business Model Canvas is a strategic management tool that helps develop new or existing business models by encouraging users to think beyond the product or service and consider customer needs, potential and strategic partners, and environmental costs and benefits.

Networks

- Since young water professionals can access quality, evidence-based data with the digitisation of information, they can contact experienced professionals to gain insights and share perspectives. Networking is paramount and can lead to many opportunities.
- While online avenues such as IWA Connect and LinkedIn could enable young people to establish and maintain contacts, they should strive for face-to-face meetings first for more effective network creation.
- Young water professionals need to be confident of their ideas, and express them with conviction through interactions in their networks.
- Mutual learning between developing and developed countries must be enhanced to accelerate the creation of new, innovative water solutions.



The huge number of young people in big cities offers immense potential to transform the future. ...Since youth are the water users of the future, they should not hesitate to become involved at all levels of policy-making for water-related plans, programmes and projects.



[From L-R] Mr Booky Oren, Chairman and Chief Executive Officer, Booky Oren Global Water Technologies; Ms Diane d'Arras, President-elect, International Water Association (IWA); Mr Randolph Webb, Member, IWA Young Water Professionals; Ms Zhang Lei, Chief Executive Officer, Aquapoten

GREAT EXPECTATIONS

The Marina Barrage, at which part of the YWLS was held, is itself concrete proof of what vision and determination can achieve.

Just 40 years ago, the Marina Channel and the upstream Singapore and Kallang Rivers were heavily polluted. Through unwavering political will, foresight, innovation and sheer hard work, Singapore cleaned up the rivers and built the barrage at the mouth of the Marina Channel, creating an urban reservoir, flood-control facility and lifestyle attraction in the heart of the city.

In its current focus on developing more weather-resilient and less energy-intensive pathways towards long-term water sustainability, Singapore continues to work closely with key stakeholders (such as the private sector and local universities) to invest in R&D; pursue innovative technologies; and develop diverse capabilities and talents. The results speak for themselves: Singapore now has a vibrant water ecosystem of more than 180 local and international companies and over 20 research institutes.

The water sector thus offers endless opportunities for the young water leaders, from whom we can expect great things.

ASEAN PLUS THREE WATER MINISTERS FORUM: ENHANCING SUSTAINABILITY AND BUILDING CLIMATE RESILIENCE IN WATER SUPPLY AND SANITATION

When it comes to the promise and problems of urban growth, perhaps no region exemplifies them more than the ASEAN Plus Three (APT) countries, which include Japan, South Korea and China.

ASEAN's gross domestic product has been growing annually at 4% to 6%, which could be sustained by its population growth of 1.3% per year. So far, the APT countries have supplied safe drinking water and basic sanitation to all or nearly all of their people. However, their rapid economic growth, which is mainly occurring in cities, will exponentially raise their demand for water and sanitation. The countries are also particularly vulnerable to climate change, which has already caused more floods and droughts, endangering their extensive and heavily populated coastlines and large agricultural sectors.

The APT Water Ministers Forum thus discussed various national plans to enhance sustainability and climate-resilience in water supply and sanitation, and how international organisations could facilitate such efforts.

CLOSER MONITORING OF WATER RESOURCES

The APT countries have drawn up plans to better survey and protect their water resources. For example, Malaysia's Natural Water Resources blueprint focuses on the location-based water demand of various sectors and exploration of alternative water sources, including groundwater, inter-basin water transfer and treated effluent reuse. Over the next 5 years, Malaysia will also implement an integrated riverbed management framework to safeguard the ecosystems and water quality of 25 key water basins.

On its part, Laos has developed National Water Resource Strategy 2025, to optimise the use of its water resources. It is implementing integrated water resources management to monitor the water quantity and quality in 10 priority river basins and other potential sub-river basins, and developing a water resources database at the central and local government levels.

STRENGTHENING AND EXPANDING INFRASTRUCTURE

The APT countries are also expanding and enhancing the resilience of their water supply. For instance, Singapore has invested in weather-independent water sources, such as desalination and NEWater, to diversify and strengthen its water supply. It is also extending its Deep Tunnel Sewerage System, which currently serves central and eastern Singapore, to western Singapore. This enables it to collect, treat and further purify every drop of used water into NEWater, helping to ensure water sustainability. Moreover, to tackle its flood risks more holistically, Singapore has adopted the Source-Pathway-Receptor approach. This reduces such risks not just along drains and canals ("Pathways") that carry storm water, but also in areas that create runoff ("Source"), and where floodwaters may flow to ("Receptors").

Brunei has also embarked on constructing dams, reservoirs and water treatment plants, to meet its water demand and sanitation up to 2035. Furthermore, Myanmar has been deepening and strengthening its dams and reservoirs in Yangon, its largest city, and conserving forests in its water basins to reduce evaporation. The country has also shut down 100 of its 760 wells for groundwater to conserve the water.

Ageing water pipes are getting an overhaul too. For instance, Japan has about 460,000 km of sewerage pipes, and most of them will exceed their service life in the near future. The country thus amended its Sewerage Law in 2015 to expand funding for the pipes' operation and maintenance, and for R&D in low-cost rehabilitation and reconstruction technology. South Korea will spend US\$2.6 billion from 2017 to 2028 to replace 2,950 km of pipes and rebuild 30 water treatment facilities. Malaysia, which loses 5,600 million litres of water every day due to damaged pipes, has set aside 1 billion RM to finance the identification of leaking pipes. The sum will also be used to reward utilities that have met their targets on reducing leakages, through a dollar-for-dollar matching scheme to incentivise and offset repair costs.



[1st row from L-R]: HE Dato Bahrin Abdullah, Minister of Development, Brunei Darussalam; HE Cham Prasidh, Senior Minister of Industry and Handicraft, Cambodia; Mr Sommad Pholsena, Minister of Natural Resources and Environment, Laos; Mr Masagos Zulkifli, Minister for the Environment and Water Resources, Singapore; HE Datuk Seri Panglima Dr Maximus Johnity Ongkili, Minister of Energy, Green Technology and Water, Malaysia; YB Datuk Ir. Haji Hamim Bin Samuri, Deputy Minister for Natural Resources and Environment, Malaysia; Mr Keiichi Yamamoto, Deputy Director-General, Water Resources Department, Water and Disaster Management Bureau, Ministry of Land, Infrastructure, Transport and Tourism, Japan; Mr Oh Jongkeuk, Director General, Ministry of Environment, Republic of Korea

[2nd row from L-R]: Mr Ong Keng Yong, Ambassador-at-Large, Ministry of Foreign Affairs, Singapore; Mr Bambang Susantono, Vice President, Asian Development Bank; Mr Ravi Narayanan, Chair, Asia-Pacific Water Forum; HE Vilaykham Phosalath, Vice Minister for Public Works and Transport, Laos; Mr Khin Maung Yi, Permanent Secretary, Ministry of Natural Resources and Environmental Conservation, Myanmar; Mr Kyaw Myint Hlaing, Director General, Ministry of Agriculture, Livestock and Irrigation, Myanmar; Mr Saroj Srisai, Head of Environment Division, Sustainable Development Directorate, ASEAN Secretariat; Dr Benedito Braga, President, World Water Council; Mr Ede Jorge Ijjász-Vásquez, Senior Director for Social, Urban, Rural and Resilience Global Practice, World Bank

DEVELOPING CAPABILITIES, INNOVATION AND TECHNOLOGY

The APT countries have also invested in their people, innovation and technology to enhance their expertise in addressing water issues. For example, Laos' National University will develop and offer Bachelor's Degrees in Hydrology and Meteorology. To further grow South Korea's water industry, a US\$300 million R&D centre, called the Korea Water Cluster, has been established in Daegu Metropolitan City.

In addition, Cambodia is planning to introduce mobile laboratories to test water quality regularly, and has also piloted a US\$70,000 compact water treatment system which supplies water to up to 3,900 people in a rural commune. Made from fibre-reinforced plastics, the system uses a declining plate water clarifier and gravity sand filter, with a high accurate chemical dosing system.

PROMOTING PARTNERSHIPS

Fostering partnerships between the public and private sectors is another priority for the APT countries. For instance, Japan plans to introduce a new water policy, under which river basin water cycle councils will be formed in different areas. These councils will comprise local governments, local branch offices of government agencies, non-government organisations, business and residents, to ensure that their areas' water supply and usage is sustainable. Myanmar had also formed the Natural Resources Committee in 2013 to foster closer cooperation between inter-governmental agencies and industries, in water-related activities.

Malaysia, for its part, plans to embark on an asset-light management scheme for water utilities. Under this scheme, the federal government would take over all water-related assets and related loans as the chief borrower, shielding the utilities from financial burdens so they can focus on operational

efficiency. The government leases the water assets back to the operators for a monthly rate through a lease agreement. Savings from low-financing costs will also be shared with the utilities, through lower lease rental.

While Cambodia has enough surface and groundwater to meet more than 100 times of the country's current water usage, the water is unevenly distributed, resulting in many areas in its central plains and plateaus lacking water during the dry season. The government is looking into solving this problem through partnerships with the private sector. Furthermore, Cambodia issues water licenses of 3 to 20 years to help firms secure bank loans.

In Laos, the Law on Investment Promotion allows foreign companies to own 100% of a domestic company, with no legal distinction between foreign and domestic companies. The government is also developing a framework to facilitate public-private partnerships for delivering water and sanitation infrastructure and services.

International and regional organisations like the Asian Development Bank (ADB), World Bank, Asia-Pacific Water Forum (APWF), and World Water Council (WWC), could be additional sources of finance and expertise for APT countries.

For instance, the ADB and several other organisations will establish the Urban Climate Change Resilience Trust Fund in December 2016, to help mid-sized Asian cities address their climate change vulnerabilities. The ADB also plans to double its annual climate financing to US\$6 billion by 2020, of which US\$4 billion is for addressing climate change mitigation while the rest is for adaptation. Moreover, the World Bank currently invests US\$5 billion in the Asia-Pacific, and is prepared to finance another US\$4 billion worth of new projects in the near future.

The APWF also plays a key role in encouraging political commitment to regional water security, through its Asia-Pacific Water Summits where senior ministerial figures can collaborate, renew commitments and build solidarity. The WWC is also working closely with local governments to help them to focus more on climate change adaptation, as there has been excessive emphasis on mitigation plans, which is unsustainable.



The ASEAN Plus Three Water Ministers Forum in session



Governments should focus more on climate change adaptation, as there has been excessive emphasis on mitigation plans, which is unsustainable.



AQUA CONVERSATIONS: STAYING AHEAD OF ECONOMIC CURRENTS – GROWTH IN ASIA AMIDST PRESENT DAY UNCERTAINTIES



[From L-R] Dr Beh Swan Gin, Chairman, Economic Development Board, Singapore; Ms Chloe Cho, Presenter and Executive Producer, Current Affairs Department, Channel NewsAsia

Asia is not a single market, but a fragmented one. Global and local companies that want to succeed in this arena must create solutions that address the diverse needs of increasingly affluent Asian customers.



By 2030, China, India, Japan and ASEAN are expected to be the four largest economies in the world, with a fast growing middle class. Travel to, from and within Asia will make up almost half of all journeys. With 40 to 50 million more people expected to live in Asian cities each year, the opportunities for water, energy and transport infrastructural projects in ASEAN alone could be worth at least US\$3 billion in the next 10 to 15 years.

Asia is not a single market, but a fragmented one. Global and local companies that want to succeed in this arena must create solutions that address the diverse needs of increasingly affluent Asian customers. Aqua Conversations thus examined how the rise of Asia presents both challenges and opportunities for the water industry.

SINGAPORE, A VALUED PARTNER

Singapore has established itself as a springboard to expand into the rest of Asia. The country's Economic Development Board has played a pivotal role in growing billion-dollar com-

panies, as well as anchoring large overseas businesses in Singapore. Since the mid-2000s, more companies have located their senior decision-making offices in Asia, and many international firms have set up shop in Singapore. Many businesses looking to enter the Indian market, in particular, have established a base in Singapore first.

One of Singapore's unique features is its concentration of experts across many different sectors, including water. Singapore is also the third largest producer of advanced technology, after China and the US, and receives more foreign direct investment from the US than Greater China combined.

Singapore's continued success, however, has to be alongside Asia's success. China, India, Japan and South-east Asia present many opportunities for Singapore. While Singapore's position as a leading hub may be diminished as other hubs emerge, a rising tide of trade and travel in the region will provide new opportunities. With increased intra-Asian cross-border interactions, Singapore can also further distinguish itself by focusing on specialised services, such as arbitration and dispute resolution, as it has already begun to do.



Aqua Conversations participants

ASIA: PLENTY OF ROOM TO GROW

While over-investment in China has slowed down, generating a ripple effect across the world, Asia still has high growth potential, especially for countries like Vietnam, Myanmar, and India. There is an underlying demand for goods and services in the region, despite the over-supply in some industries such as the marine offshore sector, and countries can leverage technological advances to sharpen their competitive edge.

