Singapore's Experience in Ensuring Water Sustainability

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PUB Singapore
September 2010
<table>
<thead>
<tr>
<th>Country Information</th>
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<tbody>
<tr>
<td>Land Area</td>
<td>710 km²</td>
</tr>
<tr>
<td>Population</td>
<td>5 mil</td>
</tr>
<tr>
<td>Annual Rainfall</td>
<td>2400 mm</td>
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</tbody>
</table>
Water resources were scarce...

Last water rationing in 1963
Floods were common occurrences...
Singapore Water
1960’s

Public Health Concerns

• Proper sanitary facilities were lacking...

• Public Health Conditions were poor...

Squatters
Street hawkers
Outdoor Latrines
Night soil buckets
Our rivers were polluted...

Singapore Water

1960’s

Kallang River

Singapore River

Kallang River
Singapore today...
Measures Adopted

- Expand **catchments**
- **Demand** Management
- Integrated **Land Use** Planning
- Leveraging on **Technology**
- **Pricing** based on cost recovery
- Strict **legislation**
Institutional Restructuring

Ministry of the Environment (ENV)
- Sewerage Department
- Drainage Department

Ministry of Trade and Industry
- Water Department

Restructured PUB in-charge of all aspects of the water loop
Closing of the Water Loop
Integrated Water Management

- Stormwater Management
- Collection of Rainfall in Drains & Reservoirs
- Treatment of Raw to Potable Water
- Desalination
- Collection of Used Water in Sewers
- Treatment of Used Water
- Reclamation of Used Water
- Supply of Water to the Population & industries
- Direct Non-Potable Use
- Indirect Potable Use

Rain → Sea
Ensuring Water Sustainability

Diversify water supply sources

Ensure diversified sources of water supply for Singapore with the Four National Taps

“Water for All”

3P Approach

Adopt a 3P approach to engage the 3P partners to use water wisely, keep the water catchments clean, and build a relationship with water

“Conserve, Value, Enjoy”
FOUR NATIONAL TAPS

Desalinated water
NEWater
Water from local catchment
Imported water (from Japan)

Water for All: Conserve, Value, Enjoy
1st National Tap - Local Catchments

Before 1960’s: Reservoirs in Protected Catchments

1970’s: Estuarine Reservoirs

1980’s: Reservoirs in Urbanized Catchments
1st National Tap - Local Water Catchments

- Half of Singapore is already water catchment
- Catchment area will be increased from half to two-thirds by 2011
- Further increased to 90% in the future with Variable Salinity Plant
Sources of pollution were identified
Case Study: **Singapore River Clean-Up**

- **Dredging & improvement works...**
- **Resettlement of squatters into proper public housing...**
- **Relocation of businesses & industries**
- **Laying of new sewers** → Separate rain and used water collection systems
Case Study: Singapore River Clean-Up

1970s 1990s
Case Study: Singapore River Clean-Up

Clean Rivers

Singapore River
3-in-1 Marina Barrage Project

1st city reservoir in the world
• Water supply
• Flood control
• Lifestyle attraction

Water for All: Conserve, Value, Enjoy
Punggol-Serangoon Reservoir Scheme

First class waterfront environment and water lifestyle activities at housing new towns in the 21st century is now a possibility.
2\textsuperscript{nd} National Tap - Imported Water from Johor

Two water agreements with Johor, Malaysia

- 1961 to 2011
- 1962 to 2061

State of Johor, Malaysia

PUB pipelines carrying water from Johor
3rd National Tap – “NEWater”

• First advanced wastewater reclamation plant set-up in 1974

• Shut down in Dec 1976 after 14 months of continuous operation because of
  – High cost
  – Unreliable technology

• Re-look in 1998
  – Demonstration plant set-up in 2000 and run over 2 years to test operational robustness and reliability
  – More than 20,000 tests for some 190 water quality parameters
Technology was there.

We needed to gain **public acceptance**
NEWater - Political Endorsement

- Launch of supply of NEWater and opening of the Visitor Centre by then Prime Minister in 2003
- Political leaders drank NEWater in major occasions
NEWater demonstration plant, 2000

From used water to new

MICROFILTRATION
- Treated used water passes through fibres. Suspended solids and bacteria of more than 0.2 microns are filtered out.

REVERSE OSMOSIS
- Water is conducted through the middle of the hollow fibre.
- High pressure forces the water through special membranes which trap contaminants (dissolved salts, chemical contaminants, drugs and viruses), allowing only the pure water through.

UV DISINFECTION
- In this final step, the water is further disinfected with ultraviolet light. The process is inexpensive and fast, and leaves no taste or odour in the water.

END-PRODUCT
- Newater is produced through a process using membranes to extract pure water from used water.

Praise for S’pore’s reclaimed water

Water reclamation plant here uses the best technology in the world, says a world-renowned water quality expert

By DOMINIC NATHAN

“Here, you have taken the best of the best and put them all together.”

Environmental Protection Agency.

