Water management in Singapore: Is NEWATER a feasible option for securing self-sufficiency in addressing the issue of water scarcity?

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Water Management in Singapore:
Is NEWater a Feasible Option for Securing Self-Sufficiency in Addressing the Issue of Water Scarcity?

Suzanne King
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ABSTRACT

Current global environmental conditions place increasing social, political and economic importance on the supply of clean drinking water. In the future it is predicted that countries with a self-sustained and autonomous supply of water, both potable and non-potable, will hold the key to economic and political power. The thriving economy of Singapore, ranked 7th in terms of GDP per capita worldwide, is no exception to the universal stress on clean water supply. This paper discusses the four national taps that currently supply Singapore with potable water and analyzes the feasibility of the small island city-state harnessing the technology of wastewater reclamation through NEWater production to achieve self-sufficiency in sourcing water. Analysis of current position and future water strategy reveals that Singapore does hold the ability to sustain itself if water is no longer imported from Malaysia. If Singapore is able to successfully harness the advanced technology it presently holds and become entirely autonomous in securing its water supply, it will enjoy considerable economic and political power in the future.

INTRODUCTION

Currently, potable and non-potable water supplied in Singapore is provided through four sources. These include local catchments and reservoirs, desalination, water reclamation and imported water. Historically, a large fraction of Singapore's water supply, roughly 50 per cent, has been delivered through contractual Water Agreements with Malaysia. The binding legal documents between these two South East Asian countries have been the root of occasional political and economic tensions since their inception in 1961 and 1962. As Singapore's first contract with Malaysia will run out in 2011, with the second one expiring in 2061, Singapore is faced with the challenge of securing its water supply before these contracts are up.

The pressing question is whether the wastewater-recycling program that produces NEWater will be a viable option for Singapore to be autonomous in generating and controlling a sufficient source of water to sustain its population in the future. The Singaporean government, led by Prime Minister Lee Hsien Loong and the People's Action Party (PAP), must determine if the benefits of being self-sufficient in sourcing potable water outweigh the costs of forfeiting the economies of importing. In addition, the social stigma associated with the consumption of recycled wastewater poses a major barrier that could stand in the way of Singapore's goal of self-sufficiency.

1. OVERVIEW OF WATER SUPPLY AND SCARCITY ISSUES

1.1 GLOBAL CONTEXT

Increasingly, water scarcity is becoming a worldwide threat, not only in developing countries, but also in many developed and wealthy countries. According to Professor Siegfried (2010) of Singapore Management University (SMU), water scarcity is a global mega trend that is rooted in one of two phenomena; economic or physical water scarcity. In countries that lack a sufficient amount of disposable income to afford potable water, particularly developing countries, economic water scarcity is the main threat. In other words, economic water scarcity means that the water supply is physically available, but because of other demographic factors, such as high population, high unemployment and low GDP per capita, the water is not available for consumption by everyone. On the other hand, the occurrence of physical water scarcity emerges when a region is unable to produce potable water due to the lack of physical availability of the resource. This could be an issue in both developing and developed countries and, regardless of a country's having the financial resources to procure water, there is no local accessibility.

The challenging issue is determining which is worse: economic or physical water scarcity? Seemingly, financial barriers preventing basic access to drinking water that is readily and physically available seems like the more unfortunate option. However, it can be argued that physical water scarcity is far worse because economic problems can be solved in the long-run through financial stimulation and the eventual economic development of countries, whereas physical water scarcity is not a situation that can be solved using such strategies; it is a much more serious issue. It is this issue of physical water scarcity that many countries today, including Singapore, are faced with.

Global water supply considerations include both the sourcing of potable water for domestic consumption as well as non-potable water for industrial and agricultural processes. The World Business Council for Sustainable Development (WBCSD) (2010) suggests most businesses are just beginning to realize the dire consequences that water scarcity entails: "everyone understands that water is essential to life. But many are just beginning to grasp how essential it is to everything in life – food, energy, transportation, nature, leisure, identity, culture and virtually all products used on a daily basis." Agriculture makes up 70% of global water usage and industry uses 22%, with domestic water use accounting for only 8% (WBCSD, 2009). These figures reinforce the importance of water in all facets of life, not just for domestic consumption. Proper management of water for agricultural and industrial use will be just as important, if not more important, than focusing solely on potable water supply.

In the future, countries that act proactively to secure both economic and physical water supply will be at an advantage on the world stage, politically and economically. Autonomy in sourcing water is becoming a crucial component in generating power and influence for such countries. According to the video "Blue Gold: World Water Wars" (2008), having control over a self-sufficient and privatized water supply will inevitably be a major source of power, security and wealth for countries and corporations. In the future it is predicted that every single drop of water will be commoditized and leveraging of water sources will be an influential means of gaining political and economic power.

