MODERNISING HONG KONG'S WATER MANAGEMENT POLICY PART I

CONSERVATION AND CONSUMPTION: TOWARDS A WATER-SMART HONG KONG

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ABOUT CIVIC EXCHANGE

Civic Exchange is an independent Hong Kong public-policy think tank established in 2000. We use in-depth research and dialogue to inform policy and engage stakeholders on addressing environmental and development challenges in Hong Kong. Civic Exchange has been ranked among the top 50 environmental think tanks in the world by the Lauder Institute at the University of Pennsylvania since 2011. For more information, visit www.civic-exchange.org.

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PREFACE

Water security is imperative for Hong Kong, which is facing increasing pressure on its supply, with competition for the water it imports from municipal use in rapidly growing cities in the Greater Bay Area, alongside the demand for non-municipal use, such as supporting increased river traffic along the Dongjiang river. Hong Kong's ageing water infrastructure further wastes the supply it has through pipeline leaks, while the growing population adds to demand, with their high usage likely encouraged by low prices.

For Hong Kong to rise above these challenges, long-term solutions are needed. This new research project by Civic Exchange, *Modernising Hong Kong's Water Management Policy*, consists of two parts. This first part studies local demand and conservation challenges to recommend policy solutions. Its sister report assesses how local water infrastructure systems can be deployed to safeguard water security and accessibility for Hong Kong in the long run. These two themes are core aspects of Hong Kong's Total Water Management (TWM) strategy, a 2008 framework that seeks to diversify the city's water sources while promoting local sustainability. As the government rightly pointed out, we have a duty to ensure reliable water supply for our future generations and for our neighbours.[1] We also have a duty to contribute to China's national effort on safeguarding our country's long-term water security,[2] and to the global ambition of ensuring availability and sustainable management of water for all as outlined in the United Nation's 2030 Agenda for Sustainable Development.[3]

This first part, devoted to conservation and consumption, shows how local demand can be reduced through responsible resource use, if only the government is prepared to strive towards setting consumption reduction targets that are more ambitious than its current ones, yet entirely realistic. This approach emphasises meeting demand by best using the water that is already available, seeking ways to improve efficiency rather than locating new sources of supply. A review and revival of Hong Kong's water tariff scheme based on a user-pays principle, while supported by policy provision to ensure affordable access to water for the underprivileged, is also long overdue.

Civic Exchange has a long-standing track record on local water issues. Its five-part *Liquid Assets* (2009) research series emphasised the centrality of water protection for social and economic well-being. More recently, *The Water Tales of Hong Kong and Singapore* (2014)[4] compared how two cities dramatically diverged in their approach to water management, while *The Illusion of Plenty* (2017)[5] examined how abundant and inexpensive water provides a false sense of security. Civic Exchange continues to use its research to engage policymakers and call for the implementation of comprehensive reforms to improve Hong Kong's social well-being.

Modernising Hong Kong's Water Management Policy assesses a range of international best practices, where other cities have recognised the need for water conservation and then applied policy tools to improve data collection, repair infrastructure and promote conservation. In particular, a core part of gathering such information involves implementing automated smart meter reading systems, to clarify consumption volumes and locate leakages for repair. Hong Kong can adopt lessons from global best practice for its own water strategy, and modernise its approach to value this increasingly scarce resource.

Natalie Chan
Senior Advisor
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ACRONYMS AND ABBREVIATIONS

AMR	Automatic Meter Reading
AU$	Australian Dollar
BASIX	Building Sustainable Index
HK$	Hong Kong Dollar
IBT	Increasing Block Tariffs
IWA	International Water Association
MIU	Meter Interfacing Unit
PRD	Pearl River Delta
TWM	Total Water Management
UP	Uniform Pricing
WDM	Water Demand Management
WELS	Water Efficiency Labelling Scheme
WIN	Water Intelligence Network
WSD	Water Supplies Department

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FINANCIAL CONVERSION RATE

US$1 = HK$7.85
AU$1 = HK$5.41
€1 = HK$8.79
As of 24 May 2019

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EXECUTIVE SUMMARY

Hong Kong's water supply is coming under increasing pressure, with growing competition for the water it imports from Dongjiang River, while Hong Kong's ageing water infrastructure further wastes the supply it has through pipeline leaks. The growing population in Hong Kong adds to the strain, its high usage likely encouraged by low prices.

For Hong Kong to rise above these challenges, long-term solutions are needed. This new research project by Civic Exchange, *Modernising Hong Kong's Water Management Policy*, consists of two parts. This first part examines local demand and conservation challenges to recommend policy solutions and show how local demand can be reduced through responsible resource use. Its sister report assesses how local water infrastructure systems can be deployed to safeguard water security and accessibility for Hong Kong in the long run.

The challenge

Hong Kong recognises that its local water resources are affected by rainfall patterns and increased urban demand under higher temperatures. Local legislative and government bodies have highlighted several key challenges to Hong Kong's water system:

- Local daily per capita water consumption is double the world average of 110 litres, once the use of seawater for toilet flushing is taken into account.
- Water prices are low, and have not been updated since 1995.
- Over 30% of fresh water went unmetered during 2006-2016 due to mains pipe leakages, unauthorised consumption and inaccurate metering.
- Outdated information, incomplete records and data gaps significantly impair the monitoring of water consumption, pipeline repair efforts and accountability enforcement.

Hong Kong's main water source is imports from the Dongjiang River Basin, which is situated in Mainland China's most populated province of Guangdong. Imported water once accounted for 20-30% of Hong Kong's total water supply, but has gradually increased to 70-80%. Hong Kong's current annual supply ceiling for water from the Dongjiang River, under the new agreement established in 2017, is 1.1 billion m^3.[6]

While the arrangement provides Hong Kong with water security and affordability, it also means the quality and consistency of local water is dependent upon the resource usage of other cities in the Pearl River Delta. In the event that extreme climate conditions in Mainland China intensify competition for water, assurances that Hong Kong will always receive its desired share may not hold. Hong Kong needs to save water to ensure that its supply remains sustainable in the face of growing competition for water in the region, coupled with climate change. We have a duty to ensure reliable water supply for our future generations and for our neighbours.[7] We also have a duty to contribute to China's national effort on safeguarding our country's long-term water security,[8] and to the global ambition of ensuring availability and sustainable management of water for all as outlined in the United Nation's 2030 Agenda for Sustainable Development.[9]

The Hong Kong government's Water Supplies Department (WSD) could adopt a more basin-wide perspective when modernising its water policies. Local conservation measures – from reducing pipe leakages to lowering domestic fresh water consumption – could ripple outwards to positively impact the Pearl River Delta. This will become increasingly necessary, given projections for growing demand among Mainland Chinese families for medium- and high-income lifestyles from 2031-2050, and with it, the growing need for sustainable access to clean water sources.

Where does Hong Kong stand?

To address the issue of water security, Hong Kong promulgated its city-wide Total Water Management (TWM) strategy in 2008. It focuses on containing the growth of local urban water use by promoting water conservation and identifying new water resources. A revised version of the strategy is scheduled to be released in late 2019.

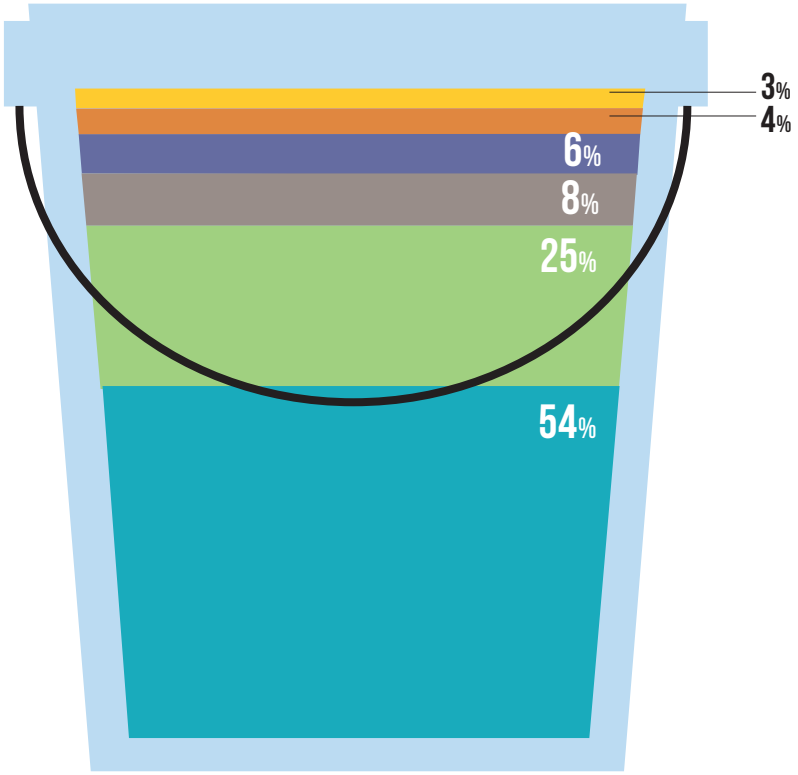
The TWM strategy consists of replacing 3,000 km of ageing water mains, dividing Hong Kong's water distribution network into discrete district metering areas under an Intelligent Network Management System, and holding regular education programmes to promote water conservation in all sectors, with specific focus on younger generations.

Overconsumption of water

Hong Kong currently stands out as a big user of water resources among its international peers,[10] despite having little manufacturing and virtually no agriculture. Domestic users are by far the largest consumer group of local fresh water, indicating the importance of promoting conservation to change household behaviour. Together with services and trade, these two sectors consume nearly 80% of local fresh water.

Sector Breakdown of Annual Fresh Water Use of Hong Kong (2016-17)

Source: WSD Annual Report 2016-17



Water use in each sector as a percentage of demand

Domestic
Service
Flushing
Industrial
Government
Construction and Shipping

There are several reasons for the high level of water consumption. The first is Hong Kong's low water prices, which have remained unchanged for more than two decades, even as the production cost and the lump-sum package cost of purchasing imported water from Guangdong have increased over the years.

Outdated pricing

Hong Kong residents spend a disproportionately small portion of their income on water bills. According to WSD, the average charge in 2016-17 was HK$48 per month, amounting to approximately 0.3% of the average monthly household expenditure.

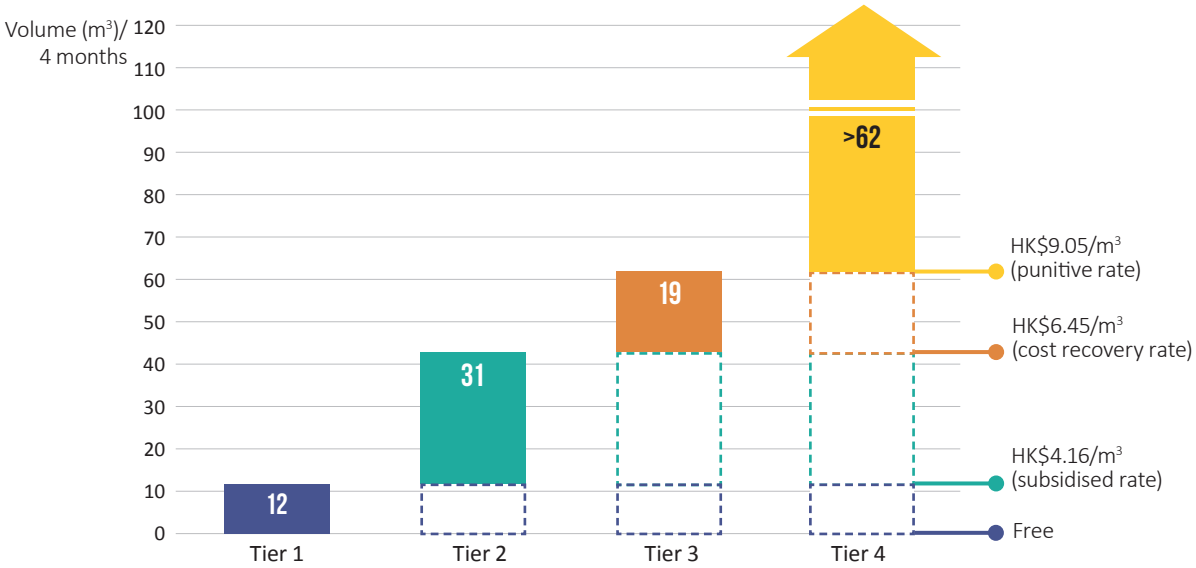
Pricing rate structures are frequently used as conservation tools: in the European Union, using high water tariffs to reduce water demand directly is the most common price intervention tool. Research also suggests that consumers who do not pay the full cost of water tend to use it inefficiently. However, utilities and policymakers must balance the concerns of affordability with efficient supply. Increasing prices can place a disparate

burden on poor households, who cannot adjust the amount of water used for basic needs, whereas wealthier households can still fail to recognise the price signal designed to curb excess consumption.

Hong Kong's water pricing uses an Increasing Block Tariffs (IBT) scheme, in which pricing is divided into blocks depending on the volume used, so the marginal price increases with each successive block but remains the same within each block. Despite this pricing system, Hong Kong's water consumption rate has not meaningfully decreased over time.

All Hong Kong consumers – whether domestic, corporate or government – can use up to 12 m^3 every four months free of charge. To cover this, the government gives more than HK$1 billion to WSD every year. Consumers then remain on the second pricing tier until they use more than 43 m^3 of water every four months. WSD's punitive rate only kicks in once users consume more than 62 m^3 of water, which is meant to reflect the true production cost. However, even this highest tier only charges HK$9.05 per m^3 of water consumed: just 54.5% of the full cost of providing it.

Tariff Structure for Domestic Use Per Tier (Every Four Months)
Source: Civic Exchange, using data from WSD Annual Report 2016-17



Given the difference in price between supplying Hong Kong residents with water and how little users pay for it, the government should look into renewing its tariff scheme by reviewing the pricing and threshold of each consumption block to promote conservation via a user-pays principle.

These changes would mean raising the price per unit, as well as lowering the total volume of water users can enjoy on tiers 1 and 2 before reaching more punitive rates. This is particularly important given that the government already subsidises HK$36 per account every four months, and the average WSD customer only pays HK$48 per month for water.

Billing cycle frequency changes could also be explored through pilot schemes to examine whether Hong Kong users would conserve water if confronted with water bills more often. Currently, Hong Kong users only receive water bills every four months due to WSD policy. Since domestic households are the biggest group of water consumers in Hong Kong, policymakers should consider deploying these economic mechanisms to correctly value water and change behaviour. It is essential, however, that this should be done with policy provision to ensure that the underprivileged have affordable access to water.

Wasted through pipe leakages

The second reason for Hong Kong's high water consumption is pipe leakages. Users may be asked and encouraged to conserve water, but high volumes of water are being lost before they even reach households and taps, the vast majority of leakages occurring in pipes carrying fresh water.

By 2030, Hong Kong aims to reduce the leakage rate in public mains to below 10% (down from 15.2% in 2017). An investigation into WSD's maintenance of government water mains by the Hong Kong ombudsman's office found that if the amount of fresh water lost through government mains each year was saved, it could meet the demand of approximately 2 million people in Hong Kong.

Lack of data and ambitions

Another issue contributing to Hong Kong's high water consumption is the lack of systematic data granularity. To better monitor, address and pre-empt water losses, it is crucial that data on a variety of usage metrics is collected systematically. Increased monitoring of usage data can nudge consumers towards conservation, but this data - especially on pipe leakage volumes - is lacking in Hong Kong.

WSD could also review its targets strategy with a view to reducing water consumption. The department publicly lists its performance targets, and its October 2017 policy agenda stated an aim of reducing per capita fresh water consumption by 10% by 2030, using 2016 as the base year. But it could begin to produce a more coherent overall strategy if it consistently compiled and updated key water consumption goals in a centralised and detailed location or website. This would demonstrate the will to meet more ambitious targets, and aspirations to methodically improve conservation on a quarterly or yearly basis.

Finally, Hong Kong could attempt to reduce water consumption by improving its Water Efficiency Labelling Scheme (WELS). Hong Kong launched its voluntary WELS as a conservation initiative in 2009. It covers a range of water-using devices, such as showerheads, washing machines, urinal equipment and flow controllers. WSD also has programmes to send households flow control devices to be installed on showers and taps in order to limit consumption.

The scheme is not compulsory, however, and even for products in Hong Kong that voluntarily adopt a WELS, the conservation thresholds they need to clear in order to be deemed most efficient are far more lenient than those in other cities.

In addition, WSD has promulgated numerous initiatives to standardise water usage across local industries in order to more widely distribute conservation practices in an institutional manner. The scope, however, is limited, with only two industries targeted: hospitality and catering, which in 2017, accounted for 16% of total fresh water consumption. In order to enhance water use efficiency in both sectors, WSD developed a set of best practice guidelines (published in both Chinese and English) to establish water-saving measures applicable to industry actors.

However, there is no auditing committee to review the commitments made, the degree of adherence or the tracking of compliance over time. Until formal evaluation procedures or enforcement mechanisms for the best practice guidelines are established, it will remain a voluntary act to promote these conservation efforts – let alone save meaningful volumes of water.

In light of the challenges outlined above, WSD has devoted resources and efforts to improving Hong Kong's water management. However, its actions represent a piecemeal approach to addressing water usage, and fall short of delivering a lasting impact on water usage and conservation.

Our recommendations

This report, therefore, makes the following seven policy recommendations:

i. Water pricing restructuring

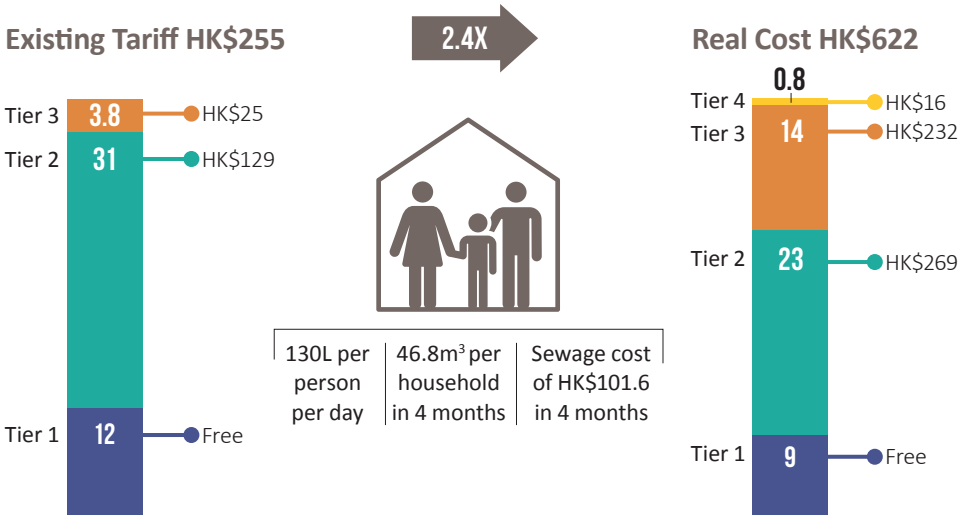
With current water prices lagging behind the cost of full recovery, a reform of Hong Kong's 1995 tariff charges is sorely needed. An imminent review of the pricing and the thresholds of the IBTs (Increasing Block Tariffs) is needed to revive the user-pays principle and cement the value of a scarce natural resource with every consumer account in Hong Kong.

The threshold of each consumption block in the IBTs reflected the average household size in public housing, which was 3.7 persons when the scheme was last reviewed in 1995. As the average household size has now shrunk by 26% to 2.75 persons, the threshold of each consumption block should be reduced accordingly.

Hong Kong's current daily domestic use of fresh water is 130 litres per person. Based on the reduced household size of 2.75 persons, as well as the the latest figures on net unit production cost and full unit production cost of water supply released by WSD,[11] the price of water following a user-pays principle for a three-people household would be HK$622 for a four-month period – 2.4 times higher than the current tariff of HK$255.

Cost of Water: Using a Three-People Household as Example

Source: Civic Exchange, using data from WSD Annual Report 2016-17



Updating the prices for water does not have to mean punitively raising costs for all societal groups – thus harming low-income groups – but it should prompt examination of whether certain pricing tiers and exemptions based on income and assets should be introduced. Local policymakers should keep this in mind when considering the use of water price adjustments to influence consumption.

Updating the prices for water does not have to mean punitively raising costs for all societal groups – thus harming low-income groups – but it should prompt examination of whether certain pricing tiers and exemptions based on income and assets should be introduced. Local policymakers should keep this in mind when considering the use of water price adjustments to influence consumption.

The frequency with which domestic accounts receive bills could increase: a notification to pay once every four months may reflect a lack of urgency or value of the water to the consumer, whereas seeing them more often could solidify the connection between water consumption and cost.

Consideration should also be given to removing the first tier of free water for all accounts, except those that fall under a certain household income level. Alternatively, if Hong Kong policymakers decide to remove this free portion for everyone, they could follow what many other countries have done to support low-income families in their water payments.

ii. More ambitious targets

Hong Kong's current long-term goals through 2030 represent baseline improvements. There could be a series of targets representing more aggressive efforts to tackle water waste, and a more ambitious track that the city could aspire to reach.

For example, Hong Kong currently has an official target of reducing the government mains pipe leakages rate to less than 10% by 2030. As the leakage rate in 2018 was approximately 15%, this goal would constitute a reduction of one third, and would save enough fresh

water (52,654,680 m^3) to supply close to 375,000 people annually. To meet the needs of a more substantial number of people (closer to half a million), the target for leaked water should be more ambitious and closer to around 8%. That would save enough fresh water (72,906,408 m^3) to supply close to 540,000 people per year.

WSD's annual reports contain goals for metrics such as accuracy of water meters, duration of suspended water supply for planned works, and fresh water supply pressure. WSD should devote more space to showcasing its progress on these goals. In addition, these targets need to be consistently updated and modified. At the time of writing this report, WSD's TWM strategy had not been updated in 10 years.

Reduction targets on water consumption (whether per capita, or ideally with more granularity, such as broken down by each sector that WSD has data on) should also be included to demonstrate alignment with water conservation.

iii. Technology

As shown above, district-level data on leaks and consumption is lacking, which impedes more rapid responses to resolving infrastructure failures.

With its high volume of water losses resulting from ageing pipes and chronic leakage, Hong Kong could benefit from an infrastructure that allows the accurate identification of leaks, and eventually the capacity to shut off water flow remotely. This would make the handling and maintenance of leakage sites much swifter and more effective, while also allowing consumers – who do not have precise and updated (let alone real-time) information on water consumption – to adjust their usage habits.

Initiatives are underway in Hong Kong to implement automatic meter reading (AMR) systems. In 2013, WSD launched a pilot scheme to evaluate the technical performance and data handling reliability of automated meter reading. Under the scheme, around 350 smart water meters designed to collect individual customer water consumption data remotely were installed in select blocks (one government quarter and two public rental housing estates).

WSD views the primary benefits of these AMR systems as improving water meter reading efficiency, enhancing the detection of leaks or abnormal consumption volumes, and engaging customers through more timely delivery of water usage data. The recognition of these technical solutions as ideal platforms for promoting water conservation is promising, and their continuing rollout could start to meaningfully address issues of chronic pipe leakage and overconsumption.

iv. Regulations

Legislative strategies to mandate certain restrictions on water use have seen certain success when it comes to specific applications, such as car washing or irrigation. However, the most obvious limitation to these initiatives is that they require policy intervention to be implemented, and may experience resistance from the community that then weakens the regulations.

Hong Kong could learn from London, Sydney and New York in areas such as achieving leakage goals, integrating water consumption reduction goals into new construction regulations, and cross-sector collaboration, as detailed in section 5.3 of this report.

v. Water-saving devices

Hong Kong could learn from Australia, whose government publishes statistics on how to effectively reduce water demand through water-saving devices. They make data publicly available on the financial consequences of toilet leakages, including litres lost on an hourly basis and how this translates into annual volumes and costs.

Hong Kong should also strengthen its WELS scheme. Equivalent Water Efficiency Labelling Schemes have seen widespread adoption around the globe. Not only do amenities such as toilets, washing machines and sinks have to use devices that meet a certain benchmark of water conservation; corresponding tiers of efficiency are far greater than the equivalent tier in Hong Kong. There is no reason for the weakest tier in other cities to match the strictest WELS tier used by WSD to indicate water savings. Ramping up what constitutes a valid water-efficient device in Hong Kong could produce substantial savings at the micro level, which would subsequently amount to significant levels at the aggregate level.

WSD's Let's Save 10L Water campaign requires residents to opt in on two fronts – sign a commitment pledge and also e-register to receive bills digitally – in order to receive two flow-limiting devices from the government, free-of-charge. Having to opt in to receive the essential tools to start conserving water is simply another step that could discourage adoption. Hong Kong should, therefore, consider having all or the vast majority of domestic consumers already opted in by default, so that a critical mass of the population receives the flow-limiting devices.

vi. Education programmes and school initiatives

Two public opinion surveys are available on WSD's website, conducted in 2011 and 2015. More frequent assessments could be produced to gauge a wider array of public attitudes on water, from overall pricing to the installation of flow-control devices. To produce meaningful action, there needs to be a purposeful, directed follow-up programme to the key findings of each survey.

A white paper or public consultation on what WSD learned from these insights, and how it plans to address the issue, would be important and helpful, and would be a step towards solving WSD's rather piecemeal approach to improving Hong Kong's water conservation.

vii. Robust and transparent data on water use

In tandem with the importance of using regulatory codes to publicise water use data, as outlined above, it is also crucial for such transparency to be applied to households. This would mean arming residents with composite information on their water usage, such as how much water is used in the kitchen or bathroom, and greatly facilitating user awareness on which household activities consume more water, as well as comparing their environmental impact.

Domestic households should have precise knowledge of how their water use compares to that of others in terms of their neighbours, building, estate and even district. This data could be anonymised and still contain useful benchmarks for residents to evaluate their own use.

Conclusion: it's time to modernise local water management

Hong Kong has been dealing with the same fundamental water issues for many years. Its consumption levels run high for a city its size, the current pricing structure distorts the value of water and the lack of available data keep policymakers in the dark about the districts where infrastructure is in greatest need of repair.

Hong Kong's wasteful water usage in its consumption habits, lack of ambitious conservation programmes and chronic infrastructure leaks not only reduce the availability of this scarce resource for the city's future generations, but also set a bad example for other cities in the Pearl River Delta.

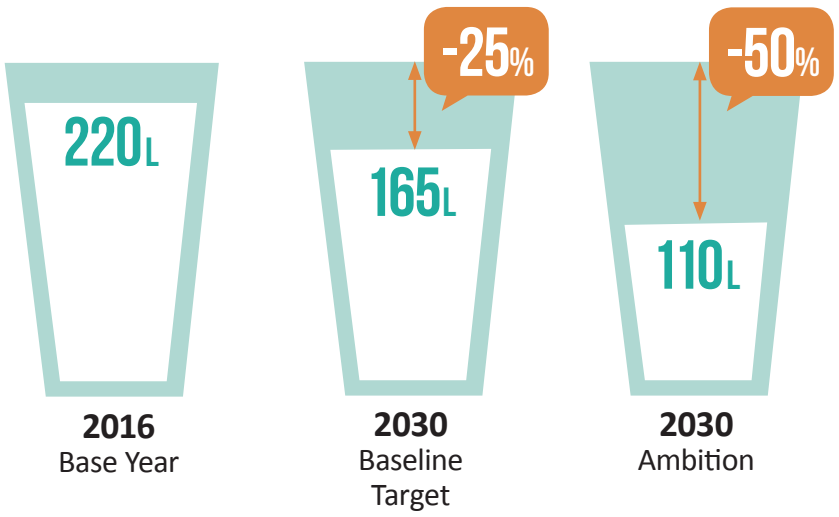
Given these challenges, Civic Exchange recommends that WSD and the Hong Kong government take specific policy actions to establish a bold directive for improving the state of domestic water control, and as a city take the initiative on effective resource management.

This study suggests that by 2030, WSD adjust two of its current goals to produce more meaningful water conservation goals in the next decade:

- Reduce **water lost** from leakages in government mains from 15% to 8% by 2030, which would save **72.9 million m³** of fresh water, or enough fresh water for more than 540,000 Hong Kong residents each year.
- Set a baseline target of reducing daily domestic water consumption by 25% by 2030, i.e. **from 220 litres to 165 litres per person**, which would result in an annual saving of **147.4 million m³** of water (fresh and seawater). A more ambitious goal would be seeking 50% reduction to bring our daily domestic water consumption to 110 litres per capita (an annual saving of 294.7 million m^3), meeting international best practice as demonstrated by comparable international cities such as Berlin and Madrid.

Daily Per Capita Domestic Water Reduction Targets for 2030

Source: Using data from WSD Annual Report 2016-17



Together, these goals would result in total annual water savings of at least 220.3 million m^3 by 2030: a volume equivalent to 17.7% of the total amount of water consumed in 2016;[12] or 367.6 million m^3 savings if we can achieve the more ambitious 50% reduction target, which would mean a 29.5% reduction in the total water consumed in 2016. Without these more ambitious targets, Hong Kong will only save around **72.3 million m^3** of fresh water

It is no longer sufficient to implement piecemeal solutions like water efficiency labelling schemes or offer flow-limiting devices if they are not part of a broader programme of frequent evaluation and data monitoring.

Should the city fail to modernise in a comprehensive, integrated and ambitious way, the longevity of its seemingly plentiful water supply will rapidly be called into question.

1 INTRODUCTION

During the 20th century, global water use increased six-fold,[13] and demand is projected to increase by 55% globally between 2000 and 2050.[14] Meanwhile, supply is under increasing strain: worldwide per capita water resources fell from 13,395 m^3 in 1962 to 6,000 m^3 in 2014, and are forecast to slump to 4,800 m^3 by 2025.[15] Large cities are particularly vulnerable to water scarcity, as they support dense concentrations of people while facing pressure from urban growth and climate change.[16]

Therefore, conservation – the preservation and control of resources - remains the conceptual basis of water demand management (WDM), particularly through any reduction in water use or losses.[17] This includes influencing individual and organisational behaviour towards more sustainable utilisation.[18] From a governance perspective, WDM functions as a policy framework to reduce water use and meet socioeconomic needs at a reasonable cost, without systemically reducing the supply available for future generations.[19] Water management should not be confined to the limits of a particular industry or environmental issue, but viewed as a multidisciplinary challenge and a core imperative for inclusive growth, territorial development and urban well-being.[20]

Meanwhile, climate change poses severe risks for water systems.[21] Added uncertainty from potential floods, droughts and extreme weather occurrences are now beginning to alter how cities manage water, and heighten the need for robust planning rather than short-term fixes.[22] Numerous municipalities worldwide face the crisis of ageing urban water infrastructure, and cannot afford to rely on near-sighted solutions.[23] To be resilient, cities need to anticipate future challenges when they invest in their drainage, sewerage and water storage infrastructure.[24]

Hong Kong already recognises that its local water resources can be affected by rainfall patterns and increased urban demand under higher temperatures.[25] To further strengthen its resilience, local legislative and government bodies have highlighted central challenges to Hong Kong's water system:

- Local daily per capita water consumption has exceeded the world average (110 litres) since 2004: current daily usage is 130 litres (fresh water only), or as high as 220 litres once seawater is also accounted for.[26]
- Low water prices have not been updated since 1995, and fail to recover full costs of production.[27]
- Over 30% of fresh water went unmetered during 2006-2016, due to mains pipe leakages, unauthorised consumption and inaccurate metering.[28]
- Outdated information, incomplete records and data gaps significantly impair the monitoring of water consumption, pipeline repair efforts and accountability enforcement.[29]

These issues require strategic and methodical solutions. To formulate meaningful responses, this report references international case studies to identify how various cities have approached similar challenges. Policy solutions adopted elsewhere range from more targeted education and information campaigns to closing the data gap with smart meter implementation and disclosing the efficiency and consumption data of commercial buildings. A combination of technological solutions and understanding of the socio-cultural behavioural factors affecting acceptance of these solutions is crucial for meaningful and systematic water reform.

This study's concluding policy recommendations are accordingly informed by these international case studies. It recommends that by 2030, the government set more ambitious, yet entirely realistic, conservation targets:

- Reduce water lost through leakages in government mains from 15% to 8% by 2030, which would save 72.9 million cubic metres (m^3) of fresh water, or enough fresh water for more than 540,000 Hong Kong residents each year.
- Set a baseline target of reducing daily domestic water consumption by 25%, i.e. from 220 litres to 165 litres per capita, generating an annual saving of 147.4 million m^3 of water. A more ambitious goal would be seeking 50% reduction to bring our daily domestic water consumption to 110 litres per capita (an annual saving of 294.7 million m^3), meeting international best practice as demonstrated by comparable international cities such as Berlin and Madrid.

Together, these goals would result in total annual water savings of at least 220.3 million m^3 by 2030, which is equivalent to 17.7% of the total water (fresh and salt) consumed in 2016; or 367.6 million m^3 savings if we can achieve the more ambitious 50% reduction target: a volume equivalent to 29.5% of the total water consumed in 2016.[30]

2 WHY DOES HONG KONG NEED TO SAVE WATER?

Hong Kong's main water source is imports from the Dongjiang River Basin, which is situated in Mainland China's most populated province of Guangdong.[31] Civic Exchange has studied this water-purchasing arrangement closely in previous research.[32] While the arrangement provides Hong Kong with water security and affordability, it also means the quality and consistency of local water is dependent upon the resource usage of other cities in the Pearl River Delta (PRD) region.[33] In the event that extreme climate conditions in Mainland China or other demand arising from economic and ecological development intensify competition for water,[34] assurances that Hong Kong will always receive its desired share may not always hold.[35]

Imported water once accounted for 20-30% of Hong Kong's total water supply, but has gradually increased to 70-80%. All supply agreements are based on consumption projections in Hong Kong: projections that account for population growth, industrial and commercial demand, as well as predictions for local yield. Hong Kong's current annual supply ceiling for water from the Dongjiang River, under the new agreement established in 2017, is 1.1 billion m^3.[36]

The Hong Kong government's Water Supplies Department (WSD) can adopt a more basin-wide perspective when modernising its water policies. Local conservation measures – from reducing pipe leakages to lowering domestic fresh water consumption – could ripple outwards to positively impact the PRD region. This will become increasingly necessary, given projections for growing demand among Mainland Chinese families for medium- and high-income lifestyles from 2031-2050, and with it, the growing need for sustainable access to clean water sources.[37]

Hong Kong could practice more responsible usage of this shared resource. The Dongjiang has played a key role in supplying drinking water to support the socio-economic development of the Pearl River Delta region and Hong Kong.[38] With more than 60 million inhabitants,[39] the PRD is by some measures the world's most populous urban conglomeration,[40] and contributed more than 9% of national GDP in 2015.[41]

Such economic activity presents challenges for environmental conservation, particularly water resource management.[42] Over time, worsening water problems have accompanied this tremendous regional growth.[43] The PRD has 693 m^3 of annual per capita water

resources, compared to 1,782 m^3 per capita for Guangdong province[44] and 2,100 m^3 per capita for Mainland China.[45] Hong Kong's Legislative Council has already deemed the exploitation level of the Dongjiang River Basin to be rapidly approaching its limit, due to a rapid utilisation rate.[46]

2.1 Local water management

Hong Kong promulgated its city-wide Total Water Management (TWM) strategy in 2008. It focuses on containing the growth of local urban water use by promoting water conservation (water demand management) and identifying new water resources (water supply management). Since the end of 2014, TWM has been under review with outside consultants to ensure an updated strategy prepares Hong Kong for uncertainties regarding climate change. A revised version of the strategy is scheduled to be released in late 2019.[47]

To address what it deems crucial urban demand issues, WSD embeds the following solutions in its TWM strategy:

- **Repair and Rehabilitation of Water Mains programme:** This initiative started in 2000 to systematically and comprehensively replace 3,000 km of ageing water mains in 15 years. As of 2017, the number of leaks is 62% lower than in 2000, while the number of burst pipes is 97% lower.[48]
- **Water Intelligent Network (WIN):** this initiative divides Hong Kong's water distribution network into discrete district metering areas. WSD relies on electromagnetic flow-meters and a data logger to transmit water and pressure data to control centres, to more actively monitor any supply issues.[49] WSD anticipates that the remaining district metering areas can be established by 2023, and an Intelligent Network Management System to detect abnormal water distribution patterns can enter into operation by the end of 2019.[50]
- **Public Education on Conservation:** the government planned to regularly launch education and publicity programmes to promote water conservation in all sectors, with specific focus on younger populations. WSD would also step up actions already underway, such as public announcements, television and radio segments, leaflets, seminars and exhibitions.[51]

The TWM's ultimate aim is to nurture a "water-wise" mindset among residents by enhancing public education on water use and savings, and creating informed citizens who appreciate the scarcity and value of water.[52]

This study will show that 10 years since the inception of TWM, Hong Kong needs to instil not just "water-wise" citizens, but responsible resource users. This could mean meeting urban need with lower volumes and at reduced costs, including environmental costs. Meaningful policies targeting behavioural change and regulation are required to change how current and future generations use this valuable resource, given the reality of the entrenched water problems facing the city.

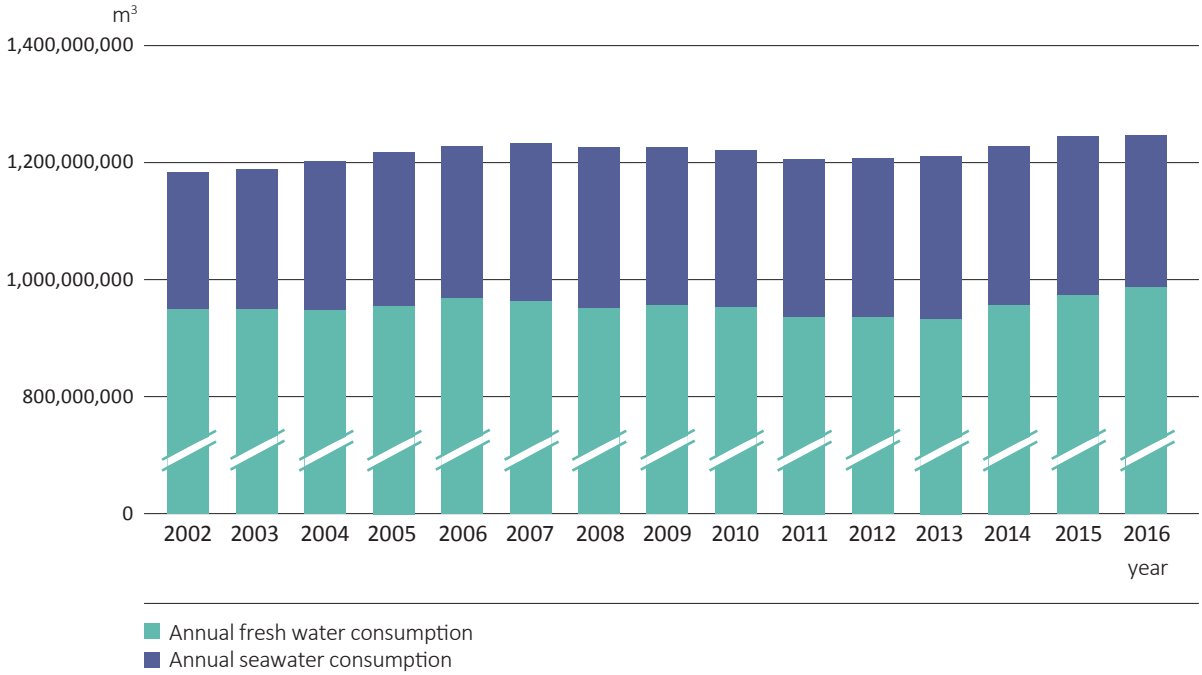
3 HONG KONG'S WATER OVERCONSUMPTION

Modernised water management can often revolve around prioritising efficiency and the productivity of households or appliances using a limited volume of water.[53] However, the underlying components of urban consumption should be critically examined to understand better where most efficiencies are needed. For Hong Kong, overall water usage has grown, with per capita consumption of fresh and seawater exceeding many peer cities and failing to decline over time.[54] In the long-term, more significant usage may cause sufficiently more strain on local sources.

Total local consumption of water has increased slightly during the last 15 years. The proportion of fresh water in the total volume used has consistently been between 70% and 80%, whilst seawater makes up the rest of the consumption. The average year-on-year increase since 2002 has been 0.6% (2016 is the latest year for which seawater consumption data is publicly available). The fresh water component grew by a year-on-year average of 0.4% during the same period.[55]

FIGURE 1 **Annual Water Consumption of Hong Kong (2002-2016)**

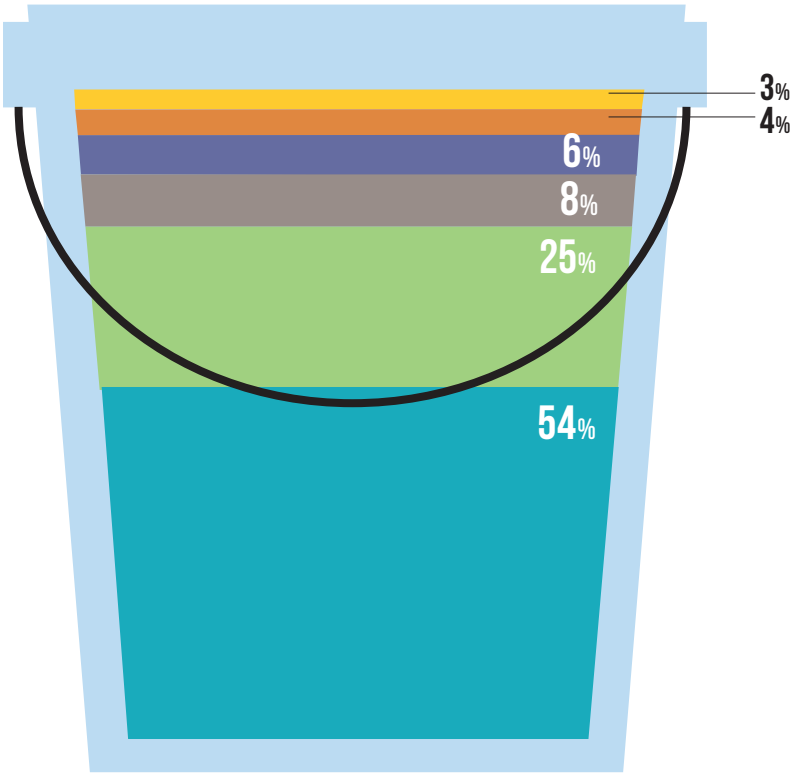
Source: WSD Annual Reports 2005-06; 2010-11; 2016-17



The composition of local fresh water consumption has mostly been consistent in recent years (see Figure 2 below for the latest breakdown). Domestic users are by far the largest consumer group, indicating the importance of promoting conservation to change household behaviour. Together with services and trades,[56] these two sectors consume nearly 80% of local fresh water. More specific information on non-domestic accounts is sparse due to privacy concerns.[57] While annual figures for government departments with the highest water consumption are available,[58] the same transparency does not apply to the most substantial users in other sectors.[59]

FIGURE 2 **Sector Breakdown of Annual Fresh Water Use of Hong Kong (2016-17)**

Source: WSD Annual Report 2016-17



Given the distinctly outsized representation of households, it is crucial to examine what demand for fresh water will look like in the next couple of decades, to better understand how to target household groups with conservation policies.

3.1 Projecting water consumption

Forecasts can provide insight into what future urban water demand might look like and enable plans to be made to meet such demand. WSD has publicised numerous versions of a simplified fresh water demand projection (only providing forecasts by the decade), up until 2030. This first began in its 2008 TWM strategy, with notable demand increases moving forward (see Table 1 below).

TABLE 1 **Official WSD Water Demand Projection Estimates**

Source: WSD, 2008

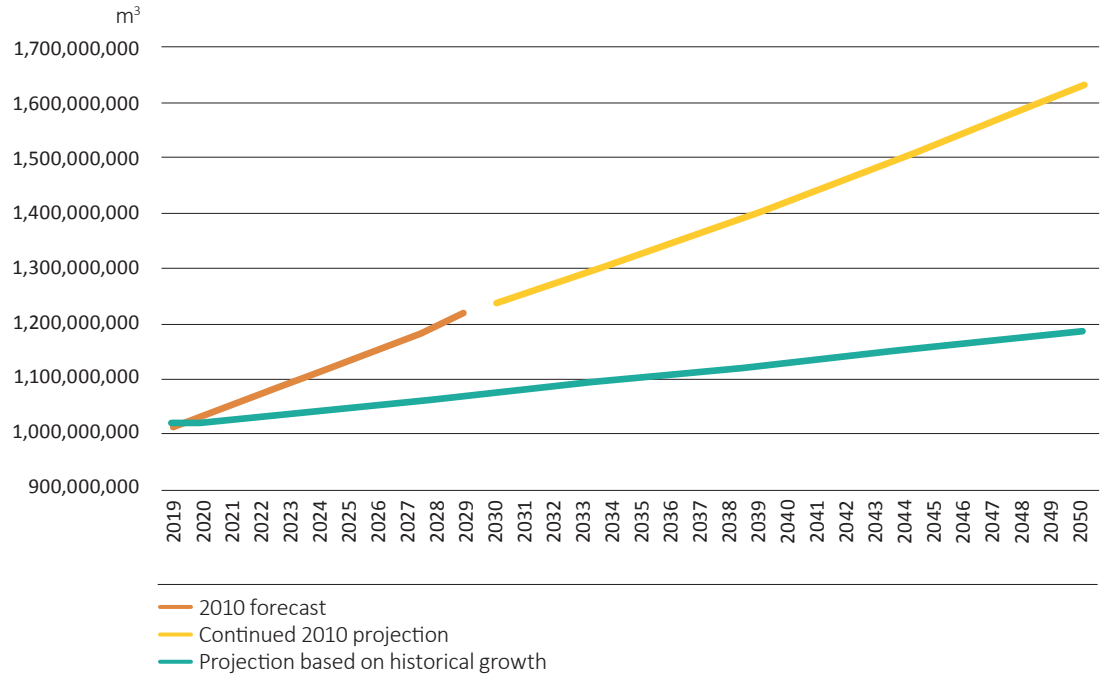
Year	Projected Fresh Water Demand (m^3)	% increase
2010	1,000,000,000	NA
2020	1,100,000,000	10%
2030	1,315,000,000	20%

In subsequent annual reports, WSD continued to publicise future estimates. These updates reduced projected water demand for the years 2020 and 2030 compared to initial projections made in 2008.[60] However, WSD does not publicly detail the assumptions that go into making these estimate changes. Such opacity throws doubts on the reliability of its projections. It is also worth noting that 2014-15[61] is the final WSD annual report to include demand forecasts, while the year 2011-12[62] is the only document featuring specific annual estimate figures up until 2030 (the figures are for projections made in 2009 and 2010). WSD says that it continues to track and forecast demand internally, and that the government will release revised numbers during its TWM strategy update.[63] It may be relevant for future consumption forecasts to include clear comparisons to population growth, so as to illustrate per capita water usage increases with demographic growth.

To visualise a simplified interpretation of water usage growth patterns, this study applied the rate of increased projected demand from WSD's 2010 forecast (an average of 1.4% year-on-year growth) to 2050.[64] In Figure 3, the red line represents demand projections up until 2030, with the yellow line continuing the forecast through mid-century. The blue line represents a projection based on the average year-on-year growth rate of historical fresh water consumption.[65] While the most obvious limitation to this linear extrapolation is its omission of other key inputs, the exercise can still paint a basic picture of future water needs. It also highlights the gap between projected demand from WSD's forecast and that based on the trend of historical consumption.

FIGURE 3 **Fresh Water Demand Projection (2020-2050)**

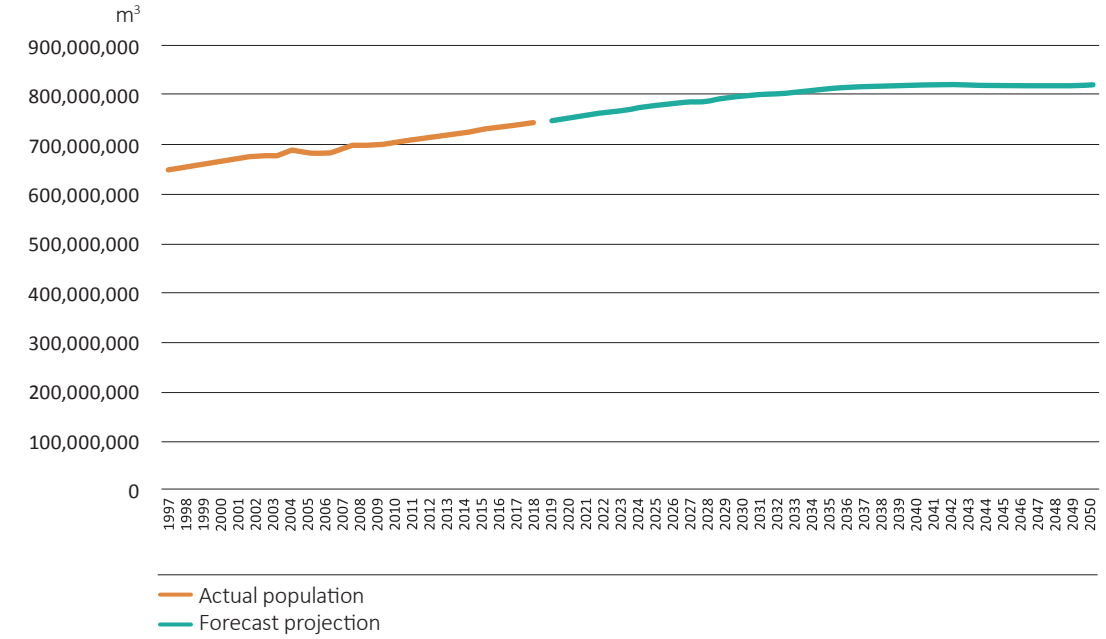
Source: WSD Annual Report, 2011-12



To formulate a per capita water usage comparison, historical trends and future estimates of Hong Kong's population are needed. As illustrated in Figure 4 below, the number of local inhabitants has grown at an average rate of 0.7% year-on-year since the 1997 handover from British rule to Chinese. Official government projections through 2050 show a baseline scenario in which the population plateaus at about 8.21 million residents in 2042-43.

FIGURE 4 **Historical Hong Kong Population Growth (1997-2018) and Forecast Projection (2019-2050)**

Source: Census and Statistics Department



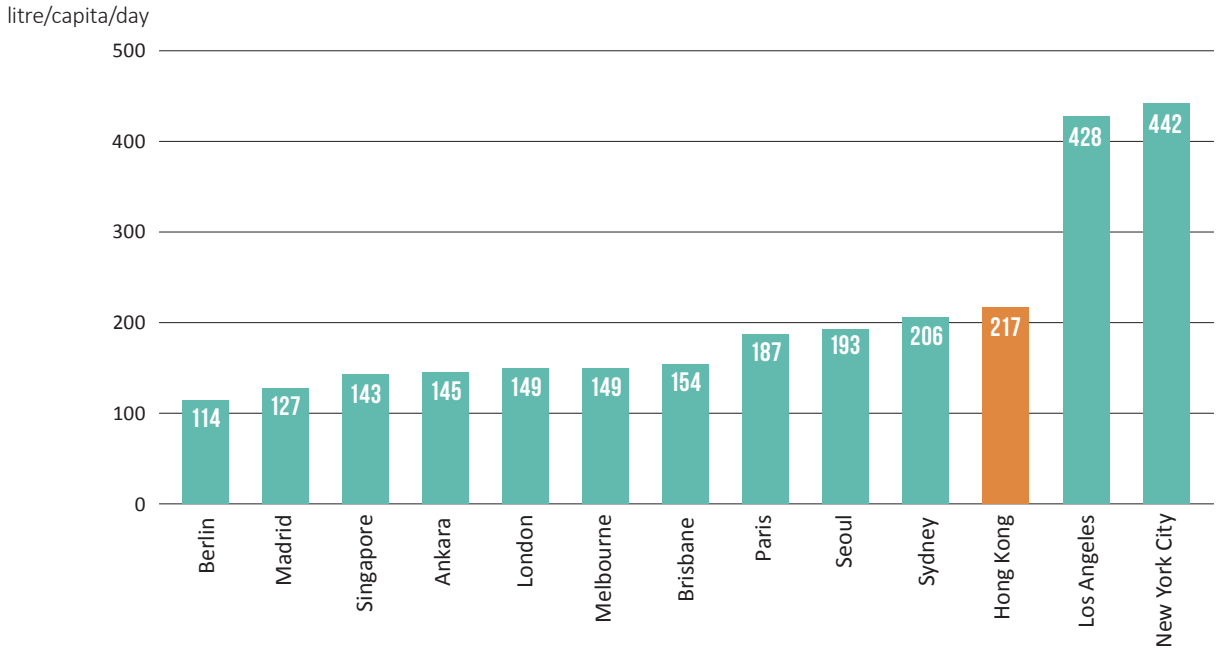
Whilst the census data projects Hong Kong population to grow with an average rate of 0.7% year-on-year up until 2030; the projected water demand from WSD's 2010 forecast is at an average of 1.4% year-on-year growth, which doubles the rate of population growth. The basis for WSD's forecast is unclear.

3.2 Water consumption of peer cities

For a comparison with international peers, this study examined the 2016 per capita household water consumption of 12 other cities (see Figure 5 below). These were selected from the International Water Association's (IWA) database because their population figures exceeded 3 million but were less than 10 million, to provide some realistic comparison with Hong Kong. The IWA defines domestic consumption as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, car washing, and watering lawns and gardens.

FIGURE 5 **Daily Per Capita Household Water Consumption of Select International Cities (2016)**

Source: International Water Association, 2016

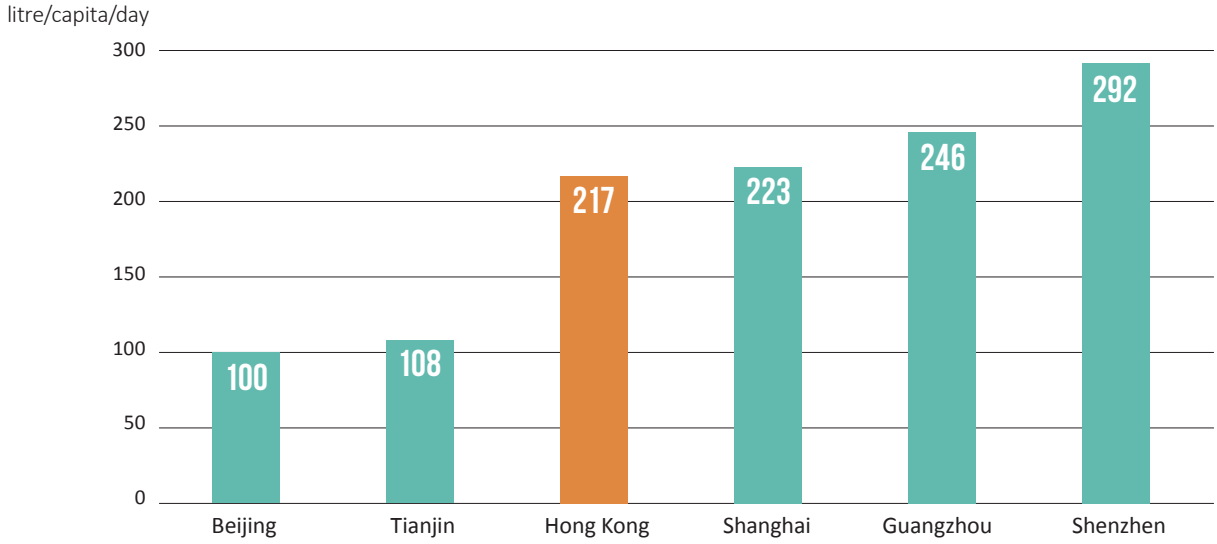


Los Angeles has substantially higher daily per capita consumption due to heavy water use to preserve plant and tree biodiversity and ecosystems.[66] In New York City, its dense residential and commercial building environment – in combination with its numerous large urban parks – has resulted in similarly high per capita consumption.[67] With the exception of these two cities in the US, Hong Kong stands out as a big user of water resources among its international peers.

Comparisons with cities sharing the same water source are also relevant. The IWA database only contained five Mainland Chinese cities, whose per capita water consumption figures for households are shown below. Hong Kong uses the least water compared to the other two cities that share its water source: Guangzhou and Shenzhen.[68] Civic Exchange has previously documented the historical rise of water consumption in five Mainland Chinese PRD cities since the early 2000s.[69] At a provincial level, Guangdong per capita water use has been steadily declining since 2010,[70] even as Guangzhou had the highest per capita water consumption in 2011 out of all PRD cities.[71]

FIGURE 6 **Daily Per Capita Household Water Consumption of Select Mainland Chinese Cities (2016)**

Source: International Water Association, 2016



These consumption trends provide context for Hong Kong, which can help develop a basin-wide perspective on conserving water. They indicate that while Hong Kong is not the worst offender, it stands out as a big water user among its comparable international peers despite having little manufacturing and virtually no agriculture.[72] The next chapter will detail the potential significant contributors to high local water consumption.

4 REASONS FOR HIGH CONSUMPTION

4.1 Low water prices

A modern water system's pricing structure should take into account the full cost of recovery and production. Hong Kong's pricing has remained unchanged for more than two decades, even when the production cost and the lump-sum package cost of purchasing imported water from Guangdong increased over the years. This begs the question: how influential is price on water use?

WSD is the sole water supplier in Hong Kong, and does not compete with multiple utility companies to provide this public resource. The department established its water pricing regime in 1979.[73] This payment scheme uses punitive charges as an economic means of discouraging high consumption. The most recent revision took place in 1996 for shipping (non-local vessels), when the final price was set at 40% higher than unit production cost in order to "discourage the taking of water in Hong Kong."[74] The pricing tiers issued by WSD are meant to approximately recover the net production cost, beginning at the second tier (since the first tier is completely free).[75] However, government research from 2015 showed that only when local consumers reached the third tier of pricing did the tariff actually reflect outdated real production costs of 1995.[76]

Given that WSD is the sole supplier of water, it does not face the controversy that utility companies in other cities do when raising prices: the issue of higher revenue when meting out harsher punishment for over-consumption.[77] Nonetheless, the perception of an increasing burden to taxpayer and general public for a cheap public resource – even if it is priced far below cost recovery and arguably improperly valued in terms of scarcity – must be taken into account.

Hong Kong residents spend a disproportionately small part of their income on water bills. According to WSD, the average charge in 2016-17 was HK$48 per month, amounting to approximately 0.3% of the average monthly household expenditure.[78] Globally, it is generally accepted that the cost of access to safe water and adequate sanitation should not exceed 5% of household income. This 5% guideline has been stated repeatedly in various United Nations reports (e.g. UNDP in 2006)[79] and implemented in many cities. Very few households globally spend more than 5% of their income on piped water services, and Hong Kong's 2.7 million domestic water customers pay far less.

While this does not mean that Hong Kong domestic water bills should reach 5% of the average monthly income, it does warrant a serious look into how effectively price adjustments could reduce water consumption.

4.1.1. Pricing as a mechanism for controlling water consumption

Hong Kong could consider systematically reviewing its tariff system to incentivise responsible water consumption and conservation. This next section outlines how pricing mechanisms around the world have been used to modernise water systems.

Charging for water can effectively manage urban demand for several reasons:

- Prices should reflect the full cost of the water supply, as well as the scarcity of the resource.[80]
- The price should be high enough to cover the water utility's operational costs.
- Water pricing should also have the goal of promoting efficient water use, in order to help achieve the sustainability of the water resources over the medium to long term.[81]

The main challenge is to ensure households pay a reasonable price based on the available water that can be supplied. Sustainable and responsible water usage is essential to provide high-quality water reliably to consumers at any time while ensuring the supplier or utility can see a return.[82] While traditional methods of education and conservation programmes still play a role, pricing rate structures are frequently used as conservation tools.[83] For instance, using high water tariffs to reduce water demand directly is the most common price intervention tool in the European Union.[84]

Research also suggests that consumers who do not pay the full cost of water tend to use it inefficiently.[85] However, utilities and policymakers must balance the concerns of affordability with efficient supply.[86] Increasing prices can place a disparate burden on poor households, who cannot adjust the amount of water used for basic needs, whereas wealthier households can still fail to recognise the price signal designed to curb excess consumption.[87]

4.1.2 Types of tariff structures

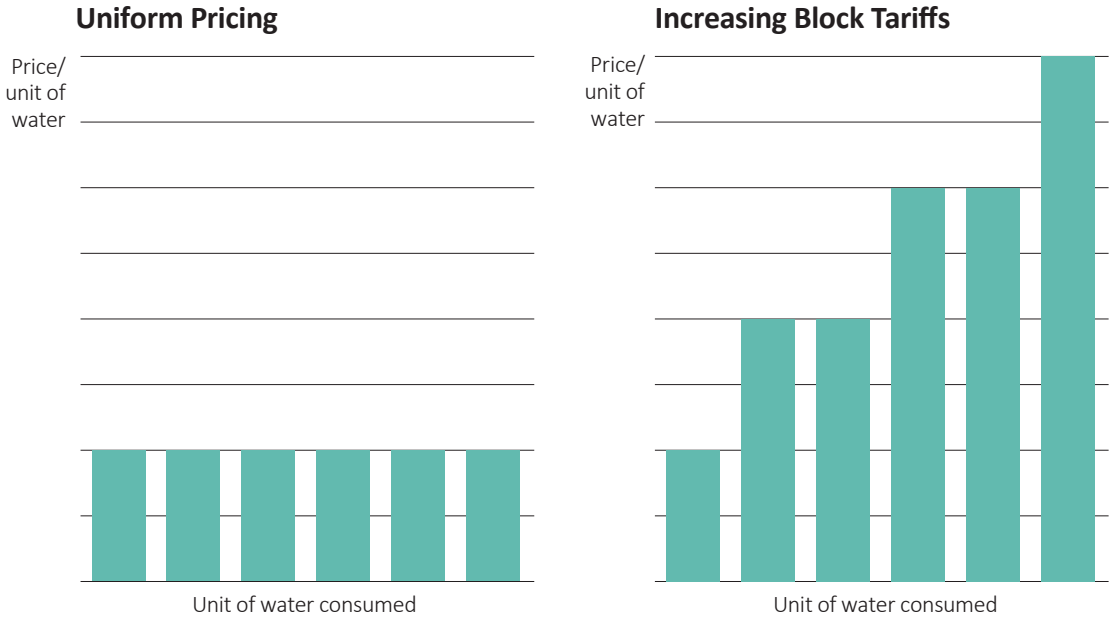
There are two main types of institutional charging mechanisms for water:

- **Uniform Pricing (UP)**
  - Also known as volumetric charges, these schemes price water at the same level (independent of use), where consumers pay proportionally to their overall consumption.
  - UP schemes used to be the most common water charge throughout the world, given the relative simplicity for consumers to understand the link between usage volume and higher bills.[88]
  - In recent years, UP schemes have been replaced by increasing block tariffs as the most common charging tool around the world.[89]

- **Increasing Block Tariffs (IBTs)**
  - Often called 'lifeline' or 'social tariffs,' these tools are used to protect the poor, by charging affordable rates for a volume designed to cover basic needs. This is the amount of the first block and is priced at a very low level, usually below the cost of production.[90]
  - Typically, the next block within the tiered structure is at a higher price, so the marginal price increases with each successive block but remains the same within each block.[91]
  - Depending on the region, the total number of blocks can vary significantly.[92]

FIGURE 7 **Conceptual Illustrations of Water Pricing: Uniform Pricing (UP) and Increasing Block Tariffs (IBTs)**

Source: Civic Exchange, with reference from US Environmental Protection Agency, 2019



Implementing IBTs to charge progressively for higher water consumption depends on consumers actively responding to price changes, and decreasing usage as it becomes more expensive. There is some evidence to support this assumption:

- The Brisbane City Council Area (Queensland, Australia) introduced an IBT scheme for residential water use in 2006 to replace a UP programme. Data recorded in 2005-2008 showed that on average, there was about a 36.5% reduction in water consumption as a result of this pricing programme shift.[93]
- Denmark instituted full-cost recovery for urban water consumers in 1992, resulting in drastic changes. The real price of water increased by 54% from 1993-2004, reducing water demand from 155 litres per person per day to 125.[94]
- At a state level, a 2011 study of 10 OECD countries featured a robust, statistically significant negative relationship between the average price of water and household water consumption.[95]

However, merely having an IBT does not automatically lead to reduced usage. Hong Kong's water pricing uses this scheme, yet as shown in section 3, its water consumption rate has not meaningfully decreased over time.

Below are other examples where IBTs offer mixed results on water use:[96]

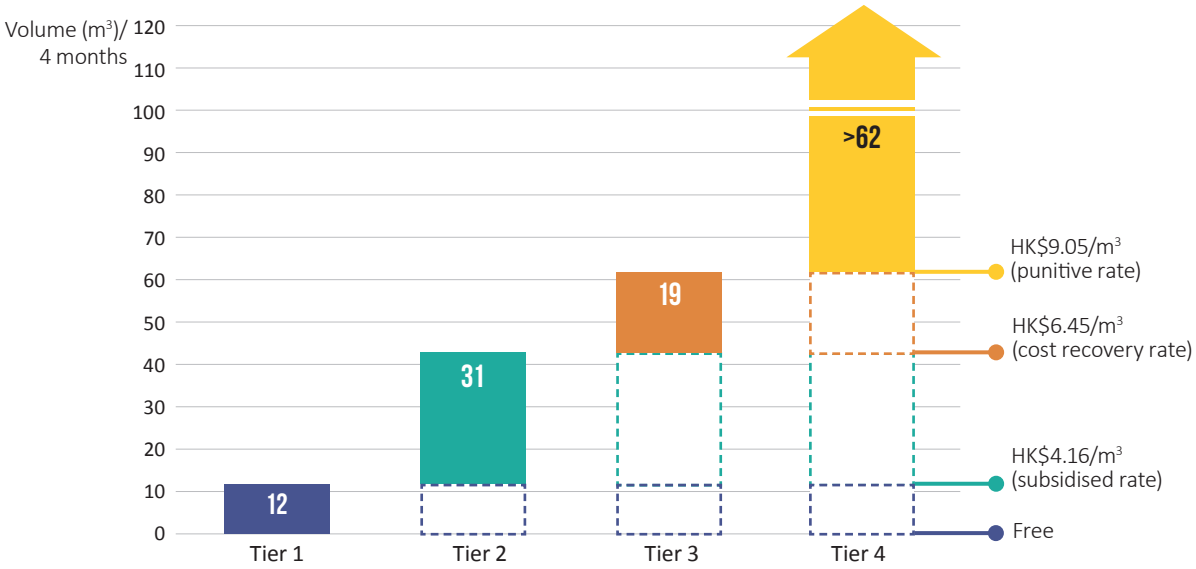
- Chapel Hill, North Carolina (US) introduced an IBT in 2007, only to see a short-term net increase in overall consumption because the prices for the first and second consumption block were actually lower compared to the previous tariff structure.[97]
- In 2012, Spanish provincial capitals (90% of which used IBTs) showed that greater water scarcity and economic activity led to more progressive blocks (i.e. more punitive charges). However, water usage decreased for smaller households and increased for larger ones.[98]
- In general, weather and outdoor water use were closely correlated, resulting in seasonal changes in residential water demand that significantly influence price sensitivity in some countries.[99] This could result in changing water consumption, irrespective of how effective an IBT might be.

It is also crucial for policymakers to recognise that tariff design is key to determining how successful it is in reducing urban consumption:[100]

- Price:
  - Many IBTs do not effectively reduce consumption because the higher tier blocks are not punitive enough in price. Adjustment of tariff block price is crucial to reflect changing environmental and socioeconomic conditions.[101]
  - Hong Kong has not updated its pricing scheme in more than 20 years, so distortions in cost could be addressed with any upcoming changes.
  - In order for Hong Kong users to consume their first 12 m^3 every four months for no charge, the government contributes more than HK$1 billion to WSD every year.[102] On a unit level, this concession covers HK$3 per m^3 of fresh water – HK$36 every four months per user account – before consumers begin paying.[103]
  - After finishing the first tier, consumers remain on the second pricing tier until they use more than 43 m^3 of water every four months (see Figure 8), which equates to roughly 215 bathtubs. WSD's punitive rate only kicks in once users consume more than 62 m^3 of water, which is meant to reflect the true production cost. However, even this highest tier only charges HK$9.05 per m^3 of water consumed, just 54.5% of the full cost of providing it.[104]

FIGURE 8 **Tariff Structure for Domestic Use Per Tier (Every Four Months)**

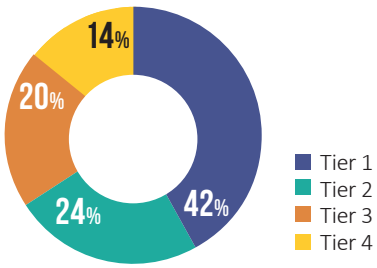
Source: Civic Exchange, using data from WSD Annual Report 2016-17



- Tier size:
  - The first consumption block within an IBT can sometimes be so large that almost all residential accounts only consume water within this level.[105]
  - This is highly relevant for Hong Kong, which allocates 12 m^3 of fresh water every four months to all consumers – domestic, corporate and government – free of charge.
  - The threshold of each consumption block in Hong Kong's IBT has not changed since 1995[106] when household size in public housing was at an average of 3.7 persons.[107] The latest data from Hong Kong Housing Authority showed that average household size in public housing in 2017 has shrunk to 2.75 persons,[108] 26% less. Hence, this raises the obvious question of whether the threshold of each consumption block should be adjusted according to average household size; and whether inaction implies our society's approval for excess water use.
  - The average water charge in 2016-17 amongst 2.7 million domestic customers (including those not required to pay any charge) was HK$48 per month.[109] See Figure 9 below for the proportion of domestic consumers in each water charge tier: more than half pay no more than HK$4.16 per m^3 every four months.

FIGURE 9 **Proportion of Households in Each Water Tariff Tier (2016-17)**

Source: WSD Annual Report 2016-17



- Billing cycle:
  - Clear and accurate bills should aid learning and reduce uncertainty surrounding water usage.[110] However, IBT regimes mean billing information can become drastically more complex for consumers, given the multiple tiers and price points.
  - Some experts argue that because Hong Kong users only receive water bills every four months due to WSD policy, consumers are not subject to more frequent monthly price signals to remind them of usage volumes.[111]
  - However, the research literature on this topic yields mixed findings.[112]

Given the difference in price between supplying Hong Kong residents with water and how little users pay for it, the government could revive its tariff scheme by reviewing the pricing and the threshold of each consumption block to promote conservation via a user-pays principle.

These changes should mean raising the price per unit, as well as lowering the total volume of water users can enjoy on tiers 1 and 2 before reaching more punitive rates in later block charges. This is particularly important given that the government already subsidises HK$36 per account every four months, and the average WSD customer only paid HK$48 per month for water. Billing cycle frequency changes can also be explored through pilots to examine whether Hong Kong users conserve water if confronted with water bills more often. Since domestic households are the biggest group of water consumers in Hong Kong, policymakers should consider deploying these economic mechanisms to correctly value water and change behaviour. This should be done with policy provision to ensure that the underprivileged have affordable access to water.

4.2 Pipe leakages

Addressing water infrastructure issues in the form of leaking pipes and burst mains is crucial. Users may be asked and encouraged to conserve water, but high volumes of water are being lost before they even reach households and taps. As such, the leakage rate – the difference between delivered water and consumed water – is a significant challenge that needs to be aggressively addressed to systematically minimise waste.

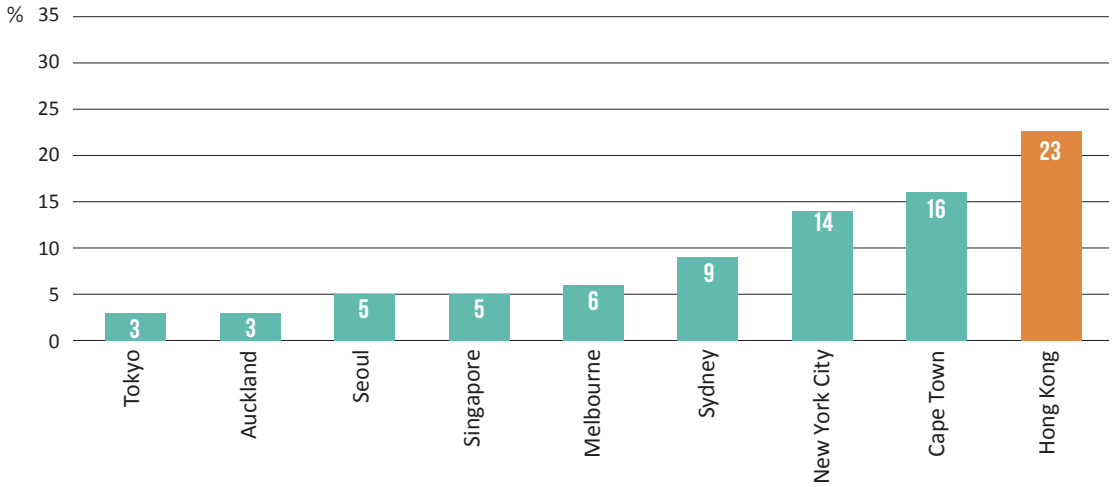
This has been a longstanding issue that has attracted multiple official inquiries from lawmakers and government authorities. In 2018, the Hong Kong ombudsman's office launched a direct investigation into WSD's maintenance of government water mains.[113] The probe was prompted by the high leakage rate (15.2%) of public mains (i.e. WSD/government water pipes).[114] Based on per capita consumption data, the investigation asserted that if the amount of fresh water lost through government mains each year was saved, it could meet the demand of approximately 2 million people in Hong Kong. Based on the average cost of Dongjiang water during the past three years (HK$5.5 per m^3), the saving would amount to approximately HK$530 million.

Tackling water losses from leaking pipes is a core priority in the Hong Kong government's 2008 TWM strategy. By 2030, Hong Kong aims to reduce the leakage rate in government water pipes to below 10% (down from 15.2% in 2017), to decrease losses occurring in public mains.[115] Over time, the number of incidences of leaking and burst pipes has decreased, and WSD plans to make further progress on this front via initiatives such as its Water Intelligent Network (WIN).

Hong Kong is a rare example of a city with a dual-water system – supplying seawater for toilet flushing, as well as fresh water – and experiences the vast majority of its leakages in pipes carrying the fresh water.[116] As a percentage, the overall pipe leakage rate in Hong Kong remains high compared to peer cities:

FIGURE 10 **Water Mains (Public & Private) Leakage Levels of Select International Cities (2017)**

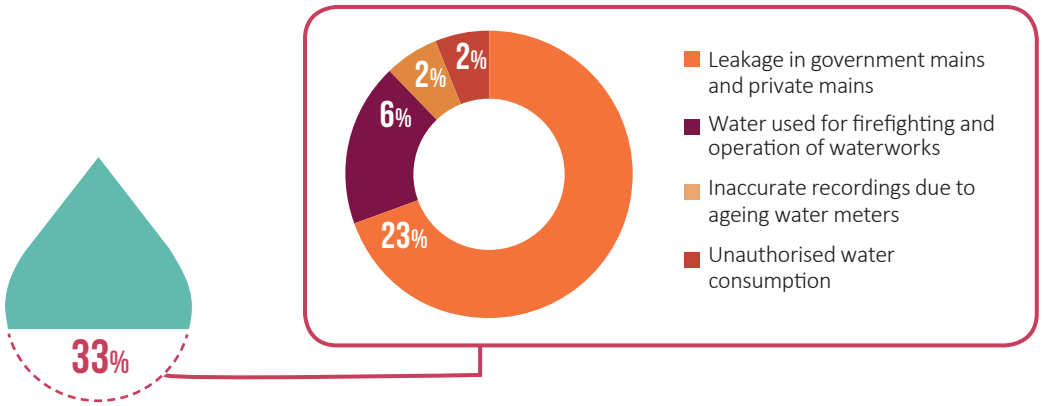
Source: Japan International Cooperation Agency, 2017; Watercare, 2017; Jang D. and Choi G., 2017; Public Utilities Board, 2015; Melbourne Water Corporation, 2018; New York City Department of Environmental Protection, 2018; City of Cape Town, 2018; WSD, 2019



Nearly 33% of fresh water is unmetered. WSD divides this into four distinct areas, which the chart below illustrates for the two most recent years.

FIGURE 11 **Composition of Unmetered Fresh Water (2017)**

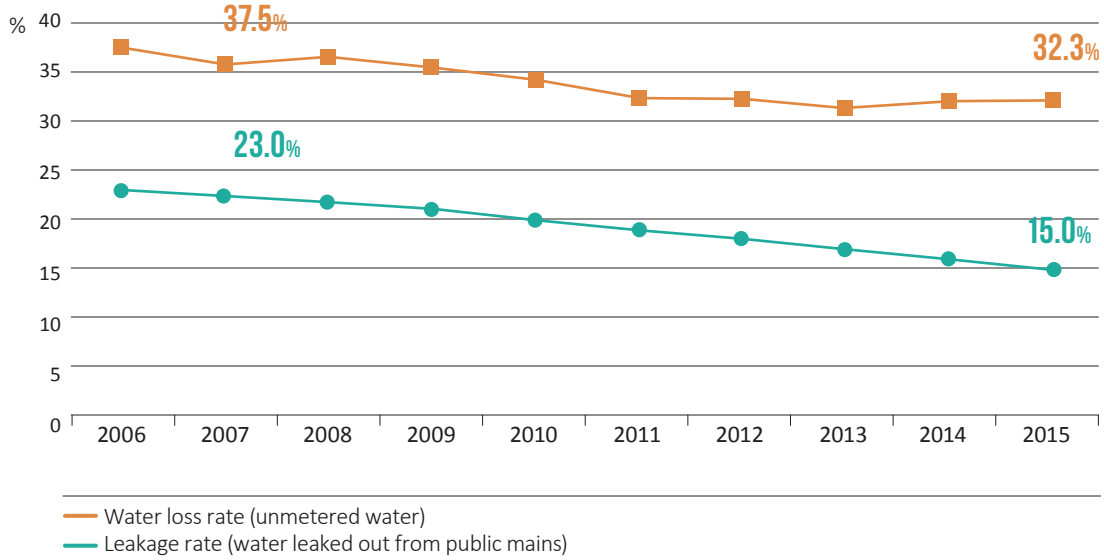
Source: WSD by request, 2019



Below is a Legislative Council chart displaying historic total water loss trends in Hong Kong, and identifying how much is lost from government-owned public mains (in green). Progress is being made, but the overall loss is still higher than that of Hong Kong's peers. Even as public pipe leakages are decreasing, overall losses are on the uptick. This challenge is significant because of the financial and natural resource waste.

FIGURE 12 **Pipe Leakages Rate (2006-2015)**

Source: Reserach Office of the Legislative Council Secretariat, 2017



In its 2018-19 budget, WSD clarified the breakdown of leakages between government and private mains, which states that government water mains leakage rate was 15.2% for 2016 and 2017, and estimated to be identical for the year 2018;[117] whilst leakages in private mains (i.e. non-government facilities, from commercial to private residential) were 9.8% and 7.8% respectively for 2016 and 2017.

According to WSD, private mains leakages occur in pipes that are no longer on government land.[118] All new private housing or public rental housing estates (constructed after 2006) with two or more building blocks have a master meter located between the public water mains and those on private land and/or within private structures, in order to track volumes leaving the government supply.[119] As of May 2018, WSD had installed master meters in approximately 500 private and public rental housing estates.[120] WSD is progressively installing meters in the remaining estates based on an assessment of their risk of leakage.

Currently, residents of these estate units bear the costs of water wastage. Any pipe bursts taking place outside government water mains – whether within a private building or the land underneath the structure – is the responsibility of the management company or private owner to resolve. WSD emphasises that households within a residential estate that has leaking pipes will bear the costs of addressing pipe leakages, but this cost is added into estate-wide management fees by the management company, rather than being included in the four-month water bill.[121] In its 2006 annual report – the same year master water meters would start being built – WSD stated that this technical implementation policy is to "help encourage the public to pay more attention to their maintenance responsibilities."[122]

The widespread occurrence of leaks across the city is compounded by the lack of visibility of specific leakage areas. Volumetric data used for monitoring or review – let alone made for public assessment – has yet to be collected systematically and efficiently.

4.3 Lack of systematic data granularity

To better monitor, address and pre-empt water losses, it is crucial for a city's water authority to systematically collect information on a variety of usage metrics. Increased monitoring of usage data – in addition to water quality, which cities closely track by default – can nudge consumers towards conservation.[123] This is lacking in Hong Kong, especially data on pipe leakage volumes.

In 2018, Secretary for Development Michael Wong claimed that corresponding values for unmetered consumption in 2017 were still being processed and were therefore unavailable.[124] This was in response to a Legislative Council question on water leak occurrences by district council. Yet Mr. Wong stated that figures for metered, unauthorised and unmetered consumption from government mains for the previous three years – also broken down by district council – were unavailable either. WSD staff categorise private and public mains bursts and leaks by four regions: New Territories West, New Territories East, Kowloon, and Hong Kong and Islands.[125]

Even with the Hong Kong government beginning to promote open data transparency for public perusal, local water resources and usage are not prominent features. The online portal Data.gov.hk allows the public to browse data on numerous topics, ranging from education and employment to commerce and industry.[126] However, searching for water as a category only yields information on drinking water quality, beach water pollution, rainfall yield and the quality of imported Dongjiang water.[127] 'Water leakage' does not yield any results.

There are also numerous issues related to water usage in subdivided housing units in Hong Kong, which has led to significant burdens for some low-income households. Subdividing refers to the act of dividing a traditional single-family apartment into two or more individual dwellings to accommodate additional families. More than 90,000 households live in such arrangements in Hong Kong.[128]

These units experience a range of chronic problems, one of which is poor water supply and distribution.[129] Tenants of these inadequate housing arrangements are often overcharged by landlords for water use, due to the latter not installing separate water meters in the flat. This has made possible extraordinary overcharging for water: in 2017, the median water price paid by surveyed tenants was HK$12 per m^3.[130] This is staggeringly high, since the most punitive water rate set by WSD is only HK$9.05 per m^3, and Figure 9 shows that more than half of domestic accounts only pay HK$4.16 per m^3. Although this practice is illegal and means landlords can be fined,[131] installing water meters remains entirely optional for landlords. This installation process is also incredibly expensive, which is why WSD even recommends that residents looking to install water meters coordinate with their neighbours to potentially split the cost.[132] At a conservation level, WSD only has information related to the government water mains leading to a specific building,[133] so household usage on a composite level (i.e. how much water is sent to the toilet, dishwasher, sink, shower etc.) within a residential unit cannot be deduced from current systems.

Overall, this lack of granular detail and publicly available information is not in line with Hong Kong's current water strategy, or its long-term interests and aspirations to modernise its water management. While WSD's aforementioned WIN infrastructure acts to detect early signs of leakage to make repair work easier, the inability to correspond these leakage values to specific district metering areas – and then translate those into council districts for engineers, policymakers and the public – is a significant bottleneck to providing reliable feedback on worsening or improving leakages.

4.4 Piecemeal approach to addressing water usage

In light of the challenges outlined above, WSD has devoted resources and efforts to improving Hong Kong's water management. However, its actions fall short of delivering a lasting impact on water usage and conservation. The design of many of these approaches can be improved and linked back to a greater strategic push to improve forward-thinking water management.

4.4.1 Targets

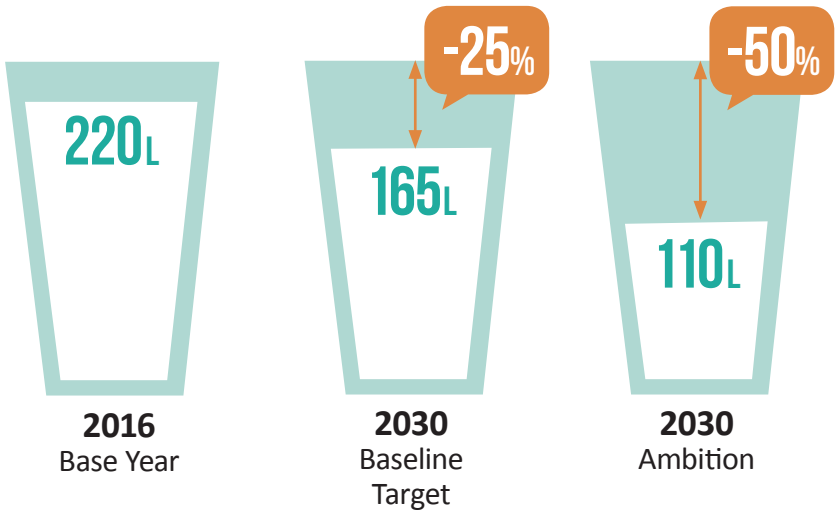
WSD publicly lists its performance targets, and its October 2017 policy agenda stated an aim of reducing per capita fresh water consumption by 10% by 2030, using 2016 as the base year,[134] which were 135 m^3 annually. This means that in a decade, per capita fresh water use would be 121.5 m^3. This would see total fresh water consumption be merely 2% lower than the equivalent usage in 2016.[135] WSD also separately produces detailed metrics on goals achieved in the previous year, yet these are overwhelmingly focused on water quality, response time to pipe leakages, mains bursts, meter inspections and account payment disputes.[136] The data on these mostly engineering issues is granular, frequently updated and tabled in each WSD annual report. However, the 2017 policy agenda target of a 10% per capita reduction in total water consumption does not appear on this WSD list. In a similar vein, WSD has a key target of reducing the leakage rate of government mains to below 10% by 2030,[137] but this goal is displayed with minimal details on a webpage that does not define what a leakage rate percentage means, how this numeric target is constructed or why this particular goal.

WSD could begin to produce a more coherent overall strategy if it consistently compiled and updated key water consumption goals in a centralised and detailed location/ website. This demonstrates leadership for more ambitious targets, with aspirations to methodically improve conservation on a quarterly or yearly basis. Just as it lists detailed accomplishments and pledges[138] regarding water salinity, supply pressure or telephone enquiry services, WSD can and should do the same with its plans and overall strategy to save water.

Alternatively, to galvanise the public in a joint effort to conserve water, the government can consider setting targets specifically on household use of water. Hong Kong's daily per capita domestic water consumption is way above the world average (110 litres) and that of comparable international cities as outlined in section 3.2 of this report. Hong Kong's current daily per capita domestic water use is 130 litres (fresh water only), or as high as 220 litres once seawater is also accounted for.[139]

Taking reference from international peers, would we have the ambition to reduce our daily domestic water consumption by 50% to 110 litres per capita, meeting international best practice as demonstrated by citizens of Berlin and Madrid? A mid-range target of 25% reduction would mean 165 litres per capita, which is still higher than half of the international peers.

FIGURE 13 **Daily Per Capita Domestic Water Reduction Targets for 2030**
Source: Using data from WSD Annual Report 2016-17



4.4.2 Water efficiency

On the technical front, Hong Kong launched its voluntary Water Efficiency Labelling Scheme (WELS) as a conservation initiative in 2009.[140] It covers a range of water-using devices, such as showerheads, washing machines, urinal equipment and flow controllers.[141] Over several years, WSD also collected the views of various stakeholders to formulate requirements (such as the flush volumes required to meet a particular water efficiency grade).[142]

However, other cities like Singapore have already replaced their voluntary WELS programmes with mandatory schemes for the aforementioned water-using products.[143] Furthermore, the various grades for water savings are much stricter than those in Hong Kong. For example, when discussing flow controllers to restrict water volume used in showerheads, the highest efficiency label for Hong Kong is for devices using less than or equal to 9 litres a minute.[144]

Meanwhile, the weakest grade of water efficiency labelling in Singapore is given to devices that use between 7-9 litres per minute, while the strongest grade is for devices that use 5 or fewer litres per minute.[145] This shows that even for products in Hong Kong that voluntarily adopt a WELS, the conservation thresholds they need to clear in order to be deemed most efficient are far more lenient than those in other cities.

WELS is part of a piecemeal effort to boost water conservation. Not all water device manufacturers have to subject their products to efficiency criteria, which means that consumers can easily find products on the market that do not indicate their water efficiency. In addition, the WELS coverage of other types of devices is slow and takes many years,[146] as WSD commissions studies to identify new products to include.

4.4.3 Structural installations

On the domestic side, WSD has programmes to send households flow control devices to be installed on showers and taps in order to limit consumption. To receive them, households have to enrol into WSD's Let's Save 10L Water campaign by signing a commitment certificate.[147] Households can also opt in to pay their water bills electronically in order to request the water-saving devices.[148] As of March 2017, nearly 140,000 households had received these complimentary devices.[149]

Since 2014, the water authority has planned to make the use of water-efficient products mandatory in new developments and retrofits of older systems in existing buildings.[150] Public housing, schools and residential households are all addressed in different phases. While WSD notes that the consumption statistics of participating estates have shown that flow controllers are effective at helping households to reduce their water use, earlier segments of this report have shown that overall city-wide water use continues to rise.

4.4.4 Limited industry best practice guidelines

WSD has also promulgated numerous initiatives to standardise water usage across local industries in order to more widely distribute conservation practices in an institutional manner. The scope, however, is limited, with only two industries targeted: hospitality and catering.

In 2017, the hotel and catering industries accounted for 16% of total fresh water consumption.[151] In order to enhance water use efficiency in both sectors, WSD developed a set of best practice guidelines (bilingual in Chinese and English) to establish water-saving measures applicable to industry actors.[152] Both documents were produced in late 2016 and serve as a reference for industry practitioners. The guidelines explicitly state that industry actors are expected to implement the water efficiency suggestions and voluntarily complete the checklists included in the guidelines: both documents contain a Yes/No checklist to confirm a series of water-saving actions, from using condensed steam cabinet water for general cleaning purposes to turning off dishwashers when not in use.

However, there is no auditing committee to review the commitments made, the degree of adherence or the tracking of compliance over time. In personal interviews, various sustainability directors of Hong Kong-based international hotel chains stated that they had never seen or heard of the best practice guidelines, let alone implemented them.[153] Furthermore, they said their dialogue with WSD on the educational engagement and water conservation front is limited, and that most interactions revolved mainly around consistent WSD meter inaccuracy.

Until formal evaluation procedures or enforcement mechanisms for the best practice guidelines are established, it will remain a voluntary act to promote these conservation efforts – let alone save meaningful volumes of water.

4.4.5 Educational campaigns

Many cities have used public education campaigns to increase awareness of water issues, but their efficacy in changing user behaviour and driving down water consumption remains mixed.[154]

In Hong Kong, WSD has a track record of using numerous programmes to boost public interaction with water-related issues, as well as producing educational exhibitions in which participants are encouraged to prioritise water conservation (see Table 3 below).

TABLE 2 **WSD Conservation and Promotion Programmes (Sept 2009-Dec 2014)**

Source: Hong Kong Audit Commission, 2015

Name of Programme	No. of Participating Organisations	No. of Participants
School Roadshow	443	134,970
Water Conservation Ambassadors Selection Scheme	180	20,661
Visit to Water Education Resources Scheme	512	16,034
School Water Audit	62	1,799
Water Conservation Design Competition	25	55
Distribution of Multi-Lingual Leaflets/Posters for Domestic Helpers	295	NA
Distribution of Teaching Kit on Water: Learn and Conserve	500	NA
Water Conservation Competition: Creative Water Sharing Habits	28	785
“Let’s Save Water” Design Competition	159	10,889
Save Water/Cherish the World (Roving Exhibition)	77	400,000 (households)
Save Water/Cherish the World (Mobile Showroom)	183	51,000
“All about H2O” Lecture Series	12	2,097
“Cherish Water Resources” Waterworks Installations Drawing Competition	102	809
“Let’s Save 10L Water” Campaign	240	126,187 (households)
Installation of Flow Controllers at Selected Housing Estates	16	13,388 (households)
Water Conservation Forum for Hotel and Catering Industry	78	200

The content and variety of these programmes cater to different audiences, showing that WSD is committed to engaging a broad section of the public with education on resource usage, technical solutions (such as flow controllers) and knowledge to generate behaviour change.

Some campaigns are currently limited in nature, and could be adjusted at the design level for greater effectiveness. For example, household water usage campaigns have primarily targeted domestic maids.[155] These include behavioural adjustments such as washing vegetables in a basin to reuse water elsewhere, with multi-lingual (Indonesian and Tagalog) educational videos to reinforce the messages. However, while technical solutions and upgrade decisions to limit water flow should be made at the tenant or property owner/ landlord level, they can also be targeted with usage and conservation educational messages.

Future campaigns and education programmes could also better emphasise the rationale behind specific figures, empowering the public to set meaningful personal water reduction targets. For example, when identifying a volume of water for households to save in its 2014 Let's Save 10L Water campaign,[156] WSD could have explained why this particular number was chosen, and what it would mean in more concrete terms for the average consumer. This could be incorporated through visualisations of different volumes (e.g. a five-minute shower is roughly 4 litres; a regular bath can be 80 litres; producing 1 kg of cotton clothing requires roughly 20,000 litres).[157]

4.4.6 School water teaching kits

WSD has made concerted efforts to create programmes that teach instructors how to expand and incorporate knowledge of water resources into the curriculum.[158] In 2011, the promotion of water conservation was incorporated into Liberal Studies categories in secondary schools, with interactive materials designed to inform and test understanding of Dongjiang water sourcing, the environmental and social importance of saving water and the history of droughts and water shortages.[159]

Bilingual (Chinese and English) in nature, these materials covered science, history and social studies, and enabled students to role play various stakeholders, such as WSD engineers, district council members and representatives of the restaurant business, and react to various water issues (such as the replacement of water pipe mains in a particular street or district).[160] Water resource usage is often tied to other environmental considerations, such as energy efficiency or waste disposal, and students are exposed to the institutional efforts and challenges behind the supply and maintenance of an urban water system.

The materials offer a diverse array of interactive solo and group activities to test the acquired knowledge. However, these efforts are still confined to the classroom, and to further expand their role in improving city-wide water savings, such school kits should ideally bridge the gap between knowledge and application. Through certain changes to its teaching kits, WSD can help provide this bridge.

5 POLICY RECOMMENDATIONS

Laid out in our view of descending importance, these policy recommendations for Hong Kong to modernise its water management are informed by improving water conservation at the city level, in order to address the numerous challenges detailed in section 4.

5.1 Technology

As highlighted in section 4.3, there are significant information gaps regarding consumption. District-level data on leaks and consumption is lacking, which impedes more rapid responses to resolving infrastructure failures. Officially, existing water meters are close to 100% accuracy.[161] However, as mentioned in section 4.2, only residential buildings constructed after 2006 have a master water meter installed to monitor the water leaving the public mains and entering the structure.[162] Technical metering solutions offering more frequently updated information on usage could lead to behaviour change, given the opportunities for increased interaction and engagement between consumers and their consumption data.[163]

It is therefore imperative for Hong Kong residents, policymakers and business operators – let alone engineers – to have a clearer understanding of key water information, such as the geographic distribution of chronic water leakages.

In addition to its Water Intelligent Network (WIN) implementation, Hong Kong is taking two main approaches to fill this gap: more frequent dataset releases and smart meter installation. Both have the potential to address two urgent issues for Hong Kong: reducing the incidence of local pipe leakages and filling data gaps concerning water use.

In late September 2018, the department posted detailed accounts of burst mains cases on its website, including locations, volume losses and public traffic affected.[164] In December 2018, WSD uploaded its annual open data plan, which documented departmental datasets to be released in 2019.[165] Among them, a dataset titled “Annual Statistics for Enhanced Water Monitoring of Hong Kong’s 18 Districts” is set to be released every six months from June 2019. This is a promising starting point for systematically documenting and publicising data that is crucial for policymaking and technical solutions. However, monthly water consumption and leakage data cannot offer the same level of granularity as daily or even hourly monitoring. This is where automated and smart metering systems can make a meaningful impact.

Smart water systems offer the potential to reshape urban water management. This form of automated technology enables the determination and real-time transmission of water consumption, with the ability to control usage volumes both locally and remotely.[166] This aspect directly addresses a core weakness of traditional customer-level metering, which requires utility labour and expertise to physically visit individual consumer sites to collect and interpret meter readings.[167]

With its high volume of water losses resulting from ageing pipes and chronic leakage, Hong Kong could benefit from an infrastructure that allows the accurate identification of leaks, and eventually the capacity to shut off water flow remotely. This would make the handling and maintenance of leakage sites much swifter and more effective, while also allowing consumers – who do not have precise and updated (let alone real-time) information on water consumption – to adjust their usage habits.

Initiatives are underway in Hong Kong to implement automatic meter reading (AMR) systems. In 2013, WSD launched a pilot scheme to evaluate the technical performance and data handling reliability of automated meter reading.[168] Under the scheme, around 350 smart water meters designed to collect individual customer water consumption data remotely[169] were installed in select blocks (one government quarter and two public rental housing estates).

WSD views the primary benefits of these AMR systems as improving water meter reading efficiency, enhancing the detection of leaks or abnormal consumption volumes, and engaging customers through more timely delivery of water usage data. The recognition of these technical solutions as ideal platforms for promoting water conservation is promising, and their continuing rollout could start to meaningfully address issues of chronic pipe leakage and overconsumption.

In other parts of the world, smart water meter initiatives have begun to emerge as significant solutions for water management.[170] This is due to increasing efforts to conserve water, boost business growth and cut down on unnecessary waste. Such metering can help increase the frequency of data measurements, improve customer engagement and expose the locations of any leaks.[171] Hong Kong could view other cities as case studies, and adopt policies to make full use of these technical solutions.

Even traditional water metering can raise citizens' awareness of the need to conserve water.[172] Smart meter technology offers an improved way for utilities or public water providers to better gauge consumer demand and to use near real-time feedback to better supply customers. A 2016 meta-analysis of 21 studies on smart water meter implementation in cities in Austria, Australia and the US found decreases in overall consumption ranging from 2.5% to 28.6%.[173] For four smart water meter implementation schemes in various Australian cities beginning in 2010, key benefits included reducing residential water use by 10%, lowering incidents of field inspections and cutting hundreds of customer complaints about leakages.[174] Communities across the country's southeast state of Queensland saw an average reduction of 11 litres per capita per day.[175] In the UK, conventional metering reduced demand by around 15%, and smart meters are expected to increase this to 17%, due to more frequent readings and the ability to detect leakages.[176]

The following are specific technical solutions programmes featuring smart meter installations at the city level.

AUCKLAND

New Zealand

2017-2020 Water Efficiency Plan[177]

- One primary aim is to install meters in all new homes, as well as communities not connected to the main metropolitan network.[178] The ultimate goal is to identify leaks on properties by analysing substantial changes in day-to-day water usage.
- To implement this, smart meters will replace ordinary meters that are more than 10 years old in homes and buildings (pilot programmes have already replaced 2,149 mechanical meters). These automated systems record the flow of water at 15-minute intervals, sending readings to centralised units once a day to notify utility companies and property managers of potential leakages or illegal connections.

Hong Kong could bypass the installation of conventional meters in communities not yet connected to the main water network, leapfrogging straight to smart meters instead of installing traditional meters that would still require physical data collection and interpretation.

Hong Kong could also establish a cut-off point similar to that in Auckland, under which all ordinary meters over 10 years old (or a more extended threshold of 15-20 years, given that local urban density is much higher than in Auckland) should automatically be deemed redundant and included in a high-priority replacement programme to install updated water systems.

LONDON

UK

2011 Water Strategy[179]

- At the time the strategy was devised, less than 25% of the city's 3.1 million households were metered. The government aimed to meter all houses and blocks of flats by 2020 and all individual flats by 2025.
- This has prompted regulators to require water utilities to install property/boundary-level smart meters, as well as provide free leak detection and repair services for first-time issues. One example is Thames Water's LeakFrog technology, part of an integrated demand management programme to help identify water leakages that would not be picked up by internal water meters.[180]
- The Department of Environment, Food and Rural Affairs recommends a mandate that requires companies to implement compulsory water metering in water-stressed zones by 2030, along with amendments to relevant regulation by the end of 2019.[181] Outside of these locations, smart meters can be introduced when the property's occupier changes, or when customers request metering.

In Hong Kong, private residential estates with pipe leakages that result in water losses are protected from paying the volumes they used (since WSD has stated that the management service raises the fee for all residents to cover repair and replacement costs). Thus, consumers do not get a sense of the precise amount of water gone to waste, as their utility bills do not reflect the water losses.

Similar to London's strategy, Hong Kong could target unmetered structures and bypass installing traditional water meters there, instead moving straight to smart meter technology to better monitor individual unit usage. Currently, Hong Kong water consumers can apply for a separate meter installation after appointing a licensed plumber, but these individual fresh water meters are not uniformly available for buildings served by a communal meter.[182]

While making all leak detection and repair services free, WSD could also further incentivise general repairs and awareness by granting a large discount for first-time issues, or making their costs redeemable through voucher programmes.

NEW YORK CITY

USA

Mobilised its Department of Environment to roll out automatic metering systems for water[183]

- Immediately, the frequency of meter readings changed from four times a year to at least four times a day – and in many places, hourly.[184]
- These smart meters are part of a longer-term goal to further decrease overall water consumption, which in 2017 was 65% lower than that during peak consumption in 1965.[185] Another aim is to extend automated metering beyond buildings into public parks, to better understand non-revenue water sources.[186] The goal is to reduce water use in parks by 1.1 million gallons (4.2 million litres) per day in five years.
- Property owners with smart meters monitoring their water pipes are eligible for a high-efficiency toilet voucher programme. The initiative offers eligible property owners a HK$982 (US$125) voucher that can be redeemed at participating vendors to purchase a high-efficiency toilet (one that uses 1.6 gallons/6.05 litres per flush).[187] This encourages active and broader participation in collecting water usage data by incentivising customer uptake and water conservation efforts.[188]

Hong Kong could utilise official targets for smart meter installation within different types of buildings (i.e. residential, commercial or government). The pilot programmes currently in place should be collecting data and reporting it publicly, with specific figures on how much water can be saved and what that could mean for the city in the long term. As with New York City, property owners should be able to receive vouchers with steep discounts on water conservation upgrades such as replacement toilets. While it is known how many

smart water systems are being trialled for the purpose of collecting water data in Hong Kong, the scope of what it hopes to achieve (i.e. cutting down consumption by a certain percentage over several years) remains unspecified.

SEOUL
South Korea

Seoul Now Water System

- This automated system monitors water quality for end users, then displays this information online in real-time for the public to view, in order to engage consumers and raise trust. The system also issues alerts upon detecting any irregularities.[189]
- This initiative also includes the development of a Smart Water Grid that can provide real-time, two-way water quantity and quality tests. The project's second phase was scheduled to finish at the end of 2018.[190]

For Hong Kong, applying technology to quantify and qualify water distribution in real-time is essential to becoming a smart city. In addition to WSD's WIN used to detect leakages and pipes on the verge of bursting, Hong Kong could install smart meters at the neighbourhood, estate and even building level to monitor and relay information. As in Seoul, those meters could measure flow by unit area in real-time to inform districts of the precise water flow in and out of the system, and facilitate the replacement and repair of old pipes.[191] The Seoul Now Water System allows the public to engage with real-time information transparently and see when there are water delivery disruptions that may affect them.

5.2 Water pricing restructuring

With current water prices lagging behind the cost of full recovery, an update to Hong Kong's 1995 tariff charges is sorely needed. An imminent review of the pricing and the thresholds of the IBTs (Increasing Block Tariffs) is needed to revive the user-pays principle and cement the value of a scarce natural resource with every consumer account in Hong Kong. It could positively influence the city's water overconsumption challenge, and potentially curb its growing per capita usage moving forward (based on existing forecasts).

Even when the management and maintenance costs of Hong Kong's water system have risen and the price of imported water from the Dongjiang River has increased over the years, consumer prices have not kept up.[192] This prompted some Legislative Council members to recently question whether WSD regularly reviews its water tariff structure with a view to encouraging water conservation.[193] The official WSD response is that it regularly reassesses the current pricing scheme.

Furthermore, pricing needs to occupy a much more central role within institutional water management efforts. WSD's 2008 TWM strategy promotes water-saving device adoption, public education, diversifying water sourcing and managing leakage control – but the framework omits price-induced conservation policies.[194] In the upcoming review of the

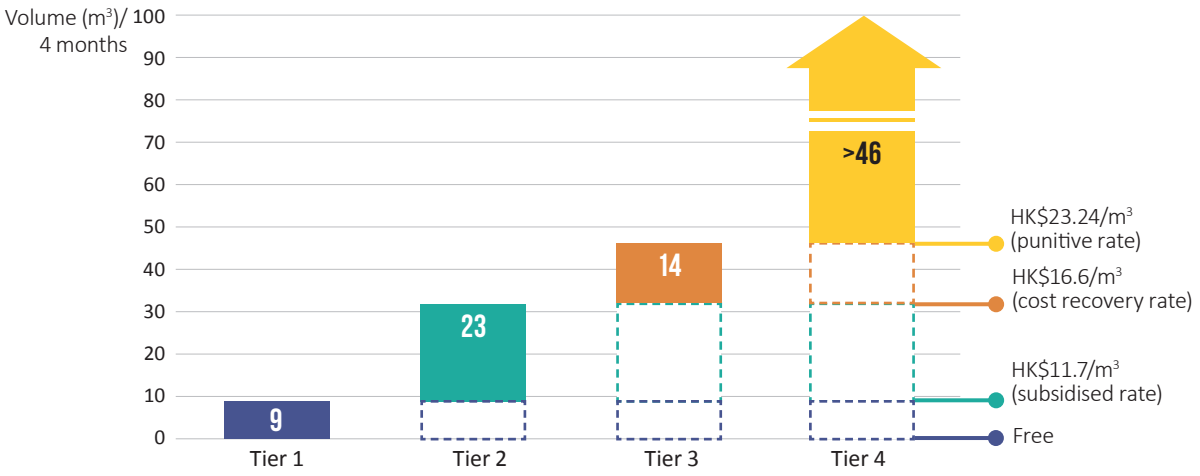
overall water strategy, pricing that reflects a user-pays principle supported by policy provision to ensure affordable access to water for low-income households should feature much more predominantly, with a clear explanation of how this policy mechanism can help to address excessive consumption.

The threshold of each consumption block in the IBTs should also be adjusted to reflect the change in average household size in public housing, which has shrunk to 2.75 persons per household from 3.7 per household when the scheme was last reviewed in 1995. High-volume accounts will then be exposed to punitive rates more quickly and appropriately, with a view to incentivising more environmentally conscious behaviour. The frequency with which domestic accounts receive bills could increase: a notification to pay once every four months may reflect a lack of urgency or value of the water to the consumer, whereas seeing them more often could solidify the connection between water consumption and cost.

Based on the reduced household size of 2.75 as well as the latest figures on net unit production cost and full unit production cost of water supply released by WSD,[195] the tariff structure following a user-pays principle should be adjusted as illustrated in Figure 14.

FIGURE 14 **Adjusted Tariff Structure for Domestic Use Per Tier (Every Four Months)**

Source: Civic Exchange, using data from WSD Annual Report 2016-17

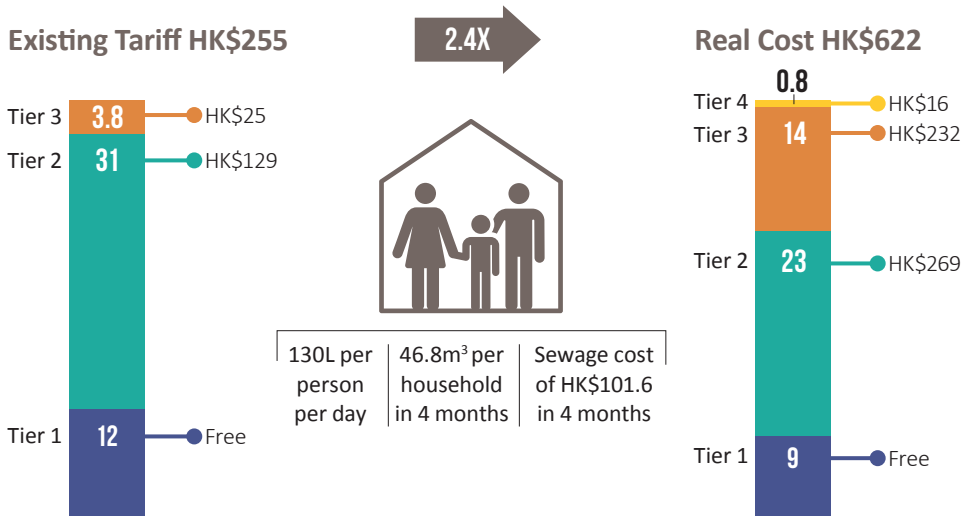


Adjusted using decreased rate of average household size of public housing estate in Hong Kong: 26%

Hong Kong's current daily domestic use of fresh water is 130 litres per person. Using a three-people household as an example, under the existing tariff structure, its water bill would be HK$255 for a four-month period. With the renewed tariff structure reflecting a 'user-pays' principle as illustrated in Figure 13, the household would have to pay HK$622 – 2.4 times more.

FIGURE 15 **Cost of Water: Using a Three-People Household as Example**

Source: Civic Exchange, using data from WSD Annual Report 2016-17



Updating the prices for water does not have to mean punitively raising costs for all societal groups – thus harming low-income groups – but it should prompt examination of whether certain pricing tiers and exemptions based on income and assets should be introduced. Local policymakers should keep this in mind when considering the use of water price adjustments to influence consumption.

There should also be serious consideration of removing the first tier of free water for all accounts, except those that fall under a certain household income level. Alternatively, if Hong Kong policymakers decide to remove this free portion for everyone, they could follow what many other countries have done to support low-income families in their water payments. Income-support initiatives could take the form of subsidy provision (such as in certain Chilean cities)[196] or discounts for low-income families (as in the case of Spain).[197]

The scope of this study is not to calculate what the new water tariffs should be in Hong Kong. Nonetheless, it remains clear that pricing strategies can be valuable tools to change how consumers view this scarce resource, and to make them modify their behaviour accordingly. A reform of Hong Kong's 1995 tariff charges by Hong Kong policymakers is long overdue and sorely needed.

5.3 Regulations

Certain regulatory mechanisms can also be used to incentivise or mandate increased water efficiency or transparency of information. Currently, as addressed in section 5.1, the opacity of data on water usage and general consumption patterns and volumes at various kinds of buildings is a major issue in Hong Kong.

Legislative strategies to mandate certain restrictions on water use have seen certain success when it comes to specific applications, such as car washing or irrigation.[198] However, the most obvious limitation to these initiatives is that they require policy intervention to be implemented, and may experience resistance from the community that then weakens the regulations.[199]

Regulatory mechanisms from other parts of the world can demonstrate efforts to address these challenges by focusing on water efficiency as a way of improving the overall sustainability of building function and reducing unnecessary waste.

LONDON

UK[200]

- To meet targets, water companies were mandated to replace leaky distribution mains, lower the water pressure and repair leaks in customer supply pipes.
- Water companies must report their progress against their leakage targets at the end of each financial year or incur fines. Given that the fiscal year ends in March right after the winter season, this deadline is to be moved to later in the calendar year to improve the coordination and cost-effectiveness of repairs.
- Local water companies were also required to evaluate and officially report the “sustainable economic level of leakage” caused by burst or faulty water pipes. This was to enable those entities to decide when it was cheaper to invest in improving the water supply rather than merely further reducing leakage.

These requirements represent concerted efforts to fix leakage goals, rather than simply setting targets. These regulations can incentivise or mandate building owners to regularly report standardised water performance and efficiency figures so that these can be compared and tracked against overall city targets.

For Hong Kong, the value of public comparative practice should not be underestimated, as seen in policies implemented by the cities below. Transparency is helpful in naming and shaming, and generates pressure to create and improve competitive branding that makes rapid water performance gains.

SYDNEY

Australia

Incorporates mandatory water sub-metering into building codes, regulating both water usage and the installation of more accurate measurement tools

- In 2004, the regional government introduced the Building Sustainable Index (BASIX), which requires all new residential buildings to commit to mandatory water, energy and greenhouse gas reductions.[201]
- New homes must use up to 40% less water compared to the average pre-BASIX structure before development is approved.[202]
- Sydney also makes detailed water demand profiles for different building types (varying by industry) publicly available in order to facilitate its goal of retrofitting old structures to improve water efficiency (i.e. reduce total water consumption by 20% at the end of 2030, compared to 2006 levels).[203]
- Using 10 years of metered water consumption data, Sydney estimated and mapped water usage and produced sector-wise breakdowns of demand, concluding that 7% of the total water consumed in 2010 went to properties in the central business district, with multi-residential and office buildings using the highest volume.[204]
- Requiring buildings to disclose potable and non-potable water usage statistics could potentially increase demand for buildings that are water efficient and drought resistant through reduced reliance on mains water. This would allow buyers and tenants to compare the relative performance of different buildings.

Hong Kong could also look to integrate similar water consumption reduction goals into mandatory building codes for new construction. In this way, units, estates or structures that achieve those water efficiency standards could be marketed as such to the public, which incentivises stronger performance for both developers and customers. Those requirements could be incorporated at the design stage as well as the operational level, so that specific water efficiency standards must be maintained – with regular audits (annual or every two-three years) – by the buildings in order to keep their sustainability ranking high.

As seen in Sydney, when years of water usage data are consistently made public, building developers and operators become increasingly aware that resource efficiency is not simply an additional bonus, but a core asset that boosts competitiveness. Moving forwards, Hong Kong could adopt a similar spirit to use building regulations and prioritise water conservation as a commercial selling point.

NEW YORK CITY

USA

Greener Greater Buildings Plan

- This scheme requires owners of large buildings (over 50,000 ft^2 for private structures and over 10,000 ft^2 for public ones) to annually measure and report their energy and water consumption for public disclosure, analysis and mapping.
- These owners have accounts that digitally and automatically report data for energy measurement, as well as to a tracking tool (Energy Star Portfolio Manager)[205] to monitor water usage patterns over time. Property owners must make annual compliance updates to ensure that data is uploaded correctly to avoid a penalty of HK$3,925 (US$500).[206]

In addition, the City of New York, together with New York University's Centre for Urban Science and Progress, publicly maps the energy and water efficiency performances of more than 26,000 buildings online:[207]

- This partnership has produced a critical analytic tool to help property owners, buyers and tenants factor water statistics (alongside energy usage and greenhouse gas emissions) into their real estate decision-making process.
- This visualisation significantly increases transparency regarding the water efficiency and performance of both private and public buildings, which would greatly benefit Hong Kong, given its current lack of publicly available relevant usage data.
- Studies have shown that the simple exercise of reporting can raise building owner awareness, and often results in significant reductions in water and energy consumption.[208]

One consistent thought expressed to Civic Exchange through numerous engagement sessions has been increased cross-sector collaboration. Environmental resilience engineers within the Hong Kong government highlighted the benefits of research on the socioeconomic impacts of water infrastructure.[209] This is because construction projects, even those designed for conservation purposes (e.g. stormwater harvesting), can adversely affect nearby populations. The compound effect of such impacts over time is of great interest to the government, yet more comprehensive case-assessment studies or cost-benefit analyses are, to a large extent, beyond their resources of time, finances and staff.

In a similar way to New York University's formal collaboration with New York City, Hong Kong could formalise synergies between private and public sectors on tracking and mapping water usage and efficiency data. Researchers, administrators and project managers at universities and other institutes specialising in such tasks could potentially pool their resources and fill the information gaps identified by those engineers. A cross-sector research institute or academy could be established with an objective or mandate to bring together these stakeholders numerous times a year for collaboration.

Hong Kong could also more explicitly coordinate official efforts, programmes and initiatives between government and private actors in order to research and develop projects focusing on improving resilience and water use. The funding needed for major projects and scalable solutions – such as smart meter development, implementation and maintenance – could be raised and distributed this way systematically. Furthermore, an official research budget could be allocated for the strict purpose of revamping and modernising Hong Kong's water management, which would send a loud and clear signal to non-governmental actors, and mobilise the development of interdisciplinary solutions.

5.4 More robust targets

On its pressing challenges of curbing pipe leakages and overconsumption of water, Hong Kong has two targets at the city level. However, as examples from other cities show, additional adjustments would showcase the city's aspiration to achieve more.

WSD can look into setting a more progressive target than reducing the government mains pipe leakages rate to less than 10% by 2030.[210] As the leakage rate in 2018 was approximately 15%,[211] this goal would constitute a reduction of one third, and would save enough fresh water (52,654,680 m^3) to supply close to 400,000 people annually.[212] A more ambitious target for leaked water could be closer to around 8%, representing a reduction by half from 2018, saving approximately 72,906,408 m^3 of fresh water, enough to supply close to 540,000 people per year.[213]

Hong Kong's current long-term goal of reducing per capita fresh water consumption by 10% by 2030, using 2016 as the base year,[214] represents a mere 2% reduction in total fresh water consumption in over a decade.[215] This conservative goal fails to inspire or demonstrate Hong Kong's commitment to water conservation. There could be a series of targets representing more aggressive efforts to tackle water wastage, and a more ambitious track that the city could aspire to reach. This could generate more collective support from public engagement with conserving water, and with viewing conservation as a core aspect of a global city.

As we suggested in section 4.4.1, the government can consider setting targets specifically on household use of water for engaging the public in a joint effort to conserve water. An ambition of reducing our daily domestic water consumption by 50%, from 220 litres[216] to 110 litres per capita, would help Hong Kong public meet international best practice as demonstrated by citizens of Berlin and Madrid. A baseline target of 25% reduction would mean 165 litres per capita, which is higher than half of the comparable international peers as outlined in section 3.2 but still represents a good conservation effort.

The following international case studies contain potential best practices for Hong Kong to adopt when it comes to an overall strategy. This could mean producing different tracks of goals, generating a vision or series of objectives for water usage in 2030 and beyond or measuring water consumption and savings in more nuanced ways.

AUCKLAND
New Zealand

- Plans to move away from measuring leakage as a percentage of total water supplied, preferring instead to measure litres per connection per day (similar to daily water use per capita).[217]
- Auckland also measures real water losses in terms of an infrastructure index. The aim is to improve best practices for leak management by standardising measurements to allow for proper comparison with other utilities.
- Hong Kong could consider looking into additional metrics of water consumption beyond the per capita indicator. By emphasising water usage per connection rather than by individual/capita, the standard unit of water consumption could include households with numerous people. Per connection could also designate residential units with multiple flats all sharing one connection, which may distort per capita water consumption figures.

LONDON
UK

- Aims to "future proof" its water management with efforts to diminish key drivers of potential increased water demand from 2030-2050. This is in line with a 2017 white paper on national water usage published by the UK government.[218]
- The targets included reducing per capita water consumption to an average of 130 litres per person per day by 2030, using metering technology, tariffs and water efficiency measures. This is roughly an 18% reduction from 2006 base levels of domestic water use in London (157 litres per person per day), which was the lowest usage volume in the decade prior to the city's water strategy.[219]
- This is a baseline goal that the government intends to exceed, as it aims for a more ambitious consumption target of 120 litres per person per day. In addition to focusing on domestic use, London aims to amend its building regulations to include a requirement for a minimum standard of water efficiency to be applied to new homes, with a whole building performance of 125 litres per day.

NEW YORK CITY

USA

- Aims to double its total water savings from the Water Demand Management Program by 2020, to 20 million gallons (75,708,000 m^3) of water per day.
- Publicises how its water policies have adapted and modernised in accordance with demographic shifts, and the official progress that new measures have made on improving water conservation and reducing consumption.
- In addition, it also meticulously lists water efficiency partnerships between the city's Department of Environmental Protection and other public entities (hospitals, schools, community centres etc.) to completely retrofit them all with water-saving solutions in 2019-2022.

PERTH

Australia

- Introduced its 50-year strategy in 2009 to provide sustainable water services.[220]
- The central principle is to emphasise climate resilience, with significant endeavours to manage water demand and supply balance through 2060 by reducing overall water use by 25%, and increase the recycling of wastewater to 60%. Perth's water corporation includes community targets in each annual report, listing both the goal and the achieved total per capita usage.[221] The main aim is to reduce overall water use in the city of Perth by 15%, primarily through decreasing residential water use to below 85,000 litres per person per year.
- The city also has a 10-year strategy with a more direct focus on drought-proofing.[222] The official proposal for the strategy contained ample detail on consumption targets, such as reasoning for specific figures (e.g. the 85,000 litre reduction per person per year is a target informed by the water corporation, the entity that supplies Perth with roughly 740,000 m^3 of water annually).[223]

SYDNEY
Australia

- Publicly details the benefits of water-saving schemes, initiatives and programmes. The city's water programme maps out volume reductions relative to a base year and compares the numerous projects with a baseline or business-as-usual scenario.
- Over time, it is easy to recognise how ambitious certain area targets are, how different initiatives compare and measure them against a baseline to determine progress and fulfilment of certain goals.
- Sydney's 2012 Decentralised Water Master Plan[224] seeks to reduce mains water consumption by 10% compared to 2006 levels by 2030, despite an anticipated 30% increase in demand for water by 2030.
- To get there, the city is constructing water efficiency retrofits for 43 high-to-moderate water-using properties, estimated to save 61 million litres annually. There are also plans to replace 30% of mains water with recycled or alternative non-potable water.
- The city will install rainwater tanks for the mains pipes of 27 council-owned structures (e.g. sports facilities, libraries, public toilets, community centres, etc.) to save 95 million litres annually.

WSD's annual reports only contain historical per capita water consumption trends, without targets for comparison.[225] Instead, the reports contain goals for other metrics, such as accuracy of water meters, duration of suspended water supply for planned works, and fresh water supply pressure, to name a few. To modernise its water management and sufficiently emphasise the importance of conserving a precious resource by moderating consumption and being more proactive about daily usage, WSD should devote more space to showcasing its progress on these goals.

Hong Kong should have a baseline target that WSD expects to meet, as well as a more public, ambitious target in order to demonstrate leadership. With a more aggressive savings target, Hong Kong would show its prioritisation of water conservation and aspirations to go beyond a baseline level. In addition, these targets need to be consistently updated and modified, with data sets readily available for public assessment. At the time of writing this report, WSD's TWM strategy had not been updated in 10 years, even as professional reviews have been in the works for at least a few years. In a May 2018 direct response to the Legislative Council, Secretary of Development Michael Wong said that a review study of the TWM strategy would be completed in 2018.[226] However, WSD's annual report for 2017-18 has not been released, meaning that public analysis can only rely on comprehensive data for the 2016 fiscal year.

WSD should also continue to include updated water demand forecasts in its annual reports, and provide clarity on the assumptions behind the forecasts and how it views water pressures going forward. Reduction targets on water consumption (whether per capita, or ideally with more granularity, such as broken down by each sector that WSD has data on) should also be included to demonstrate alignment with water conservation.

5.5 Water-saving devices

In addition to the automated smart meters covered in earlier sections, the water use of everyday devices – sink taps, toilets and urinals, public swimming and park pools, etc. – should be part of a city's overall water conservation framework.

Hong Kong could integrate this component more comprehensively into its water conservation approach. Currently, tips on saving water from WSD's website suggest using water-saving devices (efficient showerheads, dual flush toilet cisterns and installing flow controllers on taps)[227] without first highlighting the extent of the problems these solutions are addressing. In other cities and their respective water strategy and management frameworks, water-saving devices are part of a more significant effort to substantially reduce waste spending.

For instance, Dublin (Ireland) lays out the water usage metrics of such everyday devices, illustrating to the public the high-volume throughput of these domains.[228] For instance, urinals are claimed to potentially waste 315,000 litres of water annually, simply because most of them flush every hour of every day – even when no one in the building uses them. This works out as HK$4,395 (€500) of wasted water per urinal. Leaking taps are estimated to waste up to 4,500 litres annually, while toilets account for 43% of the water used in Dublin's offices and 33% of all water used domestically. These concrete breakdowns are useful financial indicators of everyday water usage, in addition to showing the savings that can be achieved.

Moreover, water-saving device solutions are introduced clearly, with adequate yet straightforward explanations for the public to understand the implications of any technical adjustments. Dublin requires all new urinals to be equipped with infrared sensors and hydraulic controls, explaining how they can save water by only flushing water when users are detected via motion sensing. Waterless urinals (with information on different designs) are presented as an option, and information on what cistern devices do to reduce toilet water usage is readily available. In addition, toilets are required to at least be dual flush (regular plus low-flush options), with annual specialist check-ups to identify that all water efficiency criteria are in place.

Utilising these technical solutions is part of a more considerable country-wide policy statement (2018-2025). Ireland's core objectives include putting conservation at the heart of its water policy and prioritising leakage control and behaviour change alongside resource management and source protection.[229]

Similarly, the Australian government publishes statistics on how to effectively reduce water demand through water-saving devices.[230] They make data publicly available on the financial consequences of toilet leakages, including litres lost on an hourly basis and how this translates into annual volumes and costs.

TABLE 3 **What Leaking Toilets Cost**

Source: Australian Department of the Environment and Energy, 2019

Severity of Leak	Litres/Hour	Litres/Year	Cost (HK$)/Year (2012)*
Slow leak, barely visible	0.5	4,400	70.33
Leak visible in bowl, no noise	1.5	13,100	210.99
Visible leak, just audible	6	52,600	854.78
Visible leak, constant hissing sound	11	96,400	1563.49

* Based on a water price HK$16.23/kL of water

In Hong Kong, failure to repair leaking toilets, install flow-controllers on sinks or adopt water-efficient washing machines is not immediately associated with financial loss. While WSD does put detailed lists online rating manufacturers and their products based on water efficiency (and categorising all WELS products along with types, from washing machines to showers), the average local consumer would find it much easier to interpret water losses in financial terms. WSD could adopt practices from the Australian government site, showing the monetary costs incurred by leaving certain problems unaddressed.

Hong Kong should also strengthen its WELS scheme. Equivalent Water Efficiency Labelling Schemes have seen widespread adoption around the globe, as highlighted earlier in cities like New York and Singapore. Not only do amenities such as toilets, washing machines and sinks have to use devices that meet a certain benchmark of water conservation; corresponding tiers of efficiency are far greater than the equivalent tier in Hong Kong. There is no reason for the weakest tier in other cities to match the strictest WELS tier used by WSD to indicate water savings. Ramping up what constitutes a valid water-efficient device in Hong Kong could produce substantial savings at the micro level, which would subsequently amount to significant levels at the aggregate level.

5.5.1 Remove opt-in step for domestic water-saving devices

Official initiatives contain a series of registration steps that consumers have to complete before they can even start to improve their water conservation.

For instance, WSD's Let's Save 10L Water campaign requires residents to opt in on two fronts – sign a commitment pledge and also e-register to receive bills digitally – in order to receive two flow-limiting devices. There are no follow-up metrics or studies led by the government to determine the successful penetration of the campaign, but even for the select part of the population that is aware of this conservation programme, having to opt in to receive the essential tools to start conserving water no doubt already results in some lost uptake.

Furthermore, the most recent WSD domestic water consumption survey was done in 2015.[231] Of the 41.8% of participating households who were aware of WELS, a vast majority (87.1%) indicated that they would or might install water efficient devices if they needed to replace their water-using appliances. This suggests that once the public has knowledge of water-saving solutions, the will to acquire and install those devices is quite strong. Having to then register and opt in to receive such devices free of charge from the government is simply another step that could discourage adoption.

Hong Kong should, therefore, consider having all or the vast majority of domestic consumers already opted in by default, so that a critical mass of the population receives the flow-limiting devices. It is safe to assume that not even everyone who has the water-saving devices will use them, but at the very least, the easy-to-install tools should be in the hands of as many households as possible.

5.6 Education programmes and school initiatives

As stated in section 4.4, there is a crucial opportunity for WSD to inculcate both current and upcoming generations of the Hong Kong populace when it comes to spreading water knowledge and best practices for conservation.

Hong Kong should survey more methodically the attitudes of its populace on water use, cost and conservation. While new initiatives like smart metering have shown merit in other parts of the world and could have a positive impact in Hong Kong, WSD needs to accurately determine how its population views various water issues, challenges and changes.

Two public opinion surveys are available on WSD's website, conducted in 2011 and 2015.[232] More frequent assessments could be produced to gauge a wider array of public attitudes on water, from overall pricing to the installation of flow-control devices. To produce meaningful action, there needs to be a purposeful, directed follow-up programme to the key findings of each survey.

For instance, in the 2015 survey, the reasons given by some respondents for not installing flow controllers were: lack of knowledge; inconvenience; wrong size.[233] This information is telling, and highlights a clear bottleneck for WSD to tackle. A white paper or public consultation on what WSD learned from these insights, and how it plans to address the issue, would be important and helpful. This would go towards solving WSD's rather piecemeal approach to improving Hong Kong's water conservation, as illustrated earlier in this report. The presence of flow-controllers may seem like a move in the right direction, but there are implementation, adoption and customer satisfaction bottlenecks that could be addressed in future education programmes.

In other cities, the role of water-related education programmes is coupled with the need for available metrics. For example, the Mayor of London and the United Kingdom Environment Agency jointly undertook a study in 2009 examining the likely social effects of introducing widespread domestic water metering in the city.[234] This revealed that only

6% of Londoners were aware of the connection between their water use and energy bills, and led to the consensus that metering initiatives needed to be accompanied by customer communications and education programmes on how to interpret more frequent and detailed batches of water use data.

Hong Kong could adjust its school education kits to deepen the learning experience and bridge the gap between classrooms and practical water saving. For instance, in Ontario, Canada, school education programmes on water conservation offer ample contextualisation of what savings and losses translate into.[235] They also allow students to conduct their own school audit, and measure or research the leakage rates of faucets, toilets and pipes. In the San Francisco regional water system, schools offer water kits to primary school students (5th grade) to allow them to install water-saving devices and perform water audits of their own homes.[236] This form of outreach can enhance a hands-on approach to monitoring and analysing water use, and actively involve both younger generations and their families in conserving a scarce public resource.

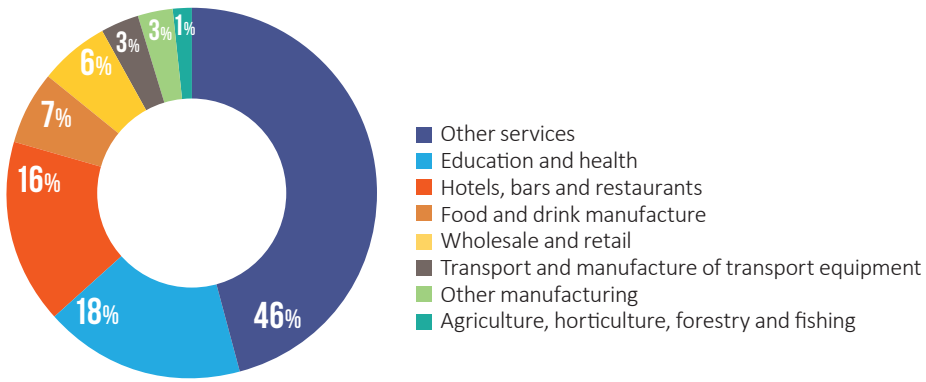
5.7 Transparent public water use data

In tandem with the importance of using regulatory codes to publicise water use data (section 5.3), it is also crucial for such transparency to be applied to households. This would mean arming residents with composite information on their water usage, such as how much water is used in the kitchen or bathroom, and greatly facilitating user awareness on which household activities consume more water, as well as comparing their environmental impacts. We can also learn from cities such as London how they engage the business sector in benchmarking and reducing their water footprints.

London (UK) details granular data on water usage in the city. Corporate use (categorised as "workplace water") in London is broken down by sector, with statistics such as the carbon emissions resulting from the water supply, consumption and wastewater treatment, in addition to its composite use inside the home.

FIGURE 16 **Water Use of Business Sector in London (Example of More Granular Water Consumption Breakdown)**

Source: Mayor of London, 2011



Domestic households should have precise knowledge of how their water use compares to that of others in terms of their neighbours, building, estate and even district. Assessing one's own water consumption is more meaningful when armed with information about the habits of peers.

This data could be anonymised and still contain useful benchmarks for residents to evaluate their own use. Not everyone will be deterred when they see their quarterly consumption exceed that of their immediate neighbours by 5%. But not everyone will find it easy to ignore the pressing need to conserve when that figure is consistently greater than 10%, or if their peers make rapid improvements.

Systematic steps should have been taken years ago to measure these data points, and it is of pressing urgency to collect these metrics and generate insights from them, whether within WSD or by consumers themselves.

6 CONCLUSION: IT'S TIME TO MODERNISE LOCAL WATER MANAGEMENT

Hong Kong has been dealing with the same fundamental water issues for many years. Its consumption levels run high for a city its size, the current pricing structure distorts the value of water and the lack of available data keep policymakers in the dark about the districts where infrastructure is in greatest need of repair.

Over the years, Hong Kong has made improvements to reduce water leakages in a system that delivers fresh water to nearly 100% of its residents. It has also put together numerous programmes to educate the public on conservation and develop technological solutions to better monitor supply problems. However, a modern water system is defined by its scope, vision and integration with other cities sharing the source. Hong Kong's wasteful water usage in its consumption habits, lack of ambitious conservation programmes and chronic infrastructure leaks not only reduce the availability of this scarce resource for the city's future generations, but also set a bad example for other cities in the PRD.

In 2014, C40 Cities – a global network of more than 70 megacities committed to addressing climate change, of which Hong Kong has been a member since 2007[237] – published an urban water blueprint for mapping conservation solutions.[238] For the nearly 30 member cities with significant power over water assets and policy, their top five priorities and actions included reducing water leaks, promoting more extensive adoption of water-efficient appliances and using incentives to introduce water efficiency measures. The importance of this global cohort should not be underplayed: peer cities are making concerted efforts to prioritise water improvements and holistic fixes at the policy level.

Given these challenges, Civic Exchange recommends that WSD and the Hong Kong government take specific policy actions to establish a bold directive for improving the state of domestic water control, and as a city take the initiative on effective resource management.

This study suggests that by 2030, the government set more ambitious, yet entirely realistic, goals to produce more meaningful water conservation impact in the next decade:

- Reduce water lost through leakages in government mains from 15% to 8% by 2030, which would save 72.9 million cubic metres (m^3) of fresh water, or enough fresh water for more than 540,000 Hong Kong residents each year.
- Set a baseline target of reducing daily domestic water consumption by 25% by 2030, i.e. from 220 litres to 165 litres per capita, generating an annual saving of 147.4 million m^3 of water (fresh and sea). A more ambitious goal would be seeking 50% reduction to bring our daily domestic water consumption to 110 litres per capita (an annual saving of 294.7 million m^3), meeting international best practice as demonstrated by comparable international cities such as Berlin and Madrid.

Together, these goals would result in total annual water savings of at least 220.3 million m^3 by 2030: a volume equivalent to 17.7% of the total water (fresh and salt) consumed in 2016;[239] or 367.6 million m^3 savings if we can achieve the more ambitious 50% reduction target, which would mean a 29.5% reduction in the total water consumed in 2016.

Without these more ambitious targets, Hong Kong will only save around 72.3 million m^3 of fresh water if only government pipe leakages were addressed, with a conservative target of 2% reduction in household water use.[240]

Hong Kong water conservation should be bolder and prioritise ambition. Therefore, the additional 220.3 million m^3 of water saved – if valued at the current price of purchased water from the Dongjiang River listed by WSD[241] – would translate into savings of HK$1.3 billion by 2030, or savings of HK$2.17 billion if the more ambitious target of saving 367.6 million m^3 would be achieved. With these savings, WSD can instead invest in strategic initiatives and technology research to safeguard Hong Kong's long-term water security.

In conclusion, it is no longer sufficient to implement piecemeal solutions like water efficiency labelling schemes or offer flow-limiting devices if they are not part of a broader programme of frequent evaluation and data monitoring. Instead, cities like Hong Kong need to assess all aspects of this multi-faceted problem, examining technical, economic (pricing) and educational solutions.

Hong Kong must adopt a bolder, basin-wide integrated water modernisation programme in order to be a robust city in the coming decades, when climate change and population growth will continue to put pressure on the source of its water. Should the city fail to modernise in a comprehensive, integrated and ambitious way, the longevity of its seemingly plentiful water supply will rapidly be called into question.

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    Source: Water Supplies Department, *Annual Report 2016-17,* Hong Kong: HKSAR Government, https://www.wsd.gov.hk/filemanager/common/annual_report/2016_17/common/pdf/wsd_annual_report2016-2017.pdf (accessed 17 Jan 2019).

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    Water supplied from Guangdong is renewed every three years, and Hong Kong is guaranteed a stable supply under current agreements. Under the lump sum package deal approach adopted since 2006, Hong Kong may import Dongjiang water as needed up to an annual ceiling of 1.1 billion m^3, to ensure 99% reliability of the water supply in Hong Kong. This entails a water supply maintained around the clock, even under extreme drought conditions. The Dongjiang River Basin Administration views the probability of extreme drought to be once in 100 years.

    The essence of the imported water relationship lies in what is known as "turnkey purchase," a principle stating that the yearly volume is fixed at 1.1 billion m^3 after Hong Kong makes its lump sum payment, but the daily quantity supplied can be adjusted according to local reservoir and rainfall conditions.

    This means that Hong Kong does not financially benefit from any of its conserved, unused annual water allotment: the agreement requires the Hong Kong government to pay for a fixed volume, regardless of how much is ultimately used or saved that year. Any unused quota cannot be transferred to third parties (i.e. resold or "lent" to other cities that need more), redeemed as credits, or stored for future use when local demand increases.

    This current arrangement has been in place for decades. Both governments continue to explore different payment pathways before the next supply agreement (post-2020), such as a combination of a fixed lump sum payment in exchange for a guaranteed portion, and then a variable sum for any quantities exceeding that allocated volume based on the water actually supplied.

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34. It is important to note the water resources distribution plan for the other 7 Mainland Chinese cities in the Dongjiang River basin, because Hong Kong is the only city that is allocated the same volume of water during both normal yield and during drought. Each of the remaining 7 cities receive anywhere from 84.6% (Meizhou) to 96.7% (Heyuan) of their normal yield allocation during times of drought. Four of these cities (Dongguan, Shenzhen, Heyuan, and Huizhou) receive 70 and 90% of their water from this source (Hong Kong is 70 to 80%), while the other three rely on Dongjiang only as a supplementary source.

    Source: Legislative Council Secretariat Research Office, *Water Resources in Hong Kong*, June 2015, Hong Kong: HKSAR Government, https://www.legco.gov.hk/research-publications/english/1415rb05-water-resources-in-hong-kong-20150611-e.pdf (accessed 17 Jan 2019).

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55. Based on WSD annual reports since 2002, the maximum year-on-year growth was 2.5% (2014) and the minimum value was a reduction of 1.7% (2011).

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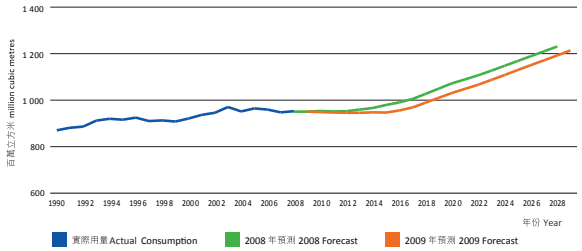
60. 二零零九年至二零二九年食水需求預測
    Fresh Water Demand Forecast Projection 2009-2029



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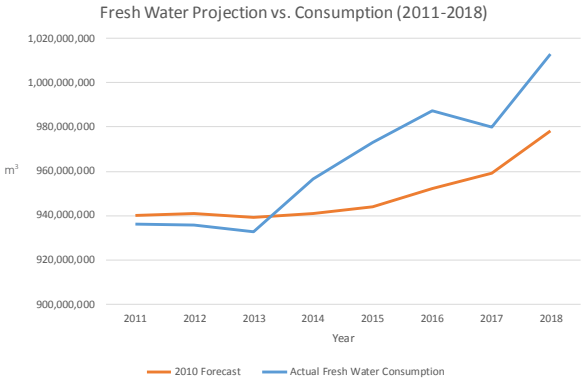
64. This 1.4% growth projection was kept unchanged due to the relative similarity of WSD's 2010 fresh water projections compared to actual projections within those same years:

Year	2010 Fresh Water Forecast (m^3)	Actual Fresh Water Consumed (m^3)	+/- (%)
2011	950,000,000	936,000,000	+1.50%
2012	949,000,000	935,430,000	+1.45%
2013	949,000,000	932,780,000	+1.75%
2014	951,000,000	956,460,000	-0.57%
2015	950,000,000	972,710,000	-2.33%
2016	959,000,000	987,220,000	-2.86%
2017	972,000,000	979,900,000	-0.81%
2018	993,000,000	1,012,590,000	-1.93%
		Average:	-0.48%



Sources:
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65. Determining historical trends of average year-on-year growth relies largely on how many years of data are used as inputs. In this study, we took the average total fresh water consumption data from 1997 to the most recent available year, which showed average growth of 0.5%. This study then applied 0.5% year-on-year growth through the year 2050.

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69. Those cities were Guangzhou, Shenzhen, Dongguan, Huizhou and Heyuan.

At the time, 2020 water usage forecasts for three of the five aforementioned cities was 35-45% higher than 2010 actual water usage. Domestic total water use for these five cities in 2006-10 trended slightly upwards, with Guangzhou exhibiting the steepest consumption growth. However, more recently updated data on this issue is limited and difficult to trace.

Source: Liu, S., *Liquid Assets IV: Hong Kong's Water Resources Management under "One Country, Two Systems,"* July 2013, Civic Exchange, Hong Kong. https://civic-exchange.org/wp-content/uploads/2013/07/569-201307WATER_LiquidAssets4_en.pdf (accessed 25 Mar 2019).

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Source: National Bureau of Statistics of China, *China Statistical Year Book 2018*, People's Republic of China, http://www.stats.gov.cn/tjsj/ndsj/2018/indexeh.htm (accessed 27 Mar 2019).

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Source: Census and Statistic Department, "Table 036: Gross Domestic Product (GDP) by major economic activity - percentage contribution to GDP at basic prices", 17 May 2019, Hong Kong: HKSAR Government, https://www.censtatd.gov.hk/hkstat/sub/sp250.jsp?tableID=036&ID=0&productType=8.

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Source: Water Supplies Department, *Annual Report 2016-17*, Hong Kong: HKSAR Government, https://www.wsd.gov.hk/filemanager/common/annual_report/2016_17/common/pdf/wsd_annual_report2016-2017.pdf (accessed 17 Jan 2019).

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    Source: Asci, S. et al., "Are price strategies effective in managing demand of high residential water users?" *Applied Economics*, 2017, Vol. 49, No. 1, pp. 66-77, https://doi.org/10.1080/00036846.2016.1192272 (Accessed 27 Mar 2019)

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Source: Ibid.

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2006 American data shows that having pricing information next to consumption levels on bills increases price elasticity by 30%, but increasing billing frequency does not necessarily help reduce water usage. This is because while seeing utility bills more often does clarify the relationship between tariff and consumption in users, bills for smaller amounts tend to receive less attention.

Sources: Carter, D. W. and Milon, J. W. "Price Knowledge in Household Demand for Utility Services," *Land Economics,* 2005, Vol. 81, No. 2, pp. 265–283, https://doi.org/10.3368/le.81.2.265 (accessed 27 Mar 2019)

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Source: "LCQ4: Loss of water due to water mains leakage," 7 February 2018, Hong Kong: HKSAR Government, https://www.info.gov.hk/gia/general/201802/07/P2018020700639.htm (accessed 20 Mar 2019)

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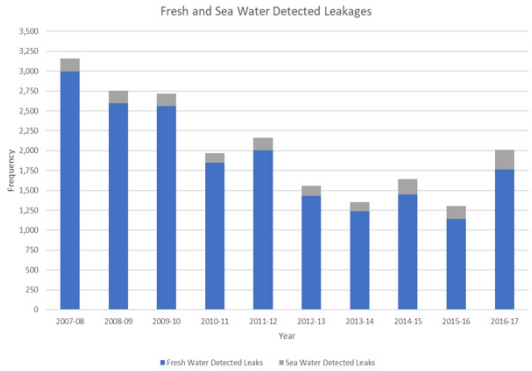
116.



Distribution of pipe leakages detected each year (2007-17) (compiled from WSD annual reports)

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    To improve on this process, emerging technologies like smart meters that more fully tilize metering and communication functions are entering common use. These technologies provide more integrated methods of metering, data storage and analytics, in addition to the free flow of information on resource control.

    Source: Berger, M. et al., *Exploring the Energy Benefits of Advanced Water Metering*, 2016, Ernest Orlando Lawrence Berkeley National Laboratory, https://www.energy.gov/sites/prod/files/2017/01/f34/Exploring%20the%20Energy%20Benefits%20of%20Advanced%20Water%20Metering.pdf(accessed 24 Jan 2019).

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    Source: Legislative Council Panel on Development, *Automatic Meter Reading for Water Supplies in Hong Kong*, CB(1)1113/17-18(09), 26 June 2018, Hong Kong: HKSAR Government, https://www.legco.gov.hk/yr17-18/english/panels/dev/papers/dev20180626cb1-1133-9-e.pdf (accessed 24 Jan 2019).

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This expansion of around 55,000 smart water meters for 2018-19 will be limited to new land sales sites in the Kai Tak Development in Kowloon East, as well as for the Development of Anderson Road Quarry Site. As of February 2017, there were six projects in the private sector and eight in the public sector in Kowloon East planning to undergo AMR system installations.

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2018 Total Fresh Water Consumption (m^3)	1,012,590,000
2018 Water losses with 15.2% mains leakage (m^3)	153,913,680
Target: Water Losses with 10% mains leakage (m^3)	101,259,000
Water Saved from Meeting Target* (m^3)	52,654,680
Demand Met with Potential Water Saved**(per capita)	**390,035**

* Difference between 15% and 10% mains leakage values
** Water Savings value divided by per capita fresh water consumption of 135 litres/year

213. Water saved if Hong Kong meets an 8% government mains leakage target:

2018 Total Fresh Water Consumption (m^3)	1,012,590,000
2018 Water losses with 15.2% mains leakage (m^3)	153,913,680
Target: Water Losses with 8% mains leakage (m^3)	81,007,200
Water Saved from Meeting Target* (m^3)	72,906,408
Demand Met with Potential Water Saved**(per capita)	**540,048**

* Difference between 15% and 8% mains leakage values
** Water Savings value divided by per capita fresh water consumption of 135 litres/year

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    Source: Water Supplies Department, *Annual Report 2016-17*, Hong Kong: HKSAR Government, https://www.wsd.gov.hk/filemanager/common/annual_report/2016_17/common/pdf/wsd_annual_report2016-2017.pdf (accessed 17 Jan 2019).

240. 19,618,300 m^3 (water saved by reducing per capita water consumption by 10% in 2030 compared to 2016 base year) + 52,654,680 m^3 (water saved from meeting 10% mains leakage target)

241. For 2019, WSD lists each m^3 of water purchased from Dongjiang to cost HK$5.90. For the 367.6 million m^3 saved by 2030, this would translate into roughly HK$2.17 billion.

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