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CASE STUDY

Tackling Singapore's Water Shortage

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Background

Water policy and governance issues are increasingly taking a centre-stage position for governments around the world. Not only is access to safe and affordable water considered a basic human right, but rapid population growth, urbanization and industrialization are forcing governments to address water issues in order to ensure sustainable social and economic growth going forward. Governments have responded by adopting a range of strategies to ensure they meet the growing demands from the industrial, agricultural and domestic sectors for access to stable and sufficient water supplies.

Singapore has long recognized the vital role the provision of a sustainable water supply plays in its future prosperity. As the country transitioned to self-governance after a period of British rule, ultimately achieving full independence in the mid-1960s, Singapore embarked on an ambitious programme of modernization to address the country's social and economic problems. In the early 1960s, the newly formed Economic Development Board began implementing strategies to encourage foreign investment and promote the development of a local manufacturing base; it also began investing heavily in public housing and education. In the 1980s, economic policy shifted towards the promotion of value-added sectors and the development of a knowledge-based economy, a policy that continues to this day. These policies led to a prolonged period of strong economic growth and a concomitant surge in the demand for the country's limited water resources.

Singapore's Ministry of Environment and Water Resources (MEWR) has overarching responsibility for water related affairs. However, Chew Men Leong, Chief Executive of the country's national water agency, the Public Utilities Board (PUB), indicates it is afforded a high degree of autonomy in designing policy and spearheading initiatives aimed at ensuring an efficient, adequate and sustainable supply of water.

Chew Men Leong explains that due to the country's small land mass and limited water storage facilities Singapore has historically been forced to rely on imported water from Malaysia, despite its relatively high and regular rainfall. Singapore's water agreements with Malaysia date back to 1927,[1] and have been a source of strategic tension between the two countries. At the local level, the country's heavily reliance on a single supplier and its exposure to potential unilateral price hikes have resulted in the water supply becoming a strategic priority for the government and wider population. As a result, Chew Men Long indicates that there has been clear political intent and wide-spread public support for ensuring national water security and establishing a diversified, clean, safe and sustainable water supply that is sufficient to meet the country's growing demand for water going forward.

In the 50 years since the PUB's establishment, Chew Men Leong indicates it has faced a number of challenges in securing a safe and sustainable water supply for Singapore. Prioritizing land use, including balancing competing demands between economic development, housing and water catchment, as well as the need to establish sustainable clean water catchments in urban areas, and engage the public in better water management practices, have presented significant challenges for the PUB. At the same time, the PUB has also needed to develop Singapore's capabilities in water

[1] Source: http://infopedia.nl.sg/articles/SIP_1533_2009-06-23.html

R&D in order to develop new technologies, innovative and large-scale water solutions, and best management practices. It has also need to change national behavior and consumption patterns in relation to the value and usage of water. The high level of funding necessary to meet the costs of R&D and infrastructure development necessary to support new water management strategies has presented the PUB with further challenges.

With the MEWR forecasting the demand for water will double over the next 50 years as a result of projected increases in industrial activity and population growth, Singapore must continue to develop new sources of water and more efficient water treatment processes.

Traditional Approaches to Water Policy

During discussions with INSEAD's Innovation & Policy Initiative, Jens Berggren, Director of the Stockholm Water Prize and Stockholm Industry Water Award at the Stockholm International Water Institute, highlighted the importance of context when evaluating the success of national water policies. Berggren indicated that water policies vary widely as they must be tailored to the specific environment and circumstances of each country, including the geographical, socio-economic and political context. Berggren cited India as an example of a country where effective water harvesting and flood mitigation are major policy issues, and compared this to arid countries with large energy reserves such as countries in the Arabian Gulf, where desalination is the paramount concern. Many countries must also manage the high water demands of agriculture, whereas this is much less of a concern in countries such as Singapore, where agriculture represents a small share of GDP.

The OECD (2009) indicates that until the 1980s, water management policies in most OECD countries traditionally focused on supply-side solutions (e.g. infrastructure, technical solutions, and water harvesting), with little attention given to demand-side issues aimed at encouraging sustainable water use. It indicates that, since the 1980s, the emphasis of water policy has moved to meet the diverse economic, environmental, and social demands relative to a scarce water supply while encouraging greater use of market based allocation mechanisms. At the same time the OECD indicates that countries have adopted more participatory and collaborative decision-making and institutional structures.

A commonly used policy instrument to tackle water scarcity is pricing. Pricing water at market rates, with the possible addition of other levies, is often considered a highly effective policy instrument for governments trying to encourage prudent water usage. More recently, appliance rating systems have become common, and in some instances, such as in Australia, water efficient appliances attract rebates. Conversely, water inefficient appliances may be subject to additional taxes. Differential pricing strategies for commercial, agricultural and household use offer further policy alternatives. Notwithstanding, political sensitivities surrounding water pricing due to commonly held beliefs that access to water is a basic human right.

Another popular instrument used by governments around the world is water supply source diversification. While this is a costlier policy measure, it allows governments to reduce vulnerabilities to shocks and disruptions to a single source. Waste water recycling has become an increasingly favoured policy measure in this respect.

A further challenge confronting countries worldwide is the need to meet the high costs of financing water infrastructure. The OECD (2009) indicates that France and the UK need to increase their water spending to around 20% of GDP to maintain water services at current levels. At the same time, the

US Environmental Protection Agency estimates that it will need to invest US $23 billion annually over the next 20 years to maintain water infrastructure and comply with stricter standards. Consequently, many governments have turned to the private sector to manage and develop water infrastructure, including through Public Private Partnerships (PPPs); these strategies appear to have met with mixed success.

Water Policy Innovation in Singapore

A recipient of the prestigious Stockholm Water Industry Award in 2007, Singapore is internationally recognised as a leader in innovative water management, and has been ranked in the top 5% of water utilities in the world (Tortajada 2006). Singapore's national water policy has served the dual purpose of both addressing the country's water shortage and driving the development of Singapore into an international water hub. Each aspect of Singapore's water policy programme is discussed below.

Developing Singapore as an International Water Hub

Driven by this lack of natural water resources, together with river pollution and a rapidly changing urban environment, following independency Singapore made the strategic policy decision to invest heavily in R&D. The aim was to build a robust, diversified and sustainable water supply with a sustainable cost base and without exposure to geopolitical stress. Policy instruments aimed at developing the country's R&D capabilities in new, diversified and more efficient water technologies, have enabled Singapore to successfully solve many of its water challenges and also establish itself as a world leader in innovative and sustainable water technologies and best management practices.

The PUB's approach to water-related R&D has encompassed the entire water value-chain, including idea conceptualization, basic research, applied research, demonstration and test-bedding, and commercialization. The PUB works closely with local and international partners, in both the public and private sectors, to conduct applied research to ensure Singapore has an efficient, adequate and sustainable water supply. It also supports cross-disciplinary research that it views as having "the potential to lead to high-impact innovations and applications in the water industry".

The PUB indicates that while the water industry's traditionally conservative approach to new and unproven technologies has protected water safety and public health this has also stifled the application of potentially revolutionary innovation. It has responded by making its research facilities available as industrial test-beds to private- and public-sector innovators for the testing of products, processes, systems and services (PUB Mar 2012). By sharing the costs and risks associated with test-bedding technologies the PUB has been able to gain buy-in and commitment of other researchers involved in developing new water technologies which can be applied to solving Singapore's water problems.

In more recent years, the MEWR has also promoted more efficient and effective water management through the establishment of the Environment & Water Industry Development Council (EWI). As both an end-user and ready market for water technologies, the PUB supports the EWI to develop the environment and water industry by promoting a whole-of-government approach to Singapore's R&D activities. The EWI facilitates cross-sector coordination among government agencies involved in water management, and aims to reduce potential conflicts of interest across sectors. The EWI works with stakeholders to support R&D into new water technologies, and to develop an eco-system for anchoring the activities of local and foreign players in the water industry.

Working in partnership with tertiary and research institutions and the private sector, and through the promotion of international collaborations, the EWI and PUB together provide a bridge between upstream research and the testing of new technologies for downstream application. Stakeholders are afforded a large degree of autonomy in their R&D, while at the same time being providing with valuable technical, financial and political support for these activities. Singapore's policy approach is reported to have attracted large-scale investment and high-calibre researchers in water R&D and has assisted Singapore-based companies to expand their business in global markets (MEWR; PUB Mar 2012).

The EWI's support of Siemens' Global Water R&D Centre based in Singapore to develop and commercialise its desalination technologies exemplifies the success of this policy. This collaboration has resulted in the development of an innovative technological solution that has significantly reduced the energy requirements of Siemens' water desalination processes, and has led to Siemens producing more efficient 'next-generation' desalination units which the company hopes will give it a competitive edge in world markets (PUB Jul 2012).

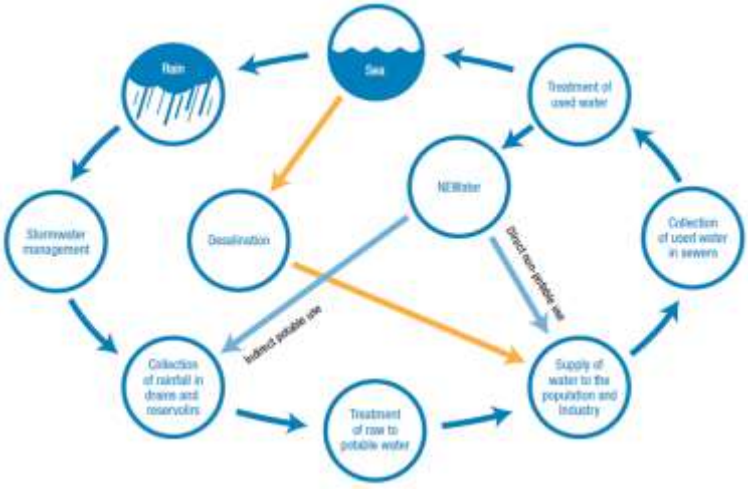
Addressing Singapore's Water Shortage through Innovative Water Management

Tasked with implementing Singapore's national water policy the PUB has implemented a range of innovative programmes designed to address both supply- and demand-side issues to ensure a sustainable national water supply going forward. Chew Men Leong claims that this innovative approach of 'system thinking' has been instrumental in the PUB's success by addressing Singapore's water shortage through a system-wide approach.

Supply-Side Policy Instruments

Singapore is one of the few countries to have addressed its water supply in its totality by adopting an innovative four-pronged approach to establish a robust, diversified and sustainable water supply (Tortajada 2006). Known as the 'Four National Taps', Singapore's water supply is based on four sources of supply: 1) local catchments; 2) imported water from Malaysia; 3) recycled water, brand named 'NEWater'; and 4) desalination. The PUB is responsible for managing each component of Singapore's water cycle, illustrated in Figure 1 (below), from sourcing and collecting water, to supplying water for domestic and industrial use, to the treatment of used water to produce NEWater.

Figure 1: Singapore's Water Cycle



Source: 'Innovation in Water: Singapore', PUB, Vol. 2, March 2012

The PUB has been very strategic in designing its water R&D programme to address each stage of the water cycle. This has resulted in a range of innovative technologies, supported by the country's on-going investments in R&D, that have enabled Singapore to improve the effectiveness and efficiency of its water catchment programmes, as well as its water processing and treatment operations.

The PUB cites its NEWater initiative as a key example of a significant innovation breakthrough and an example of how Singapore has become an early adaptor in new water treatment technologies. Using state-of-the-art membrane technologies to produce high-grade recycled waste water, Singapore's NEWater technology has won it international acclaim and helped to make Singapore a world leader in the application of water recycling technologies and sustainable water management strategies. The PUB introduced NEWater to the supply network in 2003, and it currently meets around 30% of water demand. The quality of NEWater is so high that Singapore's water-intensive micro-chop processing industry now uses it in place of potable water. Nevertheless, while NEWater is both suitable for drinking and industrial use, the PUB has encountered public resistance to the use of recycled water. It has responded by launching a public education programme, including a NEWater Visitors Centre, and by supplying NEWater to industry at a discounted rate to encourage greater usage. (CNC 2012; PUB 2011 & 2012)

Another innovative policy programme introduced by the PUB has addressed the need for improved and expanded local water catchment. The PUB has pioneered a new technology known as 'variable-salinity plant' (VSP) that enables processing facilities to process brackish rainwater collected in outlying catchment areas during the wet season and then shift to seawater desalination during the dry season according to variations in precipitation. This new technology has made the construction of water processing facilities in outlying catchment areas cost-effective and is estimated will increase water catchment to 90% in the long term. Having successfully piloted VSP technology, the PUB is now exporting it to countries interested in maximising efficiency in water use (PUB Jul 2012).

Demand-Side Policy Instruments

Concurrent to addressing supply-side issues, the PUB has implemented a comprehensive demand management policy to encourage more efficient water usage through pricing, mandatory water conservation requirements and encouraging voluntarism.

Water pricing has been a central component of demand management, with the government aiming to dissuade people from the belief that water is free and to ensure they use it carefully. The PUB's pricing policy ensures that water is priced to reflect its cost base along the entire production and supply line. It also imposes a progressive 30-45 per cent water conservation tax (WCT) on consumption to encourage water conservation. The PUB's Chew Men Leong indicates that this tax reflects the marginal cost of the "next round of water", being the cost of supplying water from alternative sources such as NEWater and desalination, including costs associated with on-going R&D activities. This has proved to be an effective policy instrument, with the PUB reporting a concomitant decline in average household water consumption as water bills have increased.

Unlike many countries that provide an amount of subsidised water to all households irrespective of their ability to pay, Tortajada (2006) argues that Singapore's tariff structure represents a more efficient policy instrument in socio-economic terms as it applies a standardised pricing structure for all households regardless of income together with a targeted subsidy to low income households. Moreover, the progressive WCT which increases as water consumption rises is also reported to have seen households more actively conserve water (Tortajada 2006).

The PUB has long appreciated the importance of communication strategies aimed at building a mind-set across stakeholders of the value of water and water conservation. The PUB indicates that it has adopted a three point communication strategy aimed at the public, private sector and government. As part of this it has implemented extensive and long-running school and public educational campaigns to raise awareness of Singapore's water issues, with all children provided a water education programme at school. Educational programmes aimed at teaching the population about the importance of not polluting waterways, especially those in urban areas, has been especially important.

Recognising that public support was crucial for demand-side policy instruments to succeed, and in a bid to encourage the public to conserve water, the PUB rolled out the "10-Litre Challenge" programme in 2006. The aim of this programme has been to get people to reduce their daily water consumption by 10 litres. It comprises a variety of initiatives including: water volunteer groups; a labelling scheme for water-efficient appliances; and the promotion of dual-flush low-capacity flushing cisterns.

In a further initiative, the "ABC Programme", short for "Active, Beautiful and Clean", was initiated in 2008, as an umbrella programme to integrate and manage all initiatives involving water catchment areas and water bodies. Chew Men Leong explains that the intention of this programme has been to encourage the public to enjoy water more with the hope that this will encourage them to place a higher value on it, in turn leading to improved water stewardship. The ABC programme has seen Singapore beautify its canals and simultaneously create community spaces for the public to enjoy. An example includes Singapore's Marina Barrage which is part of Singapore's only city reservoir and not only facilitates downtown freshwater catchment but also provides an urban recreation area for the public.

The Impact

Not only has Singapore's national water policy successfully enabled the country to secure a safe and sustainable water supply for future generations, but Singapore's investment in R&D has also seen it develop into a world-class innovation-driven water industry. The high level of autonomy afforded the PUB in the implementation of water policy, and the provision of an enabling environment for R&D activities and the development of Singapore's water sector, have been instrumental in underpinning Singapore's success.

Chew Men Leong reports that the PUB has typically enjoyed a high level of public and political support in implementing Singapore's water policy. Areas of resistance and concern have generally been dealt with through education programmes aimed at raising the awareness of the strategic importance of securing the national water supply, and programmes aimed at educating the public of the importance of water conservation. In the case of NEWater, which initially met with a level of resistance due to concerns over the safety and cleanliness of reclaimed water, the PUB reassured the public by running around 100,000 tests on the quality of NEWater, and by convening an international panel of experts to confirm that NEWater was clean, safe and reliable.

The PUB's policy of sharing the costs and risks associated with R&D between the government and private sector has also been successful in driving advancements in new water technologies where considerable risk and ambiguity surrounded potential applications and outcomes. At the household

level, this has also reduced the public cost of delivering technological innovations necessary to ensure a safe and sustainable water supply by the sharing of R&D costs through PPPs.

Through the introduction of the "Four National Taps" programmes, Singapore has successfully been able to diversify and expand its water supply. Combined with demand-side initiatives, Singapore can now meet the country's needs for water and support its continued economic growth. The MEWR and PUB report progress to date includes:

1. Local Catchment: The PUB reports that since 1973 it has spent more than US $2 billion on the construction of new drains and canals. Singapore has also increased its total number of reservoirs to 17, and has extended its water catchment areas from half to two-thirds of its land area. It now collects rainwater for treatment through an extensive network of drains, canals, rivers, storm water collection ponds and reservoirs, and is one of the few countries in the world to harvest urban storm water on a large scale for its water supply.
2. NEWater: Singapore has developed five NEWater plants which it estimates can meet 30% of the country's water needs. Between 2007 and 2010, the sale of NEWater rose from 49.2 million m^3 to 96.4 million m^3. The PUB now plans to triple NEWater production capacity to meet over 50% of Singapore's water demand by 2060.[2]
3. Desalination: Singapore has constructed its first desalination which plant can produce 30 million gallons of water daily and is estimated to meet almost 10% of the nation's water needs. A second plant with a daily production capacity of 70 million gallons is due for completion during 2013. By 2060, the PUB plans to expand its desalinated water production ten-fold, and projects this will meet up to 25% of Singapore's water demand.[3]

On the demand side, wide ranging water conservation initiatives, including education programmes, have been effective in encouraging individuals and industry to use water wisely, and have seen per capita domestic water consumption decrease from 176 litres per day in 1976, to 165 litres per day in 2003, and 152 litres per day today; the target for 2030 is 140 litres per day (PUB; MEWR).

Since the establishment of the EWI in 2006, the PUB reports that Singapore now has 25 research institutes and corporate laboratories. Working with the local research community, these organizations have undertaken an estimated 348 R&D projects valued at UD $221 million (PUB, Jul 2012). The World Bank (2006) also reports than an increasing level of private sector investment in water utilities has led to improvements in investment efficiencies and increased the capacity of Singapore's water sector.

The PUB's CEO, Chew Men Leong, claims that Singapore's investment in water research has enabled the country to turn a weakness into competitive strength by positioning Singapore as, 'a global hydro-hub boasting a vibrant water research ecosystem." It has also made Singapore a 'launch pad for the expansion of water technologies into the region' (PUB Mar 2012). Supporting this view, Deloitte (2010) surveyed 155 Singapore-based water firms in 2010, and found that over two-thirds of their revenues were earned from overseas operations. Chew Men Leong indicates that Singapore's water cluster has grown to around 100 companies, with many Singaporean companies operating in key water markets worldwide. Singaporean firms in the water recycling sector are reported to be winning contracts across the Middle East, Asia and Latin America (Keck, 2010).

[2] Source: http://www.pub.gov.sg/mpublications/Documents/OurWaterOurFuture_2013.pdf
[3] Source: http://www.pub.gov.sg/mpublications/Documents/OurWaterOurFuture_2013.pdf

Estimates by the MEWR indicate that, by 2005, Singapore's water sector contributed over US $618 million to the economy and provided a total of 6,100 jobs.

Conclusions

Water is a strategic resource for countries around the world. Securing a safe, secure and sustainable water supply is a key policy challenge for many countries. As a densely populated island that has historically suffered severe water shortages due to a lack of natural water supplies, the Singapore government has long recognized the importance of developing new sources of water and more efficient water catchment and treatment processes. In response to these challenges, the PUB, has implemented a range of policies that have successfully addressed Singapore's water problems and have been transformative in their scale.

The country's investment in innovative water R&D across the entire water value chain, and the application and integration of these technologies into water management practices, have provided both supply- and demand-side policy innovations. These have enabled the government to deliver an efficient, safe and sustainable water supply that it projects will be sufficient to meet the population's growing demand for water in the future. The PUB predicts that by the time the current water agreement with Malaysia expires in 2061, Singapore will have achieved full water sufficiency.

Singapore's significant investments in water R&D have also enabled Singapore to develop a world-class innovation-driven water industry that is increasingly exporting innovative technologies and best practices in water management to the world, and contributing to the socio-economic prosperity of the country.

In conclusion, while Singapore's position as a water-scare city state might be unique, its achievements in terms of innovative water policies offer lessons to countries seeking more effective and efficient water utilisation. These lessons include that successful policy innovation occurs across all policy dimensions and is possible so long as the enabling conditions are in place. Firstly, the PUB adopted a whole of government approach in the design and implementation of Singapore's national water policy. It has also benefited from widespread political and public support that are critical for ensuring long-term policy success. It has worked closely with other government agencies to gain agreement and support for issues including establishing land use priorities (necessary to ensure improved water catchment capacity), as well as other programmes such as the "Four National Taps". Singapore's national water policy has also benefited from the strong political will of the government to drive water policy, effective cross-sector and cross-agency coordination of water programmes and R&D activities, integrated water management strategies to reduce administrative barriers, and effective educational programmes to ensure public awareness and support of water policy initiatives.

When asked what challenges Singapore faces going forward, Chen Men Leong points to climate change, increasing energy costs, growing demand for water, and urbanisation. He also laments that a growing complacency in the Singaporean population regarding the importance of growing a safe and sustainable water supply for the future also presents an emerging challenge for the PUB.

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