To ensure that Asia continues on its growth trajectory, countries should also help to boost one another's economies to ensure a diffusion of growth. With the World Economic Forum identifying water crises as one of the planet's biggest threats, one way of doing so would be for Asian countries to share their best practices for mitigation and adaptation. Platforms for such exchanges include the Singapore International Water Week, which focuses on solutions, business, and networking. Asian cities also need to attract global investment to address their water issues, for instance, through private-public partnerships, although the long-term payback is not guaranteed. Initiatives to address bottlenecks in infrastructure financing might also be required, as some countries might not have the capacity to put in place the necessary infrastructure.

FOSTERING START-UPS

While firms in Silicon Valley in the US can go from being start-ups to industry leaders in the span of just a few weeks, thanks to being plugged into a network of entrepreneurs and venture capitalists with substantial resources, their meteoric ascents also present opportunities for other companies, including those in Asia. With technological advances often outpacing work on their applications, focusing on the latter could give firms a comparative advantage. Singapore start-ups, for instance, have excelled in applying technological discoveries to the medical industry.

The key is to ensure that venture capital, appropriate infrastructure, technological capability and partnerships are harnessed to foster innovation. As technological advances are put to different uses, investors can start to make profits and place bets on less mature technologies, creating a virtuous cycle.

Moreover, there are potential business opportunities in Singapore's Smart Nation initiative, which aims to harness digital technology to enhance quality of life. This can involve creating technological pilots to help companies develop innovative solutions. In the water sector, this could take the form of a cost-sharing partnership with national water agency PUB to develop technological solutions.

LEE KUAN YEW WATER PRIZE LECTURE: REVOLUTIONISING GROUNDWATER SCIENCE, POLICIES AND TECHNOLOGIES



Photo courtesy of Ministry of Communications and Information

[From L-R] Mr Lee Hsien Loong, Prime Minister, Singapore; Professor John Anthony Cherry, Distinguished Professor Emeritus, Department of Earth and Environmental Sciences, University of Waterloo, Ontario

Finding safe ways to tap into the water underground could be key to solving the world's water problems. Groundwater makes up 96% of global water resources, and about half of the world's population relies on it for drinking water. Even in dry regions, there is a supply of fresh water in the ground.

Professor John Anthony Cherry, a Canadian pioneer in groundwater research, received this year's Lee Kuan Yew (LKY) Water Prize for his contributions to the field's science, policies and technologies. His work has inspired more effective risk management in groundwater pollution control measures, as well as new groundwater remediation guidelines and approaches in several countries, including the US. His monitoring technologies and clean-up processes for groundwater contamination have also been used in the US, China, Brazil and other countries.

During the Lee Kuan Yew Water Prize Lecture which he personally conducted, Professor Cherry emphasised that groundwater is at the heart of the global water crisis, and we need better education, understanding, monitoring and appropriate technologies in this area. He is optimistic

that groundwater problems can be solved if key players, including governments and companies, cooperate and bring together the considerable knowledge and technology already scattered throughout various disciplines.

He highlighted 4 common problems with using groundwater, and some possible solutions.

GROUNDWATER CONTAMINATION

Groundwater contamination is easy to cause, lasts a long time and is difficult to clean up. Hence, prevention is a good management practice.

It often takes centuries or even millennia to flush out groundwater contaminants, with nitrate being the most common. In Canada's Prince Edward Island, for instance, a change to chemically intensive agriculture has resulted in nitrate seeping into the groundwater. In the US, nitrate contamination is caused by septic systems, where the sewage eventually dribbles out into the ground. Enhanced agricultural practices and sanitation systems are thus needed to solve these problems.

Moreover, new contaminants are increasingly showing up, especially from pharmaceutical waste. In the US and Western Canada, shale-gas development has also caused much concern. If fracking pads are not properly sealed, methane can escape and pollute groundwater.

PUMPING GROUNDWATER IN THE WRONG PLACES

Over 400 million people worldwide drink groundwater contaminated with naturally-produced arsenic or fluoride, because wells have been drilled in the wrong places or to the wrong depths. Many of these people are in Bangladesh, other parts of Asia, and Central and Latin America. More research is thus needed to find the right locations for groundwater wells.

USING TOO MUCH GROUNDWATER

Many countries, including the US, China, India, Mexico and Iran, are extracting groundwater excessively, often for animal farming. In the US, there has been massive loss of groundwater from the aquifer under California due to agriculture, and the rate of extraction is unsustainable. Apart from exhausting the water supply, over-extraction can also lead to land subsidence. Mexico City is sinking at 28 cm per year, Bangkok at 12 cm per year and Beijing at the rate of 11 cm per year. This will exacerbate other problems, such as rises in sea levels.

More work is also needed to monitor and renew groundwater sources. A key example is the Orange County Water District (OCWD) in California, which was awarded the 2014 LKY Water Prize for its groundwater management and water reclamation. Since 2008, the OCWD has been using reclaimed water, water from the Santa Ana River, storm flows and imported water to replenish groundwater.



Groundwater is at the heart of the global water crisis, and we need better education, understanding, monitoring and appropriate technologies in this area. ...Groundwater problems can be solved if key players are willing to cooperate and bring together the considerable knowledge and technology already scattered throughout various disciplines.



USING TOO LITTLE GROUNDWATER

Water poverty is the single largest water problem in the world. However, nearly one billion people, especially in remote mountains in Asia, live on hard bedrock which contains water. Some people have tapped the water by building cisterns and driving pipes into the ground, but these systems often draw shallow groundwater which has been contaminated by bacteria and viruses from human waste.

The solution is to drill deeper wells, since the water farther underground should be safe from contamination. As equipment used in conventional techniques would be too costly or impossible to transport in these areas, portable drills from the mining industry should be used. These can be taken apart, transported and reassembled, and drill into any rock and to any depth. Mexico City has had some success with this method.

WATER CONVENTION: STAYING AHEAD OF THE TECHNOLOGICAL CURVE



[From L-R] Mr Jonathan Clement, Chief Executive Officer, PWN Technologies; Mr Darryl Day, Chair, International Water Association (IWA) – Australian National Committee; Professor Helmut Kroiss, President, IWA; Professor Rebekah Brown, Director, Monash Sustainability Institute, Monash University; Mr Bruce Gordon, Coordinator of Water, Hygiene and Health, World Health Organisation; Mr Peter Nicol, President, Water Business Group, CH2M

The world's water challenges are growing and becoming more complex, but a smorgasbord of existing technologies can help to resolve them. Researchers are also increasingly focusing on integrated solutions to cross-cutting water issues. The Water Convention examined the latest technological trends in 5 key areas: Delivering Water from Source to Tap; Effective and Efficient Wastewater Management; Water for Liveability and Resilience; Water Quality and Health; and Water for Industries.

DELIVERING WATER FROM SOURCE TO TAP

Supplying good water to customers requires solutions that can improve both network performance and treatment processes. These include technologies for asset management, data analytics, desalination and water reuse. For example, utilities can prioritise capital spending by using non-invasive, acoustic methods to assess pipe segments' structural integrity and pinpoint leaks without disrupting service to customers. With sensors becoming cheaper, utilities can also deploy more of them to get real-time and accurate data to improve their operations and overall water management.

Emerging water treatment technologies, including ion exchange systems that swap contaminants in water with harmless substances, are also promising. In desalination, selecting pre-treatment technologies based on the nature of the seawater can reduce operational costs and boost recovery.

EFFECTIVE AND EFFICIENT WASTEWATER MANAGEMENT

Wastewater management innovations have focused on water reuse, sludge and anaerobic digestion, energy savings and new membranes for biomaterials. Aerobic granulation, for instance, is touted as the future standard for industrial and municipal wastewater treatment due to its energy-effectiveness and cost-efficiency. It has also been noted that plate and frame Membrane Bioreactor (MBR) systems with membrane PES materials have higher permeabilities, less biofouling and outstanding chemicals and temperature resistance. Other developments include large-scale MBRs in underground sewage treatment plants, such as the Jingxi Underground Sewage Treatment Plant in Guangzhou, which can optimise land use and reduce aeration energy demands. Moreover, full-scale wetlands constructed at the outlets of wastewater treatment plants (WWTPs) can remove micro-pollutants and protect receiving aquatic ecosystems.

Smart technologies can also be used in wastewater management, to remotely monitor, in real time, the discharge of highly volatile organic compounds into public sewers. For instance, microbial electrochemical sensors can detect heavy metals in used water immediately.

WATER FOR LIVEABILITY AND RESILIENCE

Challenges such as climate change and rapid urbanisation may require stakeholders to rethink how water systems and services are planned, designed and delivered. Some ways to enhance a city's liveability and resilience include integrating water systems within urban planning, water sensitive urban design, and using eco-efficiency tools.

For example, Monash University is developing a benchmarking tool called the Water Sensitive Cities Index, to support planning, enable governments to compare their cities' water management, and improve water-related practices. The WSC sets research-based targets, and goals include ensuring quality urban space (e.g. activating connected green-blue spaces), promoting adaptive infrastructure (e.g. multi-functional water infrastructure), and increasing community capital (e.g. response to extreme events). In the Netherlands, the Delta Programme's electronic guide helps public authorities and private stakeholders to co-create effective climate change adaptation plans for urban areas, which includes analysis of the climate-vulnerability of such measures, and spatial planning to retrofit attractive solutions.

In Singapore, the national water agency PUB's Active, Beautiful, Clean Waters (ABC Waters) programme transforms waterways into scenic recreational spaces that are integrated with their surroundings. PUB also established ABC Waters Design Guidelines to help developers and industry professionals implement environmentally sustainable ABC Waters design features in their developments.

WATER QUALITY AND HEALTH

Supplying safe drinking water and treating wastewater before discharging it are 2 of the most significant ways to protect public health and the environment. Health and water technologies have improved greatly due to more specific and sensitive research, more applications of scientific discoveries, and more comprehensive water quality management. For instance, since harmful algal blooms can cause drinking water shut-downs and recreational closures, the US Environmental Protection Agency and its federal partners developed a framework for a freshwater harmful algal bloom early warning system. In the Philippines, all drinking-water service providers must have Water Safety Plans, and an index model to evaluate the plans is in the pipeline.



Water technologies have improved greatly due to more specific and sensitive research, more applications of scientific discoveries, and more comprehensive water quality management. ...However, the innumerable chemicals in surface waters today necessitate more advanced detection methods and technologies.



However, the innumerable chemicals in surface waters today necessitate more advanced detection methods. In fact, traditional health risk assessments involving animal testing and extrapolation to environmentally relevant levels have been overwhelmed. Conventional regulatory schemes also rarely address the interaction of these chemicals. We should thus explore using bioanalytical tools to assess the safety of drinking water more comprehensively. It is also necessary to look into sensors for real-time monitoring of bacteria in drinking water systems.

In addition, groundwater resources must be protected, since rapid urbanisation increases their risk of pollution. The Groundwater Working Group from the faculty of engineering in Indonesia's Universitas Gadjah Mada, for instance, partnered industrial groundwater users to develop a self-evaluation tool for groundwater management. The system, called the Matriks Penilaian Perlindungan Sumber Daya Air Tanah, won the Water Convention's best poster award. It uses numerous parameters, such as whether there is a detailed hydrogeological study and a water resources control plan, to comprehensively assess groundwater management efforts and highlight areas where more work and technological investments might be needed.

WATER FOR INDUSTRIES

With industrial water usage second only to drinking water in terms of consumption, there is a greater need for industrial water stewardship and the 5Rs (Reduce, Reuse, Recycle, Recover and Replenish) to improve water efficiency. This is also because water sustainability is critical to business continuity and cost-reduction programmes, especially in areas where water costs are higher. Industries should thus turn



[From L-R] Mr Khoo Teng Chye, Executive Director, Centre for Liveable Cities, Ministry of National Development, Singapore; Dr Marion Savill, Executive Director, Affordable Water Ltd; Mr Darryl Day, Chair, IWA – Australian National Committee; Mr Michael Toh, Director, Water Supply (Network), PUB, Singapore; Mr Jonathan Clement, Chief Executive Officer, PWN Technologies; Dr Pascal Dauthuille, Director, Partnerships and Collaborative Projects, SUEZ; Professor Tony Wong, Director and Chief Executive, Centre for Water Sensitive Cities, Monash University; Dr Robert Bos, Senior Advisor, IWA; Dr Glen Daigler, Professor of Engineering Practice, Department of Environmental Engineering, University of Michigan

their water challenges into opportunities to develop new cost-effective and sustainable solutions.

One key method of reducing industrial water footprints is by conducting water-use reduction or reuse opportunity assessments. For instance, a bio-pharmaceutical facility combined such an assessment with water sampling, analytical testing and an engineering evaluation, including technical and economic aspects of water reuse. This uncovered ways to reduce its water consumption by 25% that had payback periods of less than one year.

Moreover, environmental discharge standards are becoming more stringent, not only for discharge of hazardous chemicals but also for nutrients and Chemical Oxygen Demand (COD). Hence, treatment processes in WWTPs should be designed according to the biodegradability of the wastewater streams, for more effective treatment. For example, advanced oxidation processes can be deployed for recalcitrant wastewater streams, and aerobic MBRs used to remove extremely high COD from pharmaceutical wastewater for reuse.

SUPPORTING THE DEVELOPMENT AND USE OF INNOVATION

Utilities tend to be conservative investors in new technology due to their existing assets' longevity, the high cost of errors in providing drinking water, and the capital cost of water infrastructure. However, utility leaders can inspire others to adopt new technologies, for example by opening up facilities for long-term demonstration tests in small-

sized pilot plants. Another possibility is to create a global organisation of the most progressive utilities to share best practices, which could be adapted to regional needs.

Governments can also inspire new uses of technology by changing how they plan for new infrastructure. Traditional planning systems are incremental and reactive, and aim to predict future conditions and resolve uncertainties. Contemporary planning, however, is visionary and proactive, exploring future possibilities rather than simply predicting the future. While this approach creates multiple scenarios and thus uncertainty, it can also lead to more robust planning and encourage governments to consider how different technologies could come into play.

Technological investments should be accompanied by efforts to manage water demand and encourage conservation. These include developing guidelines to promote non-domestic sectors' water efficiency and using behavioural economics to create sustained reductions in water consumption. For instance, a trial in South Africa found that households saved more water when they were given information about their consumption relative to their peers, compared to when they were given water-saving tips.

INDUSTRIAL WATER SOLUTIONS FORUM: SECURING WATER SUPPLIES IN CHALLENGING ENVIRONMENTS



Mr Masagos Zulkifli, Minister for the Environment and Water Resources, Singapore

Major industries, such as petrochemicals, power generation, electronics and food and beverage (F&B), rely heavily on water for their operations. Even as their water demand is rising, they face immense pressure to reduce their water consumption and wastewater discharge. This is because countries often reduce industries' water supply first during drought, and several governments have tightened their industrial wastewater discharge regulations.

Hence, industrial water end users are increasingly aware of how water issues affect their profits, and becoming more proactive in engaging stakeholders to enhance their water sustainability. In fact, the US\$52.8 billion industrial water solutions market is now one of the global water industry's fastest growing segments. The Industrial Water Solutions Forum thus examined how industries can boost their water efficiency and sustainability through innovative and cost-effective solutions, with help from both the government and the private sector.

BEST PRACTICES AMONGST INDUSTRIES ON INCREASING EFFICIENCY AND SUSTAINABILITY

There are key examples of how large water users from various industries can optimise their operations to increase water efficiency, reduce wastewater discharge, and lower costs.

In the petrochemical and chemical sectors, water is used for cooling and a key challenge is to secure a reliable, economical and sustainable source of high quality water to reduce the threat of scale build-up in cooling towers. In fact, scale removal is one of the largest components of cooling tower maintenance costs. As such, solution provider IDE Technologies has developed water treatments for cooling towers, with benefits including water recovery of up to 98%, and low energy and chemical consumption.



[From L-R] Mr Joppe Cramwinckel, Director of Water, World Business Council for Sustainable Development; Mr Goh Chee Kiong, Executive Director (Cleantech and Cities, Infrastructure and Industrial Solutions), Economic Development Board, Singapore; Mr Mel Karam, Global Head of Asset Management, KPMG International; Mr Rony Joseph Palathinkal, Vice President, Chief Operating Officer, Business Transformation and Execution, Credit Suisse; Mr Wilson Ang, Executive Director, Global Compact Network Singapore



Industrial water solutions must demonstrate low risk and generate long-term revenue for large water users. ...Sustainability reporting can also be an excellent tool for large water users to identify their key water-related risks and opportunities.



Some petrochemical companies have also enhanced their wastewater management. For instance, ExxonMobil has upgraded its wastewater treatment facility in Baton Rouge in the US to reduce its nitrogen discharge by 500 tonnes annually, while the Singapore Refining Company maximises its reuse of treated wastewater, and taps seawater for cooling.

In the F&B industry, the best practices include Heineken's use of 45 seconds instead of the traditional 2.5 minutes to clean a tank well, which reduces its products' water use per litre from 5.4 litres to 3.7 litres. The National University of Singapore's Centre for Water Research has also developed an efficient process comprising an upflow anaerobic sludge blanket reactor, a membrane bioreactor, and a reverse osmosis unit, to produce high quality water from breweries' wastewater for cooling, washing and pasteurisation processes.

However, F&B players often believe that water costs are too low to justify water recycling costs, and that the technologies to recycle wastewater are too expensive. Veolia Water Technologies has thus created a tool called the True Cost of Water, to quantify companies' hidden and indirect water costs, including their loss of operating licenses during water shortages. Quantifying such costs could help companies to rationalise recycling and water-saving investments.

In the power generation industry, the electric power sector accounts for about 40% of freshwater withdrawals. Thus, in South Africa, the state-owned electricity provider Eskom uses air instead of water to cool its coal power plant, so as to avoid worsening the country's water stress situation. In Singapore, large power generator YTL PowerSeraya meets 90% of its water needs by in-house desalinated water. This has reduced its reliance on water from national water agency PUB.

In the semiconductor industry, manufacturers need as much as 8,000 litres of water to create an integrated circuit on a 30 cm wafer. Micron's Fab 13 site in Singapore thus recycles about half of its wastewater through various methods, such as removing total dissolved solids with a double-pass reverse osmosis unit. In microelectronics production, a key challenge is to increase the fluoride treatment capacity without expanding the treatment system's footprint. Evoqua Water Technologies hence developed the Comag system which maintains the existing equipment's footprint, while improving overall treatment capacity and reducing cost.



[From L-R] Professor Asit K. Biswas, Distinguished Visiting Professor, Lee Kuan Yew School of Public Policy; Ms Cindy Havran, Global Discipline Technology Leader for Water Treatment and Reuse, ExxonMobil; Mr David Kiu, Vice President, Sustainable Business and Communications, Unilever; Mr Joel Beauvais, Deputy Assistant Administrator for the Office of Water, US Environmental Protection Agency; Ms Zita Schellekens, Director, Corporate Relations, Heineken

Other companies have also increased their business value or operational efficiency through water-related improvements. For instance, Unilever invented a device that decreases showers' water use by 25%, and a fabric conditioner that uses less water. In the Netherlands, one of Dow Water & Process Solutions' factories reuses water at least 3 to 5 times. GE is also committed to invest US\$500 million in water R&D and reduce its freshwater consumption by 1.8 billion gallons in the next decade.

Industries can also use data to enhance their water demand management. For example, in Singapore, PUB requires all large water users to submit a Water Efficiency Management Plan annually, so as to help them to better understand their water consumption patterns and identify water-saving opportunities in their premises or processes. Other PUB initiatives, such as the Water Efficient Building Certification, have also motivated companies such as Petrochemical Corporation of Singapore, Micron Technology, GlobalFoundries Singapore and Yeo Hiap Seng, to include water-efficient measures in their sites and operations to improve water demand management.

MOTIVATING MORE LARGE WATER USERS TO ADOPT INDUSTRIAL WATER SOLUTIONS

To boost further adoption of industrial water solutions, investors and solution providers will need to better understand large water users' concerns and motivations. Large water users still tend to be risk-averse and they consider many factors, such as potential disruptions to their operations, projected savings and break-even periods, before

implementing industrial water solutions in their processes or facilities. These solutions must therefore demonstrate low risk and generate long-term revenue for the large water users.

Investors can also play a key role in driving the adoption of industrial water solutions by taking large water users' water sustainability and environmental impacts into consideration when they make investment decisions. In fact, recognising investors' demand for greater transparency on listed companies' sustainability practices, the Singapore Stock Exchange has recently made it mandatory for all Singapore-listed companies to report their environmental, social and governance practices from the financial year 2018 onwards. If carried out well, sustainability reporting can be an excellent tool for large water users to identify their key water-related risks and opportunities.

Besides investors, governments can also facilitate the uptake of such industrial water solutions. For instance, in Singapore, PUB provides funding schemes which large water users could tap to offset the cost of implementing innovative water-saving technologies at various part of their processes, such as at boilers, scrubbers and cooling towers.

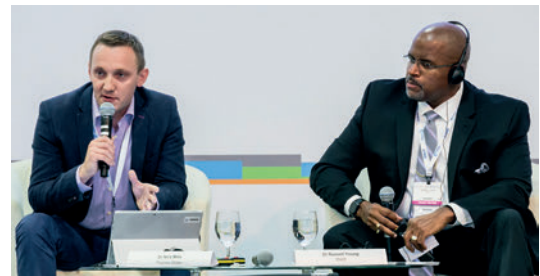
SMART WATER FORUM: MANAGING OUR WATER LOOP INTELLIGENTLY



Ms Shannon Spence, Vice President, Arcadis



Mr Michael Toh, Director, Water Supply (Network), PUB, Singapore



[From L-R] Dr Nick Mills, Head of Wastewater Innovation, Thames Water, the UK; Dr Russell Young, Global Chief Technology Officer, Hach



Utilities worldwide are increasingly tapping smart water systems to improve their performance, especially in key areas such as operations, planning and service delivery. ...Such systems also need protection against both accidents and miscreants.



Smart water systems collect, process, analyse and act upon data in real time, resulting in greater efficiency across the entire water loop – from watershed management and water treatment to water distribution networks and cyber security. The Smart Water Forum looked into how utilities worldwide are increasingly tapping such systems to improve their performance, especially in key areas such as operations, planning and service delivery. By 2025, about 80% of utilities in advanced cities and half of the utilities in developing cities are expected to have such systems, according to the McKinsey Global Institute. The growing global market of smart water grid systems alone could rise in value from US\$14 billion to US\$25 billion.

SMART WATERSHED MANAGEMENT

One example can be found in the Netherlands, which maintains numerous dykes and pumping stations daily as it is below sea level. The Delfland Regional Water Authority is developing smart watershed solutions to keep such installations safe and secure, such as an extensive one-stop information portal which contains data on the installations' operations. Delfland is working with the University of Delft to improve the system. One such upgrade will allow stakeholders to get more precise information on specific locations' operations at short notice, especially during emergencies.

In Singapore, national water agency PUB uses robotic swans to complement its online monitoring system for large-scale watershed management. The swans monitor different physical and biological parameters in Singapore's freshwater reservoirs to provide real-time water quality information more quickly. This allows PUB to react to cases of outbreak or contamination more swiftly, compared to the previous time-consuming approach of using manpower to collect samples. To manage storm water, PUB also uses CCTVs and image analytics to monitor silt discharges at construction sites. It also correlates information from water-level sensors and flow meters to provide timely alerts and support drainage operation and planning needs.

SMART WATER TREATMENT

To improve water treatment processes, the UK is adapting old infrastructure with newer and smarter control systems. For example, Thames Water installed a Real Time Control (RTC) system which significantly reduced its energy use and operational expenses by identifying inefficiencies in its wastewater treatment. RTC systems can also be used to deepen staff's understanding of operations in wastewater treatment plants, including how various systems are related.

Based on the utility's experiences, savings from RTC installations usually offset their costs in less than 2 years, assuming that a certain level of infrastructure already exists. If such infrastructure is absent, more time will be required.

SMART WATER DISTRIBUTION NETWORKS

With sensors becoming smaller and cheaper, utilities can deploy and link them into a smart water monitoring grid that requires minimal human intervention. Data analytics can help make sense of the vast amount of data from these sensors. In Singapore, PUB manages the entire water network as a system, including its design, operation and maintenance for 24/7 water delivery. PUB thus developed a comprehensive smart water grid with 3 main objectives: asset management, promoting water conservation and providing good customer service.

The grid uses more than 300 wireless sensors in the water mains to collect data on real-time pressure, flow and water quality. Risk assessment and predictive software tools help identify the top 2% of high-risk pipelines for replacement annually. An online leak detection system monitors critical large mains for leaks, locates them to within 10-metre accuracy and alerts operators within 24 hours of the leak forming. Moreover, an automated meter reading system monitors and collects domestic water consumption data continuously, while home water management systems inform residents about their usage patterns and alert them to possible leaks and over-consumption. PUB also remotely monitors the water consumption of Singapore's top 600 commercial and industrial customers, and plans to develop water efficiency benchmarks and good practice guidelines for different sectors. In addition, PUB is looking into sensors for quicker and more accurate detection of contaminants, better data analytics to filter out false alerts, and batteries to match the smart meters' 15-year lifespan.

On its part, Macao Water Supply has implemented an oversight system called Aquadvanced, which monitors consumption data collected from Macao's water network and alerts customers and operators to abnormalities. The system is easy to navigate and facilitates follow-ups after an abnormal event. For example, numerous staff might trace the reason behind an unusually high flow-rate, but their different clearance levels mean only certain users have the authority to confirm and/or close events. User profiles are divided in the system for greater management and organisation.