1.2 SINGAPORE'S CONTEXT

Being a small water-locked nation located on the southern tip of the Malaysian Peninsula, most would assume that consideration of water scarcity is an issue far removed from the minds of Singapore's politicians and inhabitants. This couldn't be further from the truth. Although Singapore has consistently

provided 100 per cent availability of fresh potable water to the population, there is a looming undercurrent of shrinking resources and time winding down on the Water Agreements with Malaysia. Ranked 170 out of 190 countries in terms or fresh water availability, Singapore "has been rated a highly water stressed country given its high domestic consumption and lack of natural resources" (Choong, Jau and Ruay, 2002, p. 48). Compared with Malaysia, with a population of 28 million that has 580 km^3 of fresh renewable water available each year, the 4.7 million inhabitants of Singapore only have 0.6 km^3 available (CIA World Factbook, 2010).

Singapore's rapid economic and industrial growth over the past 40 years, leaving the country's free market economy ranked as 7 out of 229 countries in terms of GDP per capita, has not come without increasing needs for potable and non-potable water (CIA World Factbook, 2010). In Asia, where water has always been regarded as an abundant resource, per capita availability "declined by 40 to 60 per cent between 1955 and 1990" (Choong et al., 2002). This trend will only increase as Singapore continues to expand industrially. Particularly in the prosperous industries of semiconductor and wafer production in Singapore, "high-grade water for industrial use [is required], which is reclaimed water with a purity level higher than that of normal potable water" (Solid State Technology, 2010). Analyzing the water supply for semiconductor production becomes even more interesting when examining the bilateral relations between Malaysia and Singapore.

Malaysia is beginning to establish itself as a major competitor in semiconductor production, making their water exporting agreements with Singapore more unappealing. Essentially the Water Agreements are providing cheap resources needed for semiconductor production to Singapore, Malaysia's direct competitor in the industry. In the future the competitive stance that Malaysia asserts in the semiconductor industry will certainly play a role in pricing and contractual agreements surrounding their exporting of water to Singapore.

1.3 HISTORY OF SINGAPORE'S WATER SUPPLY

The absence of a major water supply shortage in Singapore can be accounted for by the governmental policies that have been in place since the city-state gained independence from Malaysia on 9 August 1965. The government's proactive long-term strategy toward providing safe water supply for all inhabitants has not only sustained the population's health needs, but has also produced positive economic externalities by avoiding the basic water deprivation issues that most developing countries face.

The initial water agreements between Singapore and Malaysia began when the "Johor government entered into two long-term agreements in 1961 and 1962 with Singapore's Public Utilities Board" (MICA, p.4, n.d.). These agreements provide for Singapore to draw raw water and for the Public Utilities Board (PUB) in Singapore to supply treated water back to Johor (MICA, p.4, n.d.). The Water Agreements contain measures for pricing revisions through bilateral consultation and, failing which, through arbitration. In addition to the Water Agreements with Johor, Singapore has relied on local rainwater catchment in reservoirs to satisfy nearly half of their water demand. Only recently in the past decade has Singapore tapped into the technologically sophisticated water sourcing processes of desalination and wastewater reclamation.

1.4 SINGAPORE'S "FOUR NATIONAL TAPS"

In Singapore's attempts to "move towards long-term self-sufficiency and to reduce its reliance on foreign supply, the board developed a strategy called the Four National Taps" (Net Resources

International, 2010). The four taps include the two traditional domestic water sources, rainfall and imported water, as well as the recently introduced taps, desalination and reclamation.

1.4.1 Imported Water

Water imported from Johor, Malaysia accounts for half of Singapore's daily consumption of water, some 520,000 cubic meters (Choong et al., 2002). Under the Water Agreements between these two countries, "Singapore can transfer water from Johor for a price of less than 1 cent per 1000 gallons until the years 2011 and 2061, respectively" (Tortajada, 2006, p. 227). The agreements also require Singapore to provide treated water back to Malaysia after processing. The overwhelming figures on water provisions from Malaysia serve as a backdrop to bilateral relations between the two nations.

The Water Agreements cannot be viewed as merely a business transaction. There are a variety of implications and externalities generated through the agreements, both helping and hindering relations between Malaysia and Singapore. As the agreements expire in 2011 and 2061, Singapore must carefully assess whether new contracts with Malaysia should be drawn up to continue importing or if it will be economically and environmentally feasible to become self-sustaining. Presently, however, imported water from Malaysia is "one of the most cost effective sources of water supply" (Choong et al., 2002, p. 44).