A total of 191 different parameters were evaluated, from the colour of the water to detecting the presence of bacteria, viruses, hormones and the reclaimed water with natural minerals and other beneficial compounds which are removed during the purification process.

The addition of fresh water also helps overcome the “yuck factor” in drinking reclaimed water, added Prof Rose.

PANEL: Most have no problem with taste

THE Straits Times tested Newater on 21 people and 19 said it tasted different from tap water. It is more like distilled water, because minerals and other compounds found in tap water have been removed in the treatment process. Some also said the smell of chlorine, which is added early in the treatment process, reminded them of swimming pool water. All but one said they would have no problems drinking it. This is what some of them said.
CHEERS! to 37 years and Newater

Grassroots leaders happy with Newater's quality

Most of those at PUB talks do not mind drinking reclaimed water but on paper has been set yet on when homes will get it. The whole purpose of introducing Newater is to reduce the increased cost of future supply of water in Singapore. If you compare the capital cost of Singapore's desalination, Newater costs about half that of desalination. In terms of energy consumption, it's about one-quarter to one-third. As a result, the total cost of Newater production is about half that of desalination. So, the introduction of Newater helps prevent the need to increase the price of water in future.

We'll drink to that

Emily was really helpful but really singing. We don't every day but one's from the Table.

Good enough to quench the thirst

The name may not be the cleverest or the most elegant, but Newater represents the most significant breakthrough in Singapore's search for solutions to its long-term water needs. Of Singapore's current water consumption of 300 million gallons daily. But come 2011, the volume that comes onstream could amount to more than 55 mgd, when two more Newater plants, in Seletar and Ulu Pandan, come into operation.

To be sure, the reclaimed water - which, after treatment, becomes purer than tap water - will find only industrial uses for now. Still, it's a helpful start that will free up more potable sources for Singaporeans. Notably, Singapore's wafer fabrication plants - which consume copious amounts of ultra-pure water - are switching to Newater. And if Newater meets the mark for wafer fabs, with its exacting demands for high-grade water, surely it's more than good enough for other water-intensive industries that don't have such high standards.

Surely Singaporeans - who now readily drink water from the tap - don't assume that the rivers and reservoirs that currently feed Singapore's water pipes are free of virus, bacteria or other micro-organisms. And the treatment for Newater removes organisms of up to 0.0001 micron in size (a bacterium). It takes the process one step further. The entire cost of the treatment for Newater is estimated at less than a cent per liter of treated water.
Clarity in Public Communication (NEWater)

• Good Branding
• Choice of words
  – “Used Water” vs “Wastewater”;
  – “NEWater” vs “Reclaimed Water”
  – “Water Reclamation” vs “Sewage Treatment”
• Emphasis
  – Concept is not new
  – RO technology
  – Indirect Potable Use
NEWater Visitor Centre is the focal point of our public education on:

- Role of NEWater as one of the 4 national taps
- The importance of water
- The technology behind NEWater

- Targets mainly our younger generation (e.g., students)

- Opened in Feb 2003; 400,000 visitors to-date
3rd National Tap – “NEWater”

- NEWater Infrastructure Plan (NIP) and NIP Extension pipeline projects in progress to meet growing demand by industries
- NEWater to meet 30% of water needs by 2011

Water for All: Conserve, Value, Enjoy

[Image of water treatment facilities and pipeline maps with locations such as Kranji, Bedok, Ulu Pandan, and Changi, showing the capacity of NEWater production in mgd (megagallons per day).]
NEWater - Uses

Indirect-Potable Use
✓ Reservoir recharge
✓ 41,000m³/day being injected currently

Direct Non-potable Use (154,500m³/day)
✓ Wafer fabrication
✓ Power station
✓ Air-con cooling
✓ Landscaping
Focused Water Collection System

- 3310km of used water pipelines island-wide
- DTSS has more than 48 km of concrete tunnel to as low as 55 metres underground. Diameter between 3.3 to 6 metres
4th National Tap - Desalinated Water

- 20-yr DBOO 30 mgd (136,000m³/day)
  SingSpring Desalination Plant commissioned in 2005
- Tender launched in 2010 new 70 mgd desalination plant
- Plan to have desalination capacity meet 25% and 30% of water needs by 2020 and 2060 respectively
Public-Private Partnerships (PPPs)

• Increasing private sector participation thru’ public-private partnerships (PPPs)

• Design-Build-Own-Operate (DBOO) projects
  – SingSpring Desalination Plant (1st in public sector)
  – Ulu Pandan NEWater Factory
  – Changi NEWater Factory
Ensuring Water Sustainability

Diversify water supply sources

Ensure diversified sources of water supply for Singapore with the Four National Taps

3P Approach

Adopt a 3P approach to engage the 3P partners to use water wisely, keep the water catchments clean, and build a relationship with water

“Water for All”

“Conserve, Value, Enjoy”
Water Conservation Strategy

Water Conservation

Pricing
Reflect the strategic importance and scarcity value of water

Voluntary
3P approach
Promote ownership of water conservation

Mandatory
Cut down on excessive flow and