In Malta, the Water Services Corporation (WSC) installed an automated meter management system, using technology from SUEZ Smart Solutions, to improve its network performance. With the system, WSC can keep an eye on the water network, carry out more efficient and pre-emptive maintenance, warn customers early about possible leaks, improve its analysis of water consumption behaviour, and reduce water theft. WSC also plans to develop reports and software to analyse data from smart meters.

SMART SECURITY

Smart water systems need protection against both accidents and miscreants. Such systems have considerably fewer security measures compared to normal Infocomm Technology (IT) systems, and the security features of the regular IT world cannot be translated to operations technology. In IT, confidentiality is the main priority, while in operations technology, availability is key. Vital information must be protected while allowing access to those who need it. If operations systems are breached, water systems cannot be simply shut down.

For instance, the Delfland Regional Water Authority is looking into enhancing the security of online data about its many critical installations, as it has been hacked about 10 to 70 times per second for information about its sluice gates alone. Both sensors and the cloud that they transmit data to must be encrypted, as hackers could exploit vulnerabilities at either end of the system.

Another key example is the Puerto Rico Aqueduct and Sewer Authority, which continuously monitors the security of its network, telephony and data centre systems, and undertakes periodic vulnerability assessments and penetration tests to address threats of internal attacks. It has different security clearance levels for different employees, and every path through the telemetry system goes through a firewall.

However, strengthening cyber security involves not only technical solutions, but also staff training on how to use such solutions. An employee with a USB stick can easily destroy the best firewall and hardware. Staff must also be able to identify frauds and follow protocols on when they can and cannot share information.

TECHXCHANGE: WORKING TO QUENCH THE WATER SECTOR'S THIRST FOR INVESTMENT



[From L-R] Dr Steven Kloos, Partner, True North Venture Partners; Dr Reinhard Hübner, Investment Director, SKion GmbH; Mr Trevor Hill, Chief Executive Officer, Fathom; Mr Adam Lovell, Executive Director, Water Services Association of Australia; Mr Piers Clark, Chairman, Isle Utilities

The world's growing water challenges are boosting demand for more sophisticated and innovative technologies. With the water sector still viewed as a risky market, however, how can such technologies garner greater investment? TechXchange highlighted some of the water industry's latest technological developments, and how solutions could be better positioned to attract financing.

TECHNOLOGIES BREAKING NEW GROUND

Some key areas which offer opportunities in potentially game-changing solutions include water quality monitoring, leak detection, and energy-efficient wastewater treatment. While investors can help water technology start-ups to bring their solutions to customers, innovators must do their part by developing business models to scale their systems and operations, and deliver returns on investments.

For example, Vienna Water Monitoring, an Austrian firm, developed a series of fully automated devices called ColiMinder, which provide real-time measurements of microbiological contamination from ultrapure to sewage water samples. The devices identify contaminating organisms through their

enzymatic activity. The continuous measurements take just 15 minutes, and the results are put online to alert operators to potential trouble. ColiMinder's applications thus include tracking the drinking water quality in disaster zones and the quality of water discharged from treatment plants. It also won the TechXchange Industrial Innovation Competition in both the judges' and people's choice categories.

To help water utilities detect leaks more effectively, companies could develop solutions using the Internet of Things software and smart data. For instance, Israeli start-up Utilis has devised a system to detect pipe leaks from space. By processing satellite images with a patented set of computer algorithms that identify drinking water, Utilis locates underground leaks without requiring utilities to install software or hardware at their facilities. The result: leak detection that covers thousands of square kilometres. The company also generates the reports in a user-friendly Geographic Information System format, with information about the leaks' locations and sizes overlaid on a map. Utilis has successfully managed numerous projects worldwide, including the US, South America, Australia, Europe and Israel. It thus won the TechXchange Municipal Innovation Competition.

One traditional method of treating wastewater uses micro-organisms to break down and digest waste. However, micro-organisms need oxygen to do so. Thus, utilities typically use an energy-intensive system to pump air into treatment systems. There are hence potential investment opportunities in new membranes for water reuse and treatment which are more sophisticated, cost-effective and reliable.

OxyMem, an Irish company, thus developed a method to introduce the oxygen that can lower energy costs of the conventional wastewater treatment plants by up to 75%. OxyMem uses a series of hollow tubes made of gas permeable silicon membranes to transfer the oxygen to the micro-organisms. This method is less energy-intensive, more resilient, and lowers sludge production by 50%. OxyMem was the TechXchange People's Choice Winner of the Municipal Innovation Competition.

BOOSTING SUPPORT FOR INNOVATION

Investment in the water sector requires patience, as technologies may take 10 to 15 years to develop from basic study to full-scale implementation. Investors seeking shorter-term commitments may consider project financing instead, which involves funding a company with an innovative technology to take on small-scale projects. Such support is more of a loan for the company to execute the projects, and the investor typically does not take an equity stake in the firm.

Multi-stakeholder partnerships are also important in developing new water technologies, and encouraging greater adoption of their inventions through reducing or managing the risks involved. For instance, to meet current and future water challenges, and grow Singapore's water sector, national water agency PUB works with the industry to develop the next generation of solutions. This includes providing funding support and test-bedding opportunities to help transform innovative ideas into successful products or technologies.

Another example is WaterStart in the US state of Nevada, which is a public-private joint venture that identifies the technological needs of its partners, including utilities and the hospitality industry. It then recruits firms with potential solutions, and offers them expertise and funding to develop their products. Furthermore, it organises state-wide partners to establish test-sites for new water technologies.



Discussion at TechXchange

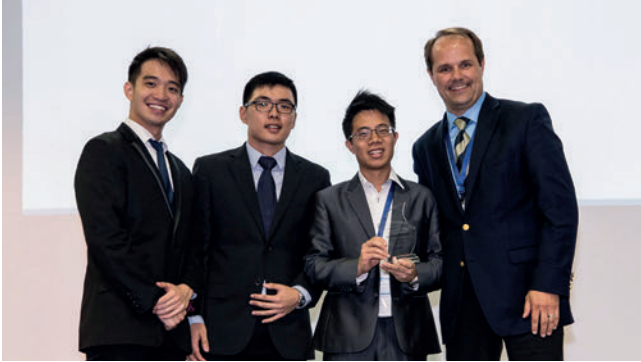
In the UK, engineering consultancy Arup has partnered WRc (a centre of excellence for innovation in the water, waste and gas sectors), to develop the Venturi online portal which aims to spearhead innovation adoption water industry. Venturi is a platform where end-users can publicise their challenges and companies can showcase their solutions. Based on insights from key players including water utilities, suppliers, regulators and investors, it also offers advice on risk-reduced processes for developing technologies, from inception to commercialisation.



While investors can help water technology start-ups to bring their solutions to customers, innovators must do their part by developing business models to scale their systems and operations, and deliver returns on investments.



HYDROPRENEUR PROGRAMME AND HYDRO PITCH DAY: SPEEDING UP THE MOVE FROM LAB TO MARKET



[From L-R] Mr Lim Chong Tee, Chief Marketing Officer, WaterROAM; Mr Vincent Loka, Chief Technical Officer, WaterROAM; Mr David Pong, Chief Executive Officer, WaterROAM; Dr Steven Kloos, Partner, True North Venture Partners

Even the best water technologists might need a little help to bring their inventions to market. Indeed, the commercialisation of water technology needs the continual support of multiple stakeholders, such as investors, incubators, utilities and water companies. The 6-month HydroPreneur Programme (HPP) was thus established to impart business skills and water industry knowledge to aspiring entrepreneurs.

The intensive HPP training programme was developed with strong support from its partners such as enterprise development agency SPRING Singapore, technology transfer office National University of Singapore (NUS) Enterprise, and investor True North Venture Partners. Key features included market validation activities, an investment pitch workshop and sharing sessions by successful water entrepreneurs. Water industry experts were also at hand to provide guidance and advice to participants.

During the HPP, participants also underwent a 10-week Lean LaunchPad (LLP) training programme organised by Singapore's national water agency PUB and NUS Enterprise. The LLP process helps researchers turn their inventive technologies into commercially viable products and feasible business ventures. HPP finalists then presented the following technologies to the world's top water companies, venture capitalists and business executives on Hydro Pitch Day at the Singapore International Water Week.

INNOVATIONS IN MEMBRANES

Thanks to its ROAMfilter Plus system, Singapore-based company WaterROAM won the Most Investment Potential award. A lightweight and portable water filtration device that works like a bicycle pump, the ROAMfilter utilises an integrated ultrafiltration membrane system design with a proven durability in industrial settings. This system can produce 250 litres of clean water per hour, weighs just 4kg, and has a replaceable membrane cartridge which can last 2 years. It can thus deliver clean water quickly to disaster zones and rural areas, and is easily scalable as it uses simple and affordable materials. WaterROAM's filters have given over 15,000 people in Cambodia, Indonesia and Malaysia access to clean drinking water.

Other technologies presented during Hydro Pitch Day could also spell dividends for the use of membranes in wastewater treatment. A team from Nanyang Technological University (NTU)'s Singapore Membrane Technology Centre (SMTC) has developed a technique called Evapo-Porometry for more accurate monitoring of membranes' pore sizes, which can shrink over time as filtered contaminants clog the pores. In addition, to mitigate fouling and increase the permeation in membrane bioreactors, another team from NTU's SMTC has come up with the Inverse Fluidized Bed (IFB). This technology exploits inexpensive buoyant particles and foams, by a judicious manipulation of the module geometry, to scour membrane surfaces repetitively. The IFB thereby replaces conventional aeration, which cannot be used in anaerobic processing, and offers a hefty 75% reduction in the cost of energy consumption.

The Environmental and Water Technology Centre of Innovation at Ngee Ann Polytechnic has also been working on multi-bore membranes. Compared to conventional single-bore hollow fibre membranes, these are more affordable, robust, and offer a larger contact area and faster de-oxygenation rates for wastewater treatment. Moreover, they have improved applicability for pond water.

FUSS-FREE WASTEWATER TREATMENT

The Most Disruptive Technology award went to the Centre for Water Research at the NUS, for its work on an emerging Advanced Oxidation Process (AOP) called Electro-Fenton. The team's invention degrades a wide variety of contaminants, turning 99.9% of the pollutants in non-biodegradable wastewater into simpler and harmless substances such as carbon dioxide and water. Unlike some wastewater treatment processes, it also produces virtually no sludge, has an easy plug-and-play set-up, and uses electricity instead of chemicals, making it more affordable and environmentally-friendly.

THE TOXIN TESTER

BacLum, a new technology that detects toxins in water through genetically modified bacteria, earned Singapore-based firm Biosensorix the Rising Hydropreneur Star award. The bacteria produces light in the presence of toxic material, with the light intensity varying according to the level of toxicity. The technology has been proven in the laboratory, and Biosensorix's goal is to develop a handheld monitoring device (BioPen) and an online system (BioFlow). Both systems will be highly scalable and use disposable cartridges containing the firm's proprietary BacLum bacteria.

A STRONG START

All of the teams which took part in Hydro Pitch Day 2016 already have at least one provisional patent each. By bringing their inventions to market, they can not only reap economic value for their investors and inventors, but also benefit consumers. It is thus hoped that these teams will go on to enjoy greater success, like some HPP 2014 participants which included Singapore-based companies WaterROAM and Eco-softh. For instance, to enhance rural residents' access to clean water, Eco-softh integrates different technologies and processes into a single platform for more effective decentralised water management. The company has also implemented over 250 projects worldwide.



Mr Chua Soon Guan, Deputy Chief Executive (Policy and Development), PUB, Singapore



[From L-R] Dr Steven Kloos, Partner, True North Venture Partners; Mr Theron Madhavan, Chief Operating Officer, Flagship Ecosystems Pte Ltd



The commercialisation of water technology needs the continual support of multiple stakeholders, such as investors, incubators, utilities and water companies.



CHINA BUSINESS FORUM: CHINA'S NEW NORMAL – BALANCING ECONOMIC GROWTH, LIVEABILITY AND ENVIRONMENTAL SUSTAINABILITY



[From L-R] Dr Liu Thai Ker, Chairman, Centre for Liveable Cities Advisory Board, Singapore; Mr Tan Cheng Guan, Executive Vice President and Head, Group Business Development and Commercial, SembCorp Industries; Ms Chen Shankun, President, Guangdong Environmental Sanitation Association; Ms Zhang Lei, Chief Executive Officer, Aquapoten; Mr Zhou Jun, Executive Chairman, SIIC Environment Holdings Ltd

China's transformation over the past 60 years from an agricultural society to an industrial society has increased its gross domestic product (GDP) per capita by 50 times, lifted 600 million of its citizens out of poverty, and improved its people's average life expectancy by 11 years. In the next decade, China will also have more than 400 million people entering the middle income group. Though now facing a seemingly inevitable economic slowdown, the Chinese government has set goals to steer the country towards a new stage of development.

Over the next 5 years, economic reform along with sustainable and inclusive growth are top priorities to help the country achieve its targeted annual GDP growth of about 6.5%. Besides China's shift from low-value to high-value manufacturing and plans to develop its service industry, there is also growing recognition from the government that water and environmental sustainability can enhance quality of life and spur national progress. The country's rapid urbanisation presents opportunities to develop green, sustainable cities, and improve water management to meet the projected increase in water demand.

The China Business Forum thus examined the high investment potential in China's economic rebalancing and sharpened environmental focus, with several policy shifts to support new projects which will power China's next stage of growth.

SHAPING THE MOVE TOWARDS HEALTHIER ECONOMIC DEVELOPMENT

One of China's most promising developments is the Belt and Road initiative, which will span 65 countries and 4.4 billion people, and could be worth RMB 21 trillion dollars in trade. The project aims to integrate the region into a cohesive economic area through cultural exchanges and infrastructural projects in key industries, such as high-end equipment manufacturing and information technology.

China's industrial growth is balanced by new goals and stronger enforcement plans in environmental protection. For instance, all industrial parks must have centralised wastewater treatment plants by 2017, and all wastewater must be treated before it is fed into the centralised facil-

ities. Online monitoring systems must also be installed at the parks by 2017, and there are new discharge standards for the petroleum, petrochemical, synthetic resins, inorganic chemicals and metallurgy industries.

The government's Water Ten Plan (or known as the Water Pollution Prevention and Control Act) will also boost GDP by around RMB 5.7 trillion. Some focus areas include soil remediation, valley water treatment, and treatment for industrial and municipal wastewater.

Provinces in China are also playing their part. The Guangdong province has about 600 landfills and 188 incineration plants. The local government thus aims to use refuse incineration as an energy source, and categorise at least 90% of the province's waste before it reaches the refuse collection point, to aid in recycling efforts. Moreover, while the current redevelopment of an old town in Xiamen is in response to citizens' desire for an improved living environment, Xiamen's local government will also focus on preserving the city's culture and old buildings.

A SECTOR AWASH WITH INVESTMENT OPPORTUNITIES

Given the government's plans to improve the country's water and environmental infrastructure, there are many investment opportunities in China. For example, SIIC Environment Holdings Ltd, a leading firm in China's environmental industry, has projects across 15 municipalities and provinces, including over 80 water treatment and supply projects with a total capacity of more than 7 million tonnes per day, as well as 3 waste incineration projects at a total design capacity of more than 3,200 tonnes per day.

Moreover, Sembcorp's Nanjing International Water Hub, slated for completion in 2018, will facilitate the commercialisation of water technologies and guide firms in breaking into the Chinese market. Admittedly, there are challenges for new entrants into China's water industry, including the need for track records, funding, networks, and market understanding. Still, investors would be wise to look into the sector: China's water market is the world's largest, with a CAPEX of US\$300 billion from 2016 to 2020 and a CAGR of 7.4%.



Mr Khoo Teng Chye, Executive Director, Centre for Liveable Cities, Ministry of National Development, Singapore

 China's rapid urbanisation presents opportunities to develop green, sustainable cities, and improve water management to meet the projected increase in water demand. ...Investors would be wise to look into its water sector: China's water market is the world's largest.



INDIA BUSINESS FORUM: THE CHALLENGE OF INDIA'S INCLUSIVE GROWTH – DEVELOPMENT ASPIRATIONS AND INVESTMENT OPPORTUNITIES

India is one of the largest economies today, with a gross domestic product (GDP) of US\$8 trillion when purchasing power parity is taken into account – the third largest in the world. Its economic growth has been fuelled by its urban centres, which contribute two-thirds of its GDP and 90% of its government revenue. India's rapid urbanisation in recent years is set to continue – over 200 million people in India are expected to move to its metropolises during the next 20 years, boosting its urban population to a projected 600 million by 2030 and 800 million by 2050. The 3 "mega cities", Delhi, Mumbai and Calcutta, already contain more than 10 million people each. The India Business Forum hence looked into initiatives to tap the investment opportunities in India's urban development.

INDIA'S KEY CHALLENGES

While India has a young and skilled workforce and many infrastructural projects in the works to meet the demands of urbanisation, key challenges lie ahead. For instance, its economic growth is expected to occur in a few urban clusters, but much of its urban landscape still lacks basic services and infrastructure. The urban infrastructural challenges in housing, transport, health, power, water and sanitation will thus be enormous.

Moreover, a large amount of funding for projects has gone untapped due to the lack of feasible business propositions. According to the Asian Development Bank (ADB), which has loaned US\$1.6 billion to help build the urban infrastructure for 101 towns and cities in India since 1995, such projects come with many problems. These include the need to acquire land and relocate existing utilities, and delays in implementation. Hence, strong state and city-level entities are needed to supervise the execution of such projects.

The challenges, however, also contain much investment potential. India's rapid urbanisation will unlock a plethora of opportunities for real estate development, which could be the single largest source of funding for city development.

HARNESSING INDIA'S URBAN POTENTIAL

To address its huge infrastructural needs, India is developing "smart cities" which will create much potential for investment. Smart cities are not only about technological innovation such as sensors, networks and analytics. They also require

governance, master-planning, institutional reform, prudent financing, and close partnership between international bodies, national and municipal governments, and private companies.

Urban development should be guided by clear goals at the outset, including feasible business proposals, measures to encourage citizen productivity, and the use of public spaces to improve the quality of life. The following 9-step economic framework can help to develop the new cities:

1. Vision for City
2. GDP and Job Creation Plan
3. Asset Class Mix
4. Phasing of Development
5. Infrastructure
6. Anchor Tenant Attraction
7. City Operations
8. Softer Elements
9. Financial Model and Funding Strategy

The technologies that must be developed, tested and implemented, and the institutions to be established, will be manifold and well beyond the scope of any single government body or private corporation. Cities might consider adopting a consortium approach, where a lead entity would oversee the entire project and be accountable for its successful implementation. This will also allow for an integrated tender system which can be examined at the consortium level, encouraging more companies to work together. Investors in India could thus reap enormous returns, if they are patient and persistent in their endeavours.

WATER: THE KEY TO ECONOMIC PROGRESS

To accelerate economic development, India must tackle its water constraints. This is also because industries are likely to congregate in areas where water is available and water management is efficient. For instance, Cisco, which manufactures information and communications technology products in India, would require 17 to 40 litres of water to optimise a single switch or router which handles 50 to 100 terabytes of data.

The Indian government is therefore focusing on reforming the water sector, which will include ensuring 100% household pipe connections, 24/7 water supply and managing wa-



India is developing "smart cities" which will create much potential for investment. Smart cities are not only about technological innovation such as sensors, networks and analytics. They also require governance, master-planning, institutional reform, prudent financing, and close partnership between international bodies, national and municipal governments, and private companies.



ter demand through metering. For the first time, the country has developed a comprehensive and integrated water resource plan for some of its new cities. It will work towards recycling used water, and a study has shown that its efforts will enable it to replenish its aquifers.

In addition, sustainable reforms in cost recovery and operational maintenance are needed. For example, state-level entities that currently operate and maintain the water supply should be replaced with new Special Purpose Vehicles. The latter can raise funds not only from multilateral organisations like the ADB, but also from the market, so they can more easily finance the rehabilitation, upgrading, maintenance and expansion of the water supply. Periodic revisions to water taxes and metering will help to ensure sufficient investment from the private, institutional and multilateral sectors. Moreover, investments in technology will help to improve the entire water loop, including water sources and distribution. For example, Supervisory Control and Data Acquisition (SCADA) systems and smart water meters can reduce pipe leaks and non-revenue water.

THE CHENNAI SUCCESS STORY

Chennai is a key illustration of how cities can brighten their economic prospects by transforming their water sectors. It is normally a water deficit area that relies mostly on its 5 reservoirs for water. In recent years, however, it has ramped up its water supply from desalination, which now contributes 16% of its supply.

Furthermore, the government has completely mechanised the cleaning of sewerage systems through suction and de-silting machines in the city, mandated rainwater harvesting in all its buildings, and used Global Positioning System (GPS) enabled water tankers to reduce the illegal diversion or pilferage of water. Chennai also has a 24/7 grievance cell, which uses web-based software to register complaints and enable customer feedback. These innovations have improved Chennai's water security and encouraged significant industrial investment in and around the city.

CONNECTING INDUSTRIAL INDIA

The Indian government has also planned 5 Industrial Corridor Projects, which will each connect 2 or more major cities to stimulate industrial growth. These are the Delhi Mumbai Industrial Corridor, Bangalore Mumbai Economic Corridor, Chennai Bangalore Industrial Corridor, Chennai Vizag Industrial Corridor and Amritsar Kolkata Industrial Corridor. All of the corridor projects are attractive prospects for anchor investors due to their large land parcels, planned communities, as well as good infrastructure and social environment.

The Delhi Mumbai corridor, for instance, will link the 2 cities with a 1,500 freight backbone, with 24 industrial areas and 8 smart cities along the way. It is one of the world's largest infrastructural projects, with an estimated investment of US\$90 million covering areas such as power, water, waste, transport, and information and communications technology. Water management in this zone will also be technology-driven.



[From L-R] Mr Vikram Kapur, IAS, Managing Director, Chennai Metro Water Supply and Sewerage Board; Mr Angshik Chaudhuri, Managing Director and Chief of Staff, Cisco Systems Inc; Mrs Teresa Kho, Country Director for India, Asian Development Bank; Mr Alkesh Kumar Sharma, Chief Executive Officer and Managing Director, Delhi Mumbai Industrial Corridor Development Corporation Limited; Mr Gopinath Pillai, Ambassador-at-Large/Special Envoy to Andhra Pradesh, Ministry of Foreign Affairs, Singapore; Mr Ravi Parthasarathy, Chairman, Confederation of Indian Industry National Mission on Smart Cities

SOUTHEAST ASIA BUSINESS FORUM: UNVEILING SOUTHEAST ASIA'S POTENTIAL – POLICY CHANGES AND BUSINESS OPPORTUNITIES

By 2020, Southeast Asia's economies are expected to be worth about US\$3 trillion while containing most of the fastest developing and emerging markets today. With rapid urbanisation, country leaders are implementing policies that facilitate greater foreign investments so as to keep up with the growth. The Southeast Asia Business Forum looked into how Southeast Asia, situated at the crossroads of China and India, the world's 2 fastest growing countries, promises great economic potential.

INGREDIENTS OF A SUCCESSFUL INFRASTRUCTURAL REPORT

With Southeast Asia's rapid urbanisation and growing middle class, continued infrastructural investments is the key to unlock the growth potential. To ensure the success of infrastructural projects, 3 groups of partners – policymakers, project owners and the business community – need to work together.

Firstly, policymakers must provide a conducive environment for infrastructural projects, which are complex and have long gestation periods. With governments often partnering the private sector for national projects, strong institutional, legal and dispute resolution frameworks must be put in place to protect the integrity of projects and contracts, even in the event of changes in political leadership.

Project owners must also ensure their projects are well-structured and bankable. This involves ensuring proper allocation of roles, risks and responsibilities, and feasibility studies conducted by experienced and qualified experts.

The business community should also build partnerships, since infrastructural projects are rarely undertaken by one company. Cross-border partnerships that combine local and foreign firms' experiences and expertise, thus potentially lowering the cost of financing, have also become more common in Singapore.

Furthermore, as infrastructural projects involve government spending which is in turn funded by taxpayers, public opinion should be taken into consideration. Moreover, projects should be developed with climate change scenarios in mind, as Southeast Asia is particularly vulnerable to rising average temperatures, storm surges, floods and droughts.

It is also important to maintain existing infrastructure. While this is expensive, the cost incurred from non-maintenance is still higher in the long term.

INNOVATIVE AND DISASTER-PROOF SOLUTIONS TO TACKLE LIMITED LAND AVAILABILITY IN THE PHILIPPINES

One of the biggest challenges in the Philippines is the lack of land for large water facilities to service big populations. Hence, there is a need for innovative and disaster-proof solutions to fulfil increasing water demand and enhance supply reliability. Coupled with loosened restrictions on foreign investment in infrastructure, there are increasing opportunities for foreign companies.

Indeed, government spending on infrastructure is projected to triple from 2013 to 2018, with the private sector pouring resources into public-private partnership (PPP) projects. Under the previous government administration, the national PPP Centre had 53 projects in the pipeline, with only 14 having been awarded or being implemented. This was due to the ineffective administrative procedures, which are expected to improve following the formation of a new administration in the government.

Moreover, the Philippines' real gross domestic product (GDP) grew by 6.2% from 2010 to 2015, due to high domestic spending, remittances from overseas Filipino workers and a strong business process outsourcing industry. For instance, Maynilad Water Services is the largest water concessionaire in terms of customer base in the Philippines, and an incubator for innovation and technology.

MYANMAR: ASIA'S NEWEST EMERGING MARKET

Myanmar's GDP growth for the 2013-2014 financial year was 7.7%, and it also received US\$8 billion in foreign direct investments for the 2014-2015 financial year. Between 2012 and 2016, the country's telecommunications market diversified from one operator to several of them, and VISA credit cards became widely accepted, highlighting Myanmar's growth potential.

Myanmar plays a strategic role in China's Belt and Road initiative, which will connect it to Western China. Significant amounts of trade can thus be expected to go through Myanmar. This spells many opportunities for foreign investors in Myanmar.

BALANCING ECONOMIC WITH SOCIETAL VALUE IN HANOI

Vietnam's economy has also grown by leaps and bounds. For instance, Hanoi's GDP increased annually by 9.23% on average in the past 5 years, and it has 3,580 ongoing foreign direct investment projects valued at US\$23.78 million. Recently, the capital unveiled 95 investment projects worth more than US\$3 billion, and it also granted investment certificates and licenses to 22 projects amounting to US\$1.7 billion.

However, Vietnam faces several challenges, including environmental pollution, wastewater treatment, and urban planning. To address them, Hanoi has set goals for its sustainable development that maintains a balance between economic development, social security, and environmental protection. It also plans to enhance its investment landscape by improving administrative processes in the public sector for better regulation.

IMPROVING BUSINESS PROCESSES IN JAKARTA

In 2015, Jakarta's GDP was US\$149.13 million – almost one-fifth of the national GDP. Most foreign direct investment in Indonesia is concentrated in Jakarta, mainly in infrastructure and basic industries. However, Jakarta is located in a low-land area, in the delta of several rivers, making it prone to water management and environmental issues such as floods. The government is thus keen to attract foreign investments to alleviate these problems, and has a growing pipeline of projects.

To facilitate more investments, the government is also looking into improving administrative procedures. For instance, a one-stop service board (BPTSP) was launched in 2014 to issue permits at all levels, from provincial to sub-district, to reduce the complexity of such processes.

Despite complex and time-consuming procedures to obtain permits for foreign investments, Singapore is the largest investor in Jakarta, followed by Hong Kong, Malaysia, China and the Netherlands. Indonesia has 226 national strategic projects, spanning various sectors including clean water and wastewater treatment. The government is also planning



With Southeast Asia's rapid urbanisation and growing middle class, continued infrastructural investments is the key to unlock the growth potential. To ensure the success of infrastructural projects, 3 groups of partners – policymakers, project owners and the business community – need to work together.



to develop the "Port of Jakarta" as a High-Value Added Industrial and Logistic Hub Zone. Hence, there exist potential downstream water projects.

THE ROAD TO UNVEILING SOUTHEAST ASIA'S POTENTIAL

One of the common obstacles of projects is the long and arduous process of tenders, leading to delays in implementation. The Philippines, Vietnam and Thailand, for instance, have thus established national PPP centres to coordinate PPP projects, and provide guidance on best practices.

Underlying the diversity and differences of Southeast Asian nations, is the common potential for growth; and their physical proximity leads to spill-over effects of domestic policies that can have an impact on the region as a whole. While Southeast Asia's growth potential is massive, it is also important for all stakeholders to play their part in tackling the common challenges so as to meet the demands of its emerging nations.



[From L-R] Professor Simon Tay, Chairman, Singapore Institute of International Affairs; Mr Jordan Z. Schwartz, Director, Infrastructure and Urban Development Hub, World Bank; Mr Wong Heang Fine, Group Chief Executive Officer, Surbana Jurong; Mr Ramoncito S. Fernandez, Chief Executive Officer, Maynilad Water Services; HE Nguyen Duc Chung, Chairman, Hanoi People's Committee; Ir Tuty Kusumawati, MM, Head of Regional Development Planning Board (BAPPEDA), DKI Jakarta (far right)

LATIN AMERICA BUSINESS FORUM: CHALLENGES AND OPPORTUNITIES IN LATIN AMERICA



[From L-R] Dr Alfonso Vega, President, Fundación Metrópoli; Mr Raphael Chua Teck Lee, Managing Director (Americas and Russia/CIS Market), Surbana Jurong; Mr Peter Lee Chung Shek, Managing Director, Changi Airport Planners and Engineers; Ms Paula Andrade, Associate Director, Asset Management, Changi Airports International; HE Flávio Soares Damico, Brazil's Ambassador to Singapore

By 2050, Latin America is expected to grow to 750 million inhabitants, with 90% of them living in cities. To cope with the transformation, the region will need more infrastructural investments, opening up opportunities for businesses. Such investment is particularly important in helping the water sector to address the impact of climate change, stricter health and environmental standards, and economic development. The Latin America Business Forum highlighted key initiatives to secure greater investment for infrastructural works in Brazil, Colombia and Mexico, which are some of the region's largest economies.

OPPORTUNITIES FOR PUBLIC-PRIVATE PARTNERSHIPS IN BRAZIL

Brazil's population and urbanisation have grown by factors of 3.5 and 7.5 respectively, increasing the demand for sanitation, water, roads and housing. Although Brazil has an overall water coverage of more than 83% by population, the figure falls to less than 60% in the north, and only 48% of the population is connected to central sewers. Furthermore, the São Paulo Metropolitan Region, with over 20 million inhabit-

ants, is enduring the worst drought observed in a hydrological record of more than 125 years of data. The country thus requires an estimated US\$75 billion worth of investments to provide universal water and wastewater treatment until the year 2033. To increase the water sector's productivity, Brazil is looking into integrated hydraulic modelling, which comprises effective communications across all water platforms to permit rapid and effective real-time decisions.

Though Brazil has a strong constitutional backing with regard to environmental protection, it is also business-friendly and open to public-private partnerships, such as the Belo Horizonte project completed by Surbana Jurong in Minas Gerais, Brazil. This project involves an integrated development comprising an airport city and new, strategic industries. Such integration has enabled industries within the region to move up the value-chain, generating over 30,000 direct jobs to date. For example, Surbana Jurong has always hired environmental consultants from the country where the project is based, because they possess expertise and knowledge relevant to the local context, which facilitates project development.

Developers who want to gain the support of Brazilian mayors and politicians for their projects should explain the benefits of structural planning, involve stakeholders, work with partners who understand Brazil well, and advocate for their projects within and outside Brazil to attract investors. Generating public awareness and interest in their proposals could also convince Brazilian politicians to come on board.

COLOMBIA: A TOP COUNTRY FOR FOREIGN INVESTMENT

Colombia has been rated as one of the world's top 20 countries for foreign investment, partially due to its drive for technological advancement and educational progression, as well as its business-friendly and free trade-oriented policies. While Latin America has achieved an economic growth of 3.1% in the past 20 years, Colombia has stood out in the region – it has secured up to US\$15 billion worth of investments, of which US\$3 billion will be channelled to Medellín, to make it Colombia's most educated and competitive city.

REALISING MEXICO'S UNTAPPED POTENTIAL

Mexico's population is expected to increase from 118.4 million in 2013 to 150.8 million by 2050, putting more pressure on its water resources and security. Furthermore, more people are moving from its rural areas to its urban centres, leading to a rise in the demand for potable water. These demographic changes and their resulting infrastructural challenges present investment opportunities.

For example, the Mexican government has prioritised funding for important water projects. Investors might also find more opportunities in Mexico than in the saturated markets of India and China. In fact, foreign investment in Mexico rose by nearly 26% from 2014 to 2015.

Mexico has also established advantageous conditions for investors through its focused economic policy, which encourages economic and macroeconomic stability, and its aggressive trade negotiation policies, which have helped it to ink free trade agreements with 44 countries and bilateral treaties with 25 countries. Companies planning to expand into Mexico should try to understand the country's business practices, and work with a local partner to maximise their chances for success.



Dr Benedito Braga, President, World Water Council and Secretary for Sanitation and Water Resources for the State of São Paulo, Brazil



Latin America will need more infrastructural investments, opening up opportunities for businesses. Such investment is particularly important in helping the water sector to address the impact of climate change, stricter health and environmental standards, and economic development.



DESALINATION AND REUSE BUSINESS FORUM: SEIZING THE FUTURE OF WATER – FORGING GLOBAL INROADS AND OPPORTUNITIES



[From L-R] Mr Leon Awerbuch, President and Chief Technology Officer, Leading Edge Technologies Ltd; Board Director, International Desalination Association; Mr Ronald Keating, Chief Executive Officer, Evoqua Water Technologies; Mr Miguel Angel Sanz, Director of Strategic Development, SUEZ; Ms Hattie Wang, Vice President (Global Market), Harbin ROPV Industry Development Centre; Mr Mohammad El Ramahi, Director, Asset Management, Engineering and Operations, Masdar

With climate change ramping up flood and drought risks across the world, countries are increasingly working to weather-proof their water supply. The Desalination and Water Reuse Business Forum thus discussed such developments, and emerging energy-efficient technologies which have helped make desalination and reuse viable sources of water.

In fact, there are now more than 1,800 desalination plants in over 160 countries, and their daily water production exceeds 90 million cubic litres. The growing perception of effluent as a precious resource has also spurred the reuse market's growth and interest in wastewater technologies globally. Membrane bioreactor systems and plants, in particular, have garnered the attention of rapidly industrialising countries such as China.

Desalination and water reuse technologies are thus riding one of the water sector's most dynamic growth trends. The annual global capital expenditure for desalination is expected to double from US\$2.8 billion to over US\$5 billion by 2020, while water reuse is a fast-growing segment of the US\$50 billion wastewater industry.

THE GROWING DEMAND FOR DESALINATION AND WATER REUSE

Saudi Arabia, for instance, has several upcoming desalination projects including the Jeddah Phase 4 Reverse Osmosis (RO) Plant, Rabigh Phase 3 RO Plant, the Haql-3, Duba-4 and Alwajh-4 desalination plants and water transmission systems, and the Jubail Desalination Plant (Phase 3). Hong Kong is focusing on water reuse and designing major desalination plants, and there is also strong potential for investment in desalination and water reuse in India.

In the US, opportunities also abound in water reuse and brackish water desalination in the south-west of the country, and in desalination along its coastline. The US already practices non-potable water reuse and indirect potable reuse, and is now exploring direct potable reuse. This could also help reduce the reliance of industry, such as the mining sector, on potable water supplies, which has been a challenge in South America.

Other key developments include Sri Lanka's plans to complete its first desalination plant, located in the city of Jaffna, by 2019. This will help Jaffna to meet its growing water demand as it develops its tourism industries. The decision to pursue desalination was made after ruling out other options to increase the water supply, including groundwater extraction which would have caused water pollution through salt intrusion.

REAPING THE FRUITS OF R&D

Firms are also finding opportunities in cutting-edge R&D to make desalination and water reuse more efficient and sustainable, for example, by reducing energy costs and tapping renewable energy.

For instance, Evoqua Water Technologies has developed an electrochemical desalination technology called NEXED, which uses an electric field and ion exchange membranes to remove salt from seawater. The system has a small footprint, quick processing rate of 20 gallons per minute, and recovery and salt reduction rates of 85% each. The technology has moved to the commercialisation phase in Singapore and is being tested in a demonstration plant with a capacity of 1,892 m³ per day. NEXED modules are also on sale.

On its part, SUEZ has pioneered a new hybridised technology called Liquid Ionic Membrane (LIM), which uses waste heat as an energy source to reduce desalination's carbon footprint. Suez also uses renewable energy for some of its desalination plants in Spain and Australia. Wind-power is used for its desalination plant in Victoria, Australia – the world's largest Build, Finance, Operate and Transfer water plant, producing 450,000 m³ per day of water, and the third largest seawater RO plant, with an 84-km underground water transfer pipeline and 87-km underground power-line.

SUEZ has also helped to increase the capacity of the wastewater treatment plant in Doha West, Qatar, from 135 million litres a day (MLD) to 280 MLD. Through an advanced membrane ultrafiltration system, the wastewater is completely recycled and used for farms, green areas and aquifer injection.

In the United Arab Emirates, where desalinated water constitutes 80% of the water supply, half of the energy used in utilities goes into desalinating water. Masdar, a subsidiary of the Mubadala Development Company, helps to advance, commercialise and deploy more energy-efficient desalina-



Ms Cindy Wallis-Lage, President of Water Business, Black & Veatch; Board Treasurer, WaterReuse Association and Research Foundation



With climate change ramping up flood and drought risks across the world, countries are increasingly working to weather-proof their water supply. ...Firms are also finding opportunities in cutting-edge R&D to make desalination and water reuse more efficient and sustainable.



tion technologies which can be powered by renewable energy and have minimal environmental footprint. Masdar provides co-financing and R&D support to industry partners for pilot projects to develop innovative desalination technologies, such as membrane distillation, RO, and forward osmosis. These reference projects will be helpful in a region which accounts for nearly half of the global desalination capacity.

Harbin ROPV Industry Development Centre in China has also developed a new technology called Multiple Vessels Integration (MVI) for desalination. Traditional RO vessel skids used in water treatment have many points that need to be sealed and connected, resulting in high material, installation and environmental costs. MVI reduces these costs, as well as potential leaks and corrosion, by using a group of vessels which are connected through a special strap and each sealed with interconnectors.

DEEP TUNNEL SEWERAGE SYSTEM PHASE 2 AND INTEGRATED WASTE MANAGEMENT FACILITY BUSINESS FORUM: WATER-ENERGY-WASTE NEXUS – THE SINGAPORE JOURNEY



Mr Yong Wei Hin, Director, DTSS 2 Department, PUB, Singapore

Singapore's Deep Tunnel Sewerage System (DTSS) Phase 2 and Integrated Waste Management Facility (IWMF) are iconic flagship projects undertaken by national water agency PUB and the National Environment Agency (NEA) respectively, for used water management and solid waste treatment. Both projects have undergone their preliminary engineering design studies and are embarking on their next phase of project development. DTSS Phase 2, comprising a conveyance system of deep tunnels and link sewers and an advanced Tuas Water Reclamation Plant (TWRP), will complete Singapore's used water system to collect, treat, dispose of and reclaim used water. To further harness the synergies from the water-energy-waste nexus, the TWRP will be co-located with the IWMF. The DTSS Phase 2 and IWMF Forum highlighted the projects' key features, which are also a rich source of potential business opportunities.

AN UNDERGROUND SUPER HIGHWAY FOR USED WATER

The DTSS was conceived in the 1990s as a sustainable and resilient long-term solution to Singapore's used water needs. It ensures adequate used water conveyance and treatment capacity to uphold public health standards, and maximise the collection of used water for NEWater production to ensure water sustainability for Singapore. Upon full completion, it will reduce the land occupied by used water infrastructure by 50%, freeing up land for



The Tuas Water Reclamation Plant will adopt an innovative design as well as advanced technologies. ...It will also be co-located with the Integrated Waste Management Facility to minimise the facilities' land footprint and reap synergies in the water-energy-waste nexus.



other high value developments, and be more cost-effective than continually renewing and expanding conventional infrastructure.

The construction of DTSS spans 2 phases. Phase 1 was completed in 2008, at a cost of S\$3.4 billion. It includes the 48 km-long North and Spur Tunnels, 60 km of link sewers, the Changi WRP, and deep sea outfall pipes, serving the eastern and central parts of Singapore. Phase 2, slated to be completed by 2025, extends the deep tunnel system to western Singapore. It will consist of 40 km of deep tunnels and 60 km of link sewers, and the advanced TWRP. Black & Veatch and AECOM Joint Venture was appointed as the overall Project Manager for DTSS Phase 2, and the companies are providing engineering and programme management services to PUB. The preliminary design for DTSS Phase 2 was completed in 2016, and the project is moving to the next stage of detailed design and construction, which will take place from 2017 until 2025.

A HOTBED OF NEW TECHNOLOGIES

DTSS Phase 2 will feature exciting new technologies and processes. For example, TWRP will adopt an innovative design as well as advanced technologies, such as enhanced primary treatment, Membrane Bioreactor (MBR) and Thermal Hydrolysis Plant (THP). These processes will enable TWRP to generate more energy from sludge, biogas, food and greasy

waste, approximately doubling the energy recovery compared to existing conventional WRPs. The MBR technology will allow TWRP to produce high quality effluent, keeping its footprint compact while allowing the used water and NE-Water treatment processes to be streamlined. When completed, TWRP will be the largest MBR facility in the world.

At the same time, TWRP will be co-located with the IWMF to minimise the facilities' land footprint and reap synergies in the water-energy-waste nexus. For instance, food waste received at the IWMF will be pre-treated and sent to TWRP for co-digestion with used water sludge, to produce more biogas for electricity. This biogas will then be fed back to the IWMF to increase its power production. In return, the IWMF will provide TWRP with electricity directly, as well as export surplus electricity to the grid.

In addition, the deep tunnel sewers are designed for minimal maintenance by setting their gradient to promote self-cleansing flow velocity, and optics fibre will be embedded in the tunnel lining to allow long-term monitoring of their structural integrity. To facilitate inspection using remote operated vehicles (ROV) equipped with high-definition CCTV, sonar and laser, all tunnel shafts are sized to accommodate the ROV and will be sited directly above the tunnel. For contingencies such as maintenance works, shafts at strategic locations along the tunnel are designed with the ability to isolate the tunnel by the installation of roller gates.

To manage the air flow in the deep tunnel and to prevent any odour nuisance, air jumpers will be installed to convey the air along the tunnel to the next available odour control facility (OCF) downstream. The OCF will then treat the air by stripping the odour before releasing it from the system. During construction of the tunnel, an integrated data management system will be adopted to improve the productivity of the acquiring and reviewing of construction data. The data management system is a web-based visual platform to monitor and track construction data and progress, with input from various sources in real time.



Mr Geoffrey Piggott, Project Director, Black & Veatch + AECOM Joint Venture



Mr Joseph Boey, Project Director (IWMF), National Environment Agency, Singapore

OPPORTUNITIES FOR THE WATER INDUSTRY

Many components of the DTSS Phase 2 and IWMF are potential business opportunities for the water industry, including the many companies in Singapore's vibrant water ecosystem. For example, from 2016, tenders will be called for Detailed Design Consultants for the link sewers and TWRP, and these will be awarded from early 2017. The construction tenders for the proposed link sewers and TWRP will subsequently be developed and called from 2018 by the respective Detailed Design Consultants. These tenders will include sewer construction by pipe-jacking, equipment procurement and contracts for influent pumping stations, liquid treatment modules, biosolids and site-wide infrastructure. As for the tunnelling contracts, there are a total of 5 contracts to be called in 2 batches. Batch 1 was called in the fourth quarter of 2016 and Batch 2 will be called in the first quarter of 2017.

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WATER LEADERS SUMMIT

Chairpersons/Moderators:

- **Professor Asit K. Biswas**, Distinguished Visiting Professor, Lee Kuan Yew School of Public Policy; Co-Founder, Third World Centre for Water Management
- **Professor Chan Heng Chee**, Ambassador-at-Large, Ministry of Foreign Affairs (MFA), Singapore; Chairman, Lee Kuan Yew Centre for Innovative Cities, Singapore University of Technology and Design
- **Mr Sean Chiao**, President of Asia-Pacific, AECOM
- **Mr Bryan Harvey**, Managing Director, Water International, CH2M
- **Mr Greg McIntyre**, President, Global Business Groups, CH2M
- **Professor Tommy Koh**, Ambassador-at-Large, MFA, Singapore; Chairperson, Water Leaders Summit (WLS)
- **Dr Julian Sandino**, Vice President, Technology Senior Fellow, CH2M
- **Ms Cindy Wallis-Lage**, President of Water Business, Black & Veatch; Board Treasurer, WaterReuse Association and Research Foundation

Speakers:

- **Mr Gerardo Ablaza Jr**, President and Chief Executive Officer, Manila Water Company
- **HE Dr Abdulrahman M. Al-Ibrahim**, Governor, Saline Water Conversion Corporation; Chief Executive Officer, National Water Co., Saudi Arabia
- **HE Mohammed bin Abdullah Al-Rumaihi**, Minister of Municipality and Environment, Qatar
- **Mr Anders Bækgaard**, Executive Director and Chief Executive Officer, VCS Denmark
- **Mr Joel Beauvais**, Deputy Assistant Administrator for the Office of Water, US Environmental Protection Agency
- **Dr Paul Bowen**, Director, Environmental Sustainability, Coca-Cola Company; President, Water Environment Federation
- **Mr Peter Brabeck-Letmathe**, Chairman of the Board, Nestlé S.A.

- **Dr Benedito Braga**, President, World Water Council; Secretary for Sanitation and Water Resources for the State of São Paulo, Brazil
- **Professor Chen Qin**, Vice Commissioner, Changjiang Water Resources Commission, China
- **Professor Choi Gyewoon**, President, Asia Water Council
- **Dr Joan Clos**, Secretary-General of the UN Conference on Housing and Sustainable Urban Development (Habitat III)
- **Mr Patrick K. Decker**, President and Chief Executive Officer, Xylem Inc.
- **Dr Emilio Gabbrielli**, President, International Desalination Association (IDA); Director, Overseas Business Development, Toray
- **HE Dr Han Seung-soo**, UN Secretary-General's Special Envoy for Disaster Risk Reduction and Water; Special Adviser to the High Level Panel on Water; Former Prime Minister, Republic of Korea
- **Mr Charles O. Holliday-Jr**, Chairman, Royal Dutch Shell PLC
- **HE Michel Jarraud**, Secretary General Emeritus, World Meteorological Organisation
- **Mr Venkatesh Kini**, President, India and South West Asia, Coca-Cola Company
- **Mr Kevin Klau**, President, Hach, Danaher Corporation
- **Ms Isabelle Kocher**, Chairman and Chief Executive Officer, Engie
- **HE Esben Lunde Larsen**, Minister for Environment and Food, Denmark
- **Mr Claude Laruelle**, Director of Global Enterprises, Veolia and Chairman, Veolia Water Technologies
- **Ms Amy Leung**, Deputy Director General, East Asia Department, Asian Development Bank
- **Mr Adam Lovell**, Executive Director, Water Services Association of Australia
- **Dr David Molden**, Director General, International Centre for Integrated Mountain Development
- **Mrs Sue Murphy**, Chief Executive Officer, Water Corporation, Australia
- **Mr Denys Neymon**, Chief Executive Officer, Treatment Infrastructure and Executive Vice-President, Group Human Resources, SUEZ
- **Mr Ng Joo Hee**, Chief Executive, PUB, Singapore
- **Mr Henk Ovink**, Special Envoy for International Water Affairs, the Netherlands
- **HE Park Won-soon**, Mayor of Seoul, South Korea
- **Dr Judith Rodin**, President, Rockefeller Foundation
- **Mr Tharman Shanmugaratnam**, Deputy Prime Minister and Coordinating Minister for Economic and Social Policies, Singapore

- **Mr Alkesh Kumar Sharma**, Chief Executive Officer and Managing Director, Delhi Mumbai Industrial Corridor Development Corporation Limited
- **HE Mrs Laurence Tubiana**, French Ambassador for Climate Change Negotiations and High Level Champion for Climate Action
- **Mr Masagos Zulkifli**, Minister for the Environment and Water Resources, Singapore

YOUNG WATER LEADERS SUMMIT

Moderators:

- **Ms Asma Bachikh**, Member, World Youth Parliament for Water (WYPW)
- **Ms Dona Geagea**, Member, Water Youth Network (WYN)
- **Ms Veronica Minaya**, Member, WYN
- **Ms Anne-Sophie Sainte-Marie**, Member, WYPW
- **Mr Randolph Webb**, Senior Analyst, Corporate Strategy and Business Development, Xylem Inc.; Member, International Water Association (IWA) Young Water Professionals

Speakers:

- **Ms Karmina Alejandro**, Head of Social Media, Maynilad Water Services Inc.
- **Ms Diane d'Arras**, President-elect, IWA; Senior Executive Vice President (Water, Western Europe), SUEZ
- **Dr Amy Khor**, Senior Minister of State, Ministry of the Environment and Water Resources and Ministry of Health, Singapore
- **Mr Booky Oren**, Chairman and Chief Executive Officer, Booky Oren Global Water Technologies Ltd
- **Mr Henk Ovink**, Special Envoy for International Water Affairs, the Netherlands
- **Mr David Pong**, Chief Executive Officer, WaterROAM
- **Mr Adam Purvis**, Co-Founder and Director, Power of Youth, The Metta Network
- **Dr Victor Sim**, Committee Member, IDA Young Leaders Programme
- **Ms Zhang Lei**, Director and Senior Vice President, Potent Environment Group; Chief Executive Officer, Aquapoten Company Limited

ASEAN PLUS THREE WATER MINISTERS FORUM

Moderator:

Mr Ong Keng Yong, Ambassador-at-Large, MFA, Singapore

Speakers:

- **HE Dato Bahrin Abdullah**, Minister of Development, Brunei Darussalam
- **Dr Benedito Braga**, President, World Water Council; Secretary for Sanitation and Water Resources for the State of São Paulo, Brazil
- **Mr Ede Jorge Ijjász-Vásquez**, Senior Director for Social, Urban, Rural and Resilience Global Practice, World Bank
- **Mr Khin Maung Yi**, Permanent Secretary, Ministry of Natural Resources and Environmental Conservation, Myanmar
- **Mr Ravi Narayanan**, Chair, Asia-Pacific Water Forum
- **Mr Oh Jongkeuk**, Director General, Ministry of Environment, Republic of Korea
- **HE Datuk Seri Panglima Dr Maximus Johnity Ongkili**, Minister of Energy, Green Technology and Water, Malaysia
- **Mr Sommad Pholsena**, Minister of Natural Resources and Environment, Laos
- **HE Vilaykham Phosalath**, Vice Minister for Public Works and Transport, Laos
- **HE Cham Prasidh**, Senior Minister of Industry and Handicraft, Cambodia
- **YB Datuk Ir. Haji Hamim Bin Samuri**, Deputy Minister for Natural Resources and Environment, Malaysia
- **Mr Saroj Srisai**, Head of Environment Division, Sustainable Development Directorate, ASEAN Secretariat
- **Mr Bambang Susantono**, Vice President, Asian Development Bank
- **Mr Keiichi Yamamoto**, Deputy Director-General, Water Resources Department, Water and Disaster Management Bureau, Ministry of Land, Infrastructure, Transport and Tourism, Japan
- **Mr Masagos Zulkifli**, Minister for the Environment and Water Resources, Singapore

AQUA CONVERSATIONS

Moderator:

Ms Chloe Cho, Presenter and Executive Producer, Current Affairs Department, Channel NewsAsia

Speaker:

Dr Beh Swan Gin, Chairman, Economic Development Board, Singapore

LEE KUAN YEW WATER PRIZE LECTURE

Chairperson:

Professor Kishore Mahbubani, Dean and Professor in the Practice of Public Policy, Lee Kuan Yew School of Public Policy

Speaker:

Professor John Anthony Cherry, Distinguished Professor Emeritus, Department of Earth and Environmental Sciences, University of Waterloo, Ontario – Lee Kuan Yew Water Prize Winner

WATER CONVENTION

Chairpersons:

- **Mr Darryl Day**, Chair, IWA – Australian National Committee
- **Professor Helmut Kroiss**, President, IWA
- **Dr Marion Savill**, Executive Director, Affordable Water Ltd

Speakers:

- **Dr Robert Bos**, Senior Advisor, IWA
- **Professor Rebekah Brown**, Director, Monash Sustainability Institute, Monash University
- **Mr Jonathan Clement**, Chief Executive Officer, PWN Technologies
- **Dr Glen Daigger**, President, One Water Solutions LLC; Professor of Engineering Practice, Department of Environmental Engineering, University of Michigan
- **Dr Pascal Dauthuille**, Director, Partnerships and Collaborative Projects, SUEZ
- **Mr Bruce Gordon**, Coordinator of Water, Hygiene and Health, World Health Organisation
- **Mr Khoo Teng Chye**, Executive Director, Centre for Liveable Cities, Ministry of National Development, Singapore
- **Mr Peter Nicol**, President, Water Business Group, CH2M
- **Mr Michael Toh**, Director, Water Supply (Network), PUB, Singapore
- **Professor Tony Wong**, Director and Chief Executive, Centre for Water Sensitive Cities, Monash University

INDUSTRIAL WATER SOLUTIONS FORUM

Chairpersons:

- **Professor Asit K. Biswas**, Distinguished Visiting Professor, Lee Kuan Yew School of Public Policy; Co-Founder, Third World Centre for Water Management
- **Mr Joppe Cramwinckel**, Director of Water, World Business Council for Sustainable Development
- **Dr Glen Daigger**, President, One Water Solutions LLC; Professor of Engineering Practice, Department of Environmental Engineering, University of Michigan

Speakers:

- **Mr Ashish Aneja**, Advanced Technologies Leader, GE Water & Process Technologies
- **Mr Wilson Ang**, Executive Director, Global Compact Network Singapore
- **Mr Joel Beauvais**, Deputy Assistant Administrator for the Office of Water, US Environmental Protection Agency
- **Mr Stephane Boyer**, Managing Director, SUEZ Industrial Solutions
- **Mr Alan Chan**, Asia-Pacific Commercial Director, Dow Water & Process Solutions
- **Ms Angeline Chia**, Manager, Environmental Protection, BASF
- **Mr Goh Chee Kiong**, Executive Director (Cleantech and Cities, Infrastructure and Industrial Solutions), Economic Development Board, Singapore
- **Ms Cindy Havran**, Global Discipline Technology Leader for Water Treatment and Reuse, ExxonMobil
- **Mr Mel Karam**, Global Head of Asset Management, KPMG International
- **Mr David Kiu**, Vice President, Sustainable Business and Communications, Unilever
- **Mr Alan G. Knapp**, Director, Global Business Development, Evoqua Water Technologies
- **Mr Andrew Lau**, Director, Southeast Asia Pacific Region, Ovivo
- **Mr Lee Chit Wei**, Director of Fab 13, Micron
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- **Dr Chirla Chandra Sekhara Reddy**, Technology and Optimisation Manager, Singapore Refining Company
- **Ms Zita Schellekens**, Director, Corporate Relations, Heineken
- **Mr Yaniv Schmidt**, Director, IDE Technologies
- **Mr Amit Sharma**, Vice President of Eastern Operations, Aquatech International
- **Mr Peter Stokes**, Director (Global Key Accounts), Veolia Water Technologies
- **Mr Tan Yi Mian**, Head Operations, Utilities Group, YTL PowerSeraya
- **Mr Sanjeev Tandale**, Lead Engineer Process Systems, M+W Group
- **Mr Masagos Zulkifli**, Minister for the Environment and Water Resources, Singapore

SMART WATER FORUM

Moderators:

- **Ms Jay Iyengar**, Chief Innovation and Technology Officer, Xylem Inc.
- **Mr Thomas Perianu**, Senior Vice President (Smart Water), SUEZ
- **Ms Shannon Spence**, Vice President, Arcadis
- **Dr Russell Young**, Global Chief Technology Officer, Hach

Speakers:

- **Mr Michiel van Haersma Buma**, Chairman, Delfland Regional Water Authority, the Netherlands
- **Mr Alberto Lázaro**, Executive President, Puerto Rico Aqueduct and Sewer Authority
- **Mr Jacky Lei**, Senior Operations Manager, Macao Water Supply
- **Dr Nick Mills**, Head of Wastewater Innovation, Thames Water, the UK
- **Mr Luke Pace**, Mechanical Engineer, Malta Water Services Corporation
- **Mr Michael Toh**, Director, Water Supply (Network), PUB, Singapore

TECHXCHANGE

Moderator:

Dr Steven Kloos, Partner, True North Venture Partners

Speakers:

- **Mr Piers Clark**, Chairman, Isle Utilities
- **Mr Paul-Joël Derian**, Vice President, Scientific and Technologies Group, SUEZ
- **Mr Trevor Hill**, Chief Executive Officer, Fathom
- **Dr Reinhard Hübner**, Investment Director, SKion GmbH
- **Mr Ujjwal Kumar**, Senior Technical Evangelist, Microsoft
- **Mr Adam Lovell**, Executive Director, Water Services Association of Australia
- **Ms Patricia Mulroy**, Distinguished Maki Faculty Advisor, Desert Research Institute
- **Mr Harry Seah**, Chief Engineering and Technology Officer, PUB, Singapore
- **Mr Martin Shouler**, Associate Director, Arup

HYDRO PITCH DAY

Moderator:

Mr Theron Madhavan, Chief Operating Officer, Flagship Ecosystems Pte Ltd

Speakers:

- **Mr Chua Soon Guan**, Deputy Chief Executive (Policy and Development), PUB, Singapore
- **Dr Steven Kloos**, Partner, True North Venture Partners

CHINA BUSINESS FORUM

Chairperson:

Dr Liu Thai Ker, Chairman, Centre for Liveable Cities (CLC) Advisory Board, Singapore

Speakers:

- **Dr Chen Changsheng**, Deputy Director-General, Department of Macroeconomic Research, Development Research Centre of the State Council, China
- **Ms Chen Shankun**, President, Guangdong Environmental Sanitation Association
- **Mr Khoo Teng Chye**, Executive Director, CLC, Ministry of National Development, Singapore
- **Ms Song Xiaozhi**, Deputy Director-General, Ministry of Environmental Protection, China
- **Mr Tan Cheng Guan**, Executive Vice President and Head, Group Business Development and Commercial, SembCorp Industries; President, Singapore Water Association
- **Ms Zhang Lei**, Director and Senior Vice President, Potent Environment Group; Chief Executive Officer, Aquapoten Company Limited
- **Mr Zheng Yunfeng**, Executive Vice Mayor, Xiamen Municipal Government, China
- **Mr Zhou Jun**, Executive Chairman, SIIC Environment Holdings Ltd

INDIA BUSINESS FORUM

Moderator:

Mr Gopinath Pillai, Ambassador-at-Large/Special Envoy to Andhra Pradesh, MFA, Singapore; Director, Savant Infocomm Pte Ltd; Chairman, Institute of South Asian Studies

Speakers:

- **Mr Angshik Chaudhuri**, Managing Director and Chief of Staff, Cisco Systems Inc
- **Mr Vikram Kapur**, IAS, Managing Director, Chennai Metro Water Supply and Sewerage Board
- **Mrs Teresa Kho**, Country Director for India, Asian Development Bank
- **Mr Subbu Narayanswamy**, Senior Partner and India Infrastructure Practice Leader, McKinsey & Company

- **Mr Ravi Parthasarathy**, Chairman, Confederation of Indian Industry National Mission on Smart Cities; Chairman, Infrastructure Leasing and Financial Services Limited
- **Mr Alkesh Kumar Sharma**, Chief Executive Officer and Managing Director, Delhi Mumbai Industrial Corridor Development Corporation Limited

SOUTHEAST ASIA BUSINESS FORUM

Moderator:

Professor Simon Tay, Chairman, Singapore Institute of International Affairs

Speakers:

- **Mr Ramoncito S. Fernandez**, Executive Director, Metro Pacific Investments Corporation; President and Chief Executive Officer, Maynilad Water Services Inc.
- **Ir Tuty Kusumawati**, MM, Head of Regional Development Planning Board (BAPPEDA), DKI Jakarta
- **HE Nguyen Duc Chung**, Chairman, Hanoi People's Committee
- **Mr Jordan Z. Schwartz**, Director, Infrastructure and Urban Development Hub, World Bank
- **Mr Tan Soon Kim**, Assistant Chief Executive Officer, International Enterprise Singapore
- **Mr Wong Heang Fine**, Group Chief Executive Officer, Surbana Jurong Pte Ltd

LATIN AMERICA BUSINESS FORUM

Chairperson:

Dr Alfonso Vegara, President, Fundación Metrópoli

Speakers:

- **Ms Paula Andrade**, Associate Director, Asset Management, Changi Airports International Pte Ltd
- **Dr Benedito Braga**, President, World Water Council; Secretary for Sanitation and Water Resources for the State of São Paulo, Brazil
- **Mrs María Margarita Dafne Lobato Calleros**, Head of Project National Laboratory Network, CONAGUA (National Water Commission of Mexico)
- **Mr Wagner Carvalho**, Senior Project Manager, AEGEA
- **Mr Raphael Chua Teck Lee**, Managing Director (Americas and Russia/CIS Market), Surbana Jurong Pte Ltd
- **HE Flávio Soares Damico**, Brazil's Ambassador to Singapore
- **Mr Peter Lee Chung Shek**, Managing Director, Changi Airport Planners and Engineers

- **HE Rogelio Granguillhome Morfin**, Mexico's Ambassador to Singapore
- **Mr Oon Chong Howe**, Senior Managing Director, Hyflux Ltd
- **Mr Satvinder Singh**, Assistant Chief Executive Officer, International Enterprise Singapore
- **Mr Sergio Escobar Solórzano**, Executive Director, Agency for Cooperation and Investment of Medellín and the Metropolitan Area (ACI)

DESALINATION AND REUSE BUSINESS FORUM

Moderator:

Mr Leon Awerbuch, President and Chief Technology Officer, Leading Edge Technologies Ltd; Board Director, IDA; Chairman, IDA's Technical Programme Committee

Speakers:

- **Eng. Abdullah Al-Breakeit**, Deputy Governor, Projects and Technical Affairs, Saline Water Conversion Corporation
- **Mr Mohammad El Ramahi**, Director, Asset Management, Engineering and Operations, Masdar
- **Dr Emilio Gabbrielli**, President, IDA; Director, Overseas Business Development, Toray
- **Mr Ronald Keating**, Chief Executive Officer, Evoqua Water Technologies
- **Mr Miguel Angel Sanz**, Director of Strategic Development, SUEZ; Board Director, IDA
- **Ms Cindy Wallis-Lage**, President of Water Business, Black & Veatch; Board Treasurer, WaterReuse Association and Research Foundation
- **Ms Hattie Wang**, Vice President (Global Market), Harbin ROPV Industry Development Centre
- **Eng. Thilina Senani Wijetunge**, Deputy General Manager, National Water Supply and Drainage Board

DEEP TUNNEL SEWERAGE SYSTEM (DTSS) PHASE 2 AND INTEGRATED WASTE MANAGEMENT FACILITY (IWMF) BUSINESS FORUM

Speakers:

- **Mr Joseph Boey**, Project Director (IWMF), National Environment Agency, Singapore
- **Mr Geoffrey Piggott**, Project Director, Black & Veatch + AECOM Joint Venture
- **Ms Woo Lai Lynn**, Deputy Director (Conveyance), DTSS 2 Department, PUB, Singapore
- **Mr Yong Wei Hin**, Director, DTSS 2 Department, PUB, Singapore

ABOUT SINGAPORE INTERNATIONAL WATER WEEK (SIWW)

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The 8th SIWW will be held from 8th to 12th July 2018 at the Sands Expo and Convention Centre, Marina Bay Sands in Singapore.

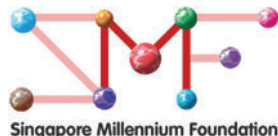
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