1.4.2 Local Catchments

Given that average annual rainfall in Singapore is about 2400 mm, well above the global average of 1050 mm, the country is "not short of fresh water, but short of catchments and storage" (Choong et al., 2002, p. 109). Currently, there are 17 reservoirs in Singapore used to collect storm water (PUB, 2008). According to Choong et al. (2002), building more reservoirs and damming the sea between islands would not provide a big enough catchment area for rainfall to meet Singapore's future water needs. Herein lies the greatest challenge for Singapore to utilize the water yield from the abundant hydrological cycle. Space constraints of the small island nation do not present an unlimited area for capture with, "two-thirds of Singapore's land area" already providing water catchment areas (PUB, 2008). After storm water is captured through urban runoff and reservoir catchment systems it is processed to meet global Drinking Water Standards mandated by the US Environmental Protection Agency (USEPA) and the World Health Organization (WHO).

1.4.3 Desalination

Desalination is a relatively new process that Singapore is tapping. The country has effectively taken advantage of recent technological advancements that have made desalination more efficient and cost effective (Soon, 2009). Desalination uses reverse osmosis via membranes to filter salt water from oceans into potable water. The strategic position of Singapore's 193 km of coastline presents few difficulties in acquiring seawater to process in Singapore's desalination plants (CIA World Factbook, 2010). Along with ease of access, "desalination provides a steady source of water, unaffected by variations in rainfall" (Loong, 2005). The first municipal-scale desalination plant, the Tuas Desalination Plant, was opened in 2005 (Tortajada, 2006). The membranes used in desalination are easily scalable, meaning they "can be implemented in modules and can easily accommodate technological advances" (Soon, 2009, p. 240). These same membranes are also used in the production of NEWater, which is described below.

1.4.4 Reclaimed Water

Singapore's first pilot water reclamation plant was built in 1974, but was decommissioned within one year. PUB continued to monitor developments in membrane technology and during the 1990s was able to capitalize on the opportunity to reinitiate the water reclamation project when membrane prices dropped. In 1998, a NEWater plant was again commissioned in Singapore proving that it was "economically viable to produce NEWater on a large scale" (Soon, 2009, p. 239). NEWater is projected to account for 30 per cent of Singapore's water supply by 2011, just in time for the expiration of their first water contract with Johor (Onn, 2003). The NEWater produced caters mainly to industries that require high-quality water, such as semiconductor production and wafer fabrication plants.

NEWater goes through three stages of filtration beginning with conventional treatment that meets globally recognized standards. Following initial treatment is the first step unique to the NEWater treatment involving micro-filtration through a membrane. The second phase uses a membrane with even smaller pores to conduct reverse osmosis (RO). Finally, to provide a safety back up to the RO stage, the third stage involves high-intensity ultraviolet disinfection; this is the stage that adds considerable expense (Soon, 2009). Although NEWater is widely accepted for use in industrial processes, there remains to be an overall consensus that it is unacceptable for household use, despite it being well within, and even exceeding, the WHO guidelines for safe potable water.

1.4.3.1 Benefits of NEWater

Harnessing the use of water reclamation addresses the threat of water scarcity in its entirety by eliminating the need for fresh water resources that Singapore lacks. As mentioned above, the membranes used to filter reclaimed water are scalable making the technology cost effective and easily adaptable to change. The three treatment stages of NEWater are responsible for "NEWater quality [falling] well within the USEPA and WHO drinking water standards" (Soon, 2009, p. 144).

Aside from these benefits, other positive externalities include the prospect of being a self-sustaining nation in terms of water supply and easing any tension between Singapore and Malaysia over the Water Agreements. NEWater also creates a "multiplier effect" on water supply. The multiplier effect suggests, "if 50 per cent of water is recycled, the water supply could theoretically be doubled" (Soon, 2009, p. 147). This means that instead of building up new capacity through catchment expansion, which is difficult in the small area of Singapore, or desalination, which is costly, Singapore can generate all the water it needs through the multiplier effect of recycling.

1.4.3.2 Perceived problems with NEWater

In essence, there is only one major barrier that stands in the way of piping NEWater on a national scale, and that is the psychological stigma surrounding the consumption of reclaimed wastewater. At present, NEWater is not piped through faucets for direct potable use regardless of the safety standards it meets for human consumption. NEWater has only been bottled for public sampling, reaching a total of 10 million bottles in 2008 (Soon, 2009). In order to circumvent this psychological barrier, treated NEWater is injected into reservoirs and mixed with captured water, which then goes through additional treatment. Aside from the challenge of gaining societal consensus on consumption of recycled water,

the only remaining barrier to NEWater production is the added cost involved in treatment using ultra-violet filtration. Treatment of NEWater is, however, a less costly option than desalination.

1.4.3.3 Distribution/Pricing Policies

Currently, distribution policies regulate that NEWater can be supplied for both indirect potable use and direct non-potable use. NEWater can be piped for use directly though taps in industrial processes that require high-grade water, but is not piped to households for domestic use. At present, indirect potable consumption of NEWater is only available through purchase of the bottled product.

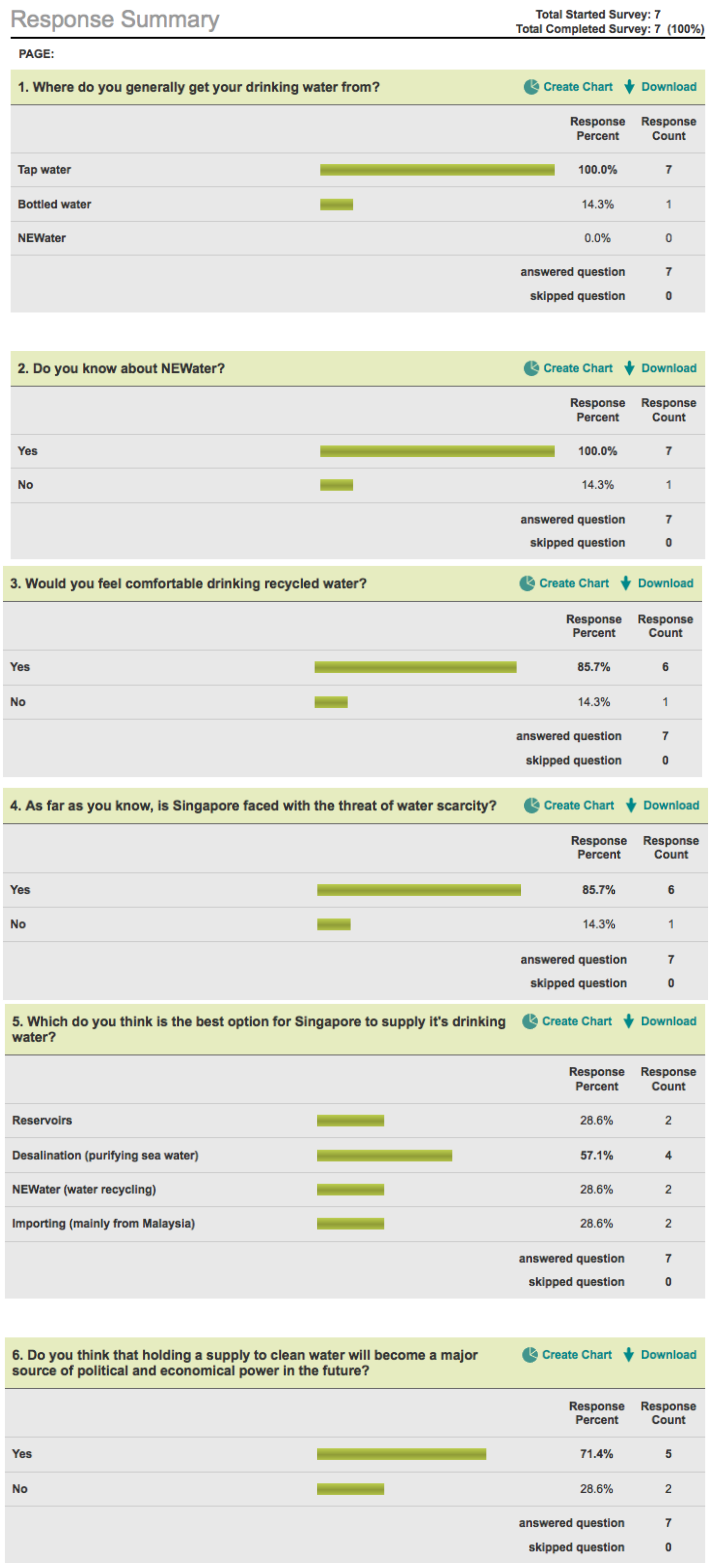
Pricing policy of NEWater is not static, but rather is a function of the raw water supply. It is more costly to produce than Public Utilities Board (PUB) water (basic treatment of storm water collected in reservoirs) but less costly than desalination. That being said, "NEWater is priced at a cheaper rate than PUB water because it does not attract water conservation tax" (PUB, 2008). The combination of higher production costs and lower selling price, presents an interesting problem for NEWater in profit generation. PUB's reasoning behind this cost-price trade-off is that production could effectively close "the water loop through recycling of used water to produce NEWater" (Soon, p. 147, 2009). The number of consumers and relative cost of producing NEWater is demonstrated in Figure 1. According to Tortajada (2006), the cost of producing NEWater is S$0.30/$m^3$ and sells at a price of S$1.15/$m^3$, which covers production, transmission and distribution costs (p.232).

	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995
Employees at the end of the year	3125	3232	3333	3426	2143	2116	2163	2138	2190	2219
Customers (Number of accounts at the end of each year)										
Water	1 173 434	1 153 195	1 129 815	1 108 255	1 063 331	1 049 438	1 013 495	974 467	942 925	910 712
NEWater	51	24	–	–	–	–	–	–	–	–
Used water	1 173 462	1 153 196	1 129 792	1 108 232	–	–	–	–	–	–
Domestic Water Consumption (lpcd)	162	165	165	165	165	165	166	170	170	172
Number of accounts served per PUB employee at the end of the year	376	357	339	324	496	496	468	456	431	NA
Capital expenditure										
Water	95.8	214.8	88.0	115.6	144.0	197.4	108.7	84.0	50.5	43.7
NEWater	58.4	89.6	96.5	12.8	–	–	–	–	–	–

***Figure 1*- Statistical Summary of Consumers and Relative Cost of Producing NEWater (1995 – 2004)**
Source: Tortajada, p. 231, 2006.

2. LOOKING AHEAD – FUTURE OF WATER SUPPLY IN SINGAPORE: Is NEWater Alone a Feasible Solution?

The previously discussed data shows that NEWater is a feasible option for sustaining Singapore's direct non-potable and indirect potable usage in theory. According to Soon (2009), the multiplier effect NEWater creates is strategically significant and can be ramped up in times of need to boost water supply. The main barriers that impede the successful full-scale implementation of NEWater as a direct potable source that could be tapped for domestic use in all Singaporean households are psychological stigma and high costs.



Response Summary

Total Started Survey: 7
Total Completed Survey: 7 (100%)

PAGE:

1. Where do you generally get your drinking water from? Create Chart Download

	Response Percent	Response Count
Tap water	100.0%	7
Bottled water	14.3%	1
NEWater	0.0%	0
answered question		7
skipped question		0

2. Do you know about NEWater? Create Chart Download

	Response Percent	Response Count
Yes	100.0%	7
No	14.3%	1
answered question		7
skipped question		0

3. Would you feel comfortable drinking recycled water? Create Chart Download

	Response Percent	Response Count
Yes	85.7%	6
No	14.3%	1
answered question		7
skipped question		0

4. As far as you know, is Singapore faced with the threat of water scarcity? Create Chart Download

	Response Percent	Response Count
Yes	85.7%	6
No	14.3%	1
answered question		7
skipped question		0

5. Which do you think is the best option for Singapore to supply it's drinking water? Create Chart Download

	Response Percent	Response Count
Reservoirs	28.6%	2
Desalination (purifying sea water)	57.1%	4
NEWater (water recycling)	28.6%	2
Importing (mainly from Malaysia)	28.6%	2
answered question		7
skipped question		0

6. Do you think that holding a supply to clean water will become a major source of political and economical power in the future? Create Chart Download

	Response Percent	Response Count
Yes	71.4%	5
No	28.6%	2
answered question		7
skipped question		0

***Figure 2* - Drinking Water In Singapore Survey Results**

Source: Survey conducted by Suzanne King, (2010)

Various sources have different figures relating to the public acceptance of NEWater and water recycling in general. Results from a small-scale survey conducted among local Singaporean university students demonstrated that 86 per cent of respondents would feel comfortable drinking recycled water as their primary source of potable water (Figure 2). A different survey carried out on a much larger scale in Singapore pointed towards an a similar overwhelming public acceptance of NEWater, "with 82 per cent of respondents indicating they were prepared to drink it directly and 16 per cent prepared to drink it indirectly, after mixing with reservoir water" (Soon, 2009).

In order to determine the economic viability of NEWater, a detailed cost-benefit analysis would have to be conducted, which is beyond the scope of the research conducted for this report. It will be the duty of the Singaporean PAP government to carefully assess the public acceptance rate, risk and accompanying costs associated with NEWater production to determine if an acceptable price for NEWater can be implemented to ensure viability.

2.1 COMBINATION OF WATER SOURCES

In the long run, the most attractive option for Singapore will be a continuation of its policy toward sourcing multiple water supplies. The city-state should, however, consider eliminating imported water as one of their national taps. In theory, Singapore does hold the ability to be entirely self-sufficient through NEWater production, but it will be essential to maintain back-up sources in the form of rainwater catchments, reservoirs and desalination plants. Soon (2009) states clearly, "a combination of more than one option may have to be pursued simultaneously to ensure redundancies and safeguard the interests of Singapore due to the strategic importance of water to the security of Singapore" (p. 42).

Future plans for NEWater will involve increasing the initial blending of 3 mgd of NEWater (about 1% of total daily water consumption) into raw water reservoirs to about 2.5% of total daily water consumption by 2011 (PUB, 2008) for the time being, until Singapore can sway public mentality in favor of direct consumption of reclaimed water. Perhaps the higher cost may be an impediment; the process of blending NEWater with reservoir water may be the most effective method. Figure 3 highlights PUB's plans for a closed water loop using a combination of NEWater, storm water treatment and desalination, omitting the need for imported water, which would render Singapore self-sufficient.

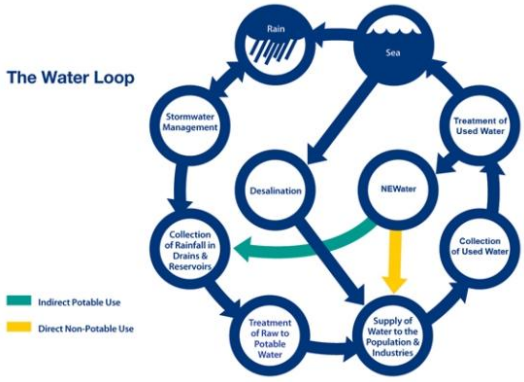


Figure 3 Source: PUB (2008)

3. MANAGING WATER DEMAND

Up until this point, the reported information has mainly pertained to the management of water supply in Singapore. However, the demand for water and the behavioral water usage patterns must be analyzed to further ascertain the true feasibility of NEWater as a component in Singapore's future water supply strategies.

3.1 MENTALITY TOWARD CONSERVATION

Historically, Singaporeans do not hold the reputation of being a population that is proactive in terms of conservation. According to PUB, past behavior patterns must be fundamentally altered in order to

curtail the demand for water (2008). Because of the Singapore government and PUB's active presence in altering the stance on water conservation, "domestic water use per person has fallen from 165 litres a day in 2003 to 155" in 2010 (The Economist, 2010). Even though domestic consumption is trending toward a steady decrease, industrial water usage is a large source of wasted water in Singapore.

3.2 MEASURES TO CURTAIL WATER DEMAND

The Ministry of Environment and Water Resources (MEWR), as well as PUB, are working toward altering the behavioral patterns of water consumption in Singapore through a variety of sustainability measures. As Singapore's population and economy continue to expand, the demand for water can be moderated through education and persuasion, fiscal incentives and disincentives and by administrative and legislative control (Choong et al., 2009). Most notably MEWR has designed a "Sustainable Singapore" program, which is widely promoted to individuals, companies and the government alike (MEWR, 2009).

Figure 4 **- Campaign Poster created by PUB to Promote Water Conservation**
Source: PUB, (2008)

PUB is working toward the same goal through initiatives to educate the public on the realities and benefits of NEWater's role in water conservation. The survey conducted for the purposes of this report reveal that 100 per cent of respondents know what NEWater is but, of the four national taps that provide water to Singapore, 57 per cent believe desalination should be the primary source to Singapore, with only 27 per cent choosing NEWater (Figure 2). These figures demonstrate the need to further educate the public about NEWater. According to Soon (2009), if people understand the safe technology behind the production of NEWater it will lead to a greater public acceptance of recycled water.

In support of this, the intensive publicity programme promoting NEWater launched in 2002 by PUB gave a boost to the public acceptance of reclaimed water. Figure 4 above outlines a seven-step water conservation process that PUB promotes to the public. PUB must continue with these measures as well as begin to promote the use of water-efficient household appliances and water saving devices to further curtail water demand and effectively change usage patterns. The positive correlation between these educational and promotional conservation programmes and the steady pattern of decline in domestic water consumption is clearly evidenced in Figure 5.

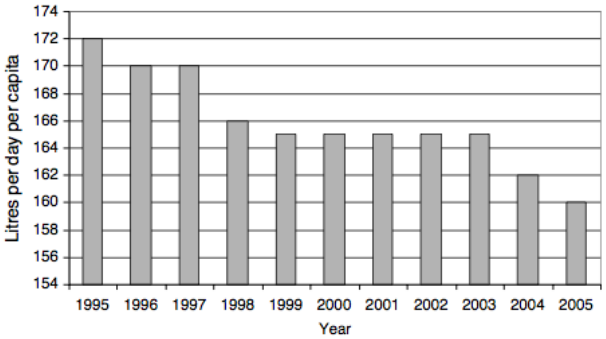


Figure 5 **- Domestic Water Consumption in Singapore (1995-2005)** Source: Tortajada, p. 235 (2006)

3.3 WATER TARIFFS

In a further effort to reduce the demand for water in Singapore, the government holds the option to augment taxes and tariffs on water based on supply and demand. Appendix F outlines the current tariffs on water in Singapore. When pricing water, Singapore applies a water tariff and the water conservation tax (WCT). The water tariff is explicitly set to recover the full cost of production and supply, while the WCT reflects the higher cost of alternative water supplies (Soon, 2009). The WCT is the main disincentive levied by the Singaporean government to reinforce water conservation measures.

Effective in 2000, the WCT rose from 15 per cent to "30 per cent of the tariff for the first 40 m^3/month for domestic consumers and all consumption for non-domestic consumers" (Tortajada, p.234, 2006). Additionally, there is a fee for various sanitary applications and industry faces even higher charges (The Economist, 2010). Comparing the figures from Figure 5 and Figure 6, the time period when the Singapore government began raising the WCT correlates positively with the gradual decline of domestic water consumption.

These statistics demonstrate just how effective tariff and tax increases can be in moderating water demand. However, there must be a careful balance when setting taxes, because if set too high they could put national potable water supply out of reach for those inhabitants with lower income.

Water Tariff

Tariff Category	Consumption Block (m^3 per month)	Tariff($/m^3$) [before GST]	Water Conservation Tax (% of tariff) [before GST]
Domestic	0 to 40	1.1700	30
	Above 40	1.4000	45
Non-Domestic	All units	1.1700	30
Shipping	All units	1.9200	30

Tariff Category	Consumption Block (m^3 per month)	Waterborne Fee ($/$m^3$) [before GST]	Waterborne Fee ($/$m^3$)* [after GST]	Sanitary Appliance Fee [before GST]	Sanitary Appliance Fee * [after GST]
Domestic	All units	0.2803	0.30	$2.8037/- per chargeable fitting per month	$3.00/- per chargeable fitting per month
Non-Domestic	All units	0.5607	0.60		
Shipping	All units	-	-	-	-

Industrial Water Tariffs (inclusive of GST)

Tariff Category	Consumption Block (m^3 per month)	Tariff (cents/m^3)	WCT (% of tariff)	WBF (cents/m^3)
Industrial Water	All units	43	-	-

Figure 6 **– Water Tariffs established by Singapore Government (2008)**
Source: PUB, (2008)

4. WATER BECOMING "BLUE GOLD"

According to Siegfried (2010), the global trend of water scarcity is creating a situation where holding a definite supply of water will be a source of great economic and political power. Additionally, 72 per cent of survey respondents believe that holding a supply to clean water will become a major source of political and economical power in the future (Figure 2). The video "Blue Gold: World Water Wars" (2008), highlights just how critical this claim is becoming. The video suggests that water privatization is becoming a trend of the future with water increasingly being viewed as a commodity and a function of supply and demand, rather than a precious resource to life. Controlling water will be critical to success and large corporations are handed power when they control the resource. These companies aim to create a type of water cartel so that one day every single drop of water will be owned and controlled (Blue Gold Video, 2008).

Singapore cannot overlook these consequential facts when strategizing the future of its water supply. Particularly in the vein of the Water Agreements with Malaysia, Singapore is not secure from potential conflict and security disputes with its neighbor over water. This is one of the most alarming issues that recently surfaced in water management, not only in Singapore, but also on a global scale. The intensifying importance of water as a key to political and geographical security and power makes Singapore's efforts to become self-sustaining all the more pressing.

According to Financial Times Columnist, John Burton (2005), "Singapore *wants* to be self-sufficient in water by 2061, when its water agreements with Malaysia expire." It is clear that Singapore is doing all it can to become autonomous in water sourcing, not only for future capitalization on the privatization of water, but also to insure its security against Malaysia and other South East Asian nations. In support of this, Choong et al. (2009) state, "from a security viewpoint, Singapore should be as totally self-sufficient as possible in water" (p. 44). The challenge, therefore, lies in the conflicting economic viewpoint arguing that the most cost-effective water supply system should be adopted, which in fact is imported water from Malaysia.

5. IMPLICATIONS OF WATER MANAGEMENT IN SINGAPORE

5.1 BUSINESS IMPLICATIONS

As the "Blue Gold: World Water Wars" video suggests, corporations that successfully control water will hold a great deal of power that can be leveraged in business. However, it will be the responsibility of these corporations to re-evaluate the externalities they generate when controlling and commoditizing water. All industries are affected by water in one way or another due to the costs passed on to them from water suppliers. Siegfried (2010) argues that business opportunities lie in the creation of water treatment companies and water-saving devices. An example is the Singapore firm Hyflux Ltd., which specializes in reclaimed water treatment using membranes.

Hyflux is the company that currently produces NEWater in Singapore. Because of the success that Hyflux has achieved in Singapore it is planning to expand Singapore's water industry abroad (Hyflux, Ltd, 2009). This global expansion "will test Hyflux's ability to maintain the rapid growth that made it a favorite on the Singapore stock exchange" (Burton, 2005). Analysts remain sceptical about whether Hyflux has sufficient financial resources to compete against larger and more capital intensive international rivals such as General Electric and Siemens (Burton, 2005). Companies that take advantage of water treatment business opportunities, like Hyflux, are able to gain a competitive advantage and most likely generate a monopoly on the water reclamation processes in Singapore.

5.2 POLITICAL IMPLICATIONS

Due to the new business opportunities presented in the era of water scarcity and in Singapore's attempts to become self-sufficient, it will be the responsibility of the Singapore Government to keep such corporations in check. The government must put firm regulations and legislation in place to monitor the amount of water they control. It will also be responsible for initiating and funding conservation programmes and implementing incentives and disincentives to conserve water and alter the public's consumption behaviors. The PAP government is already on the right track through the application of Water Conservation Taxes and tariffs. In the future it should continue to ramp up taxes in industries where high quality water usage is highest. Evidenced below is the important role that government plays in water pricing:

> *Correct pricing of water has been touted as the best policy to ensure its proper use. Current pricing levels in most countries are far too low to cut down on wastage. On the other hand, high water price could lead to protests and even riots (Soon, 2009, p. 31).*

Recognizing that water is essential to life, the Singapore government should also adopt a program of aid for citizens with lower incomes to ensure the entire population has access to safe drinking water. Currently the government has policies in place that provide tax rebates for 1- and 2- bedroom flats

during difficult economic times (Tortajada, 2006). In addition, the government can further assist those with lower incomes by subsidizing water supply.

In the immediate future the government of Singapore must come to a decisive conclusion whether to extend the water agreements with Malaysia. Analysis of costs and gains from self-sufficient water production should be conducted and the government must develop a long-term water strategy. It has been proved that NEWater is physically feasible, but the government must determine whether it is economically viable as well. Moreover, the government has to perform risk analysis before continuing to contract and open more NEWater treatment plants. If millions of dollars are spent on construction of new plants without a majority public acceptance of NEWater, Singapore could fall deeply into debt.

5.3 SOCIETAL IMPLICATIONS

The major societal impacts of implementing NEWater as a main measure for Singapore to become self-sustaining include difficulties in creating fundamental behavior change in water usage, overcoming the psychological barrier to consuming recycled water and, finally, having to pay higher prices for water, at least in the short-run. Reclaimed water will also have a number of positive benefits on society and can "even improve the public health and food supply" (Huebsch*, n.d.).* Mainly, the Singaporean population will have to be prepared for "continual initiatives and efforts at the community level" (Soon, 2009) in order to educate and alter their behavior patterns. In addition to increasing awareness of water conservation, energy conservation and environmental sustainability measures should also be channelled through the same processes, because of the close interaction between these global trends (Siegfried, 2010). In order to further these measures, PUB is working on initiatives to encourage residents in their constituencies to install water-saving devices and adopt good water-saving habits (Soon, 2009).

CONCLUSION

Drawing from the primary and secondary data analyzed in this report it is evident that "greater self-reliance in water is the way to go" (Onn, 2003). Singapore has ideally positioned itself to take off in the direction of complete self-sufficient water supply. The young city-state's efforts in reducing its dependence on Malaysia for water by diversifying its sources of supply and managing demand are collectively inducing an opportunity to become entirely self-sufficient and eliminate the current threat of water scarcity. It will not only ease bilateral relations with Malaysia, but autonomous water supply through recycled water will effectively reduce the water stress Singapore is faced with.

It remains to be seen if the Singapore government will officially take on the challenge, but it is currently in the process of conducting large-scale long-term cost-benefit analyses and risk assessment to determine viability. According to the data in Figure 7, Singapore is able to produce an excess of the projected amount it requires through eliminating water imports and harnessing the three remaining national taps, which are NEWater, desalinated water and storm water collection.

Total Water Requirement for Singapore		1.2 to 1.3 million m^3
Domestic Reservoirs and Catchments (a)	**0.68 million m^3**	
Desalination (b)	**0.40 million m^3**	
NEWater (c)	**0.25 million m^3**	
Total: a+b+c		**1.33 million m^3**

***Figure 7* – Major Water Sources in Singapore**
Source: Long (2002), The Straights Times, Various Issues

If Singapore is able to effectively implement wastewater reclamation as a long term, large-scale solution to water sourcing and sway its population to overcome the accompanying psychological barriers, self-sufficiency in water supply will be attainable for the small city-state. Additionally, NEWater as a

component of the autonomous water supply in Singapore will serve as an important base of political power as the country continues to grow rapidly and water becomes the new blue gold. In the future we can only wait and see what the Singaporean government decides, but one would hope that they take advantage of their thriving economic and technological capacity to tap into the most sustainable water supply process in the world to become entirely self-sufficient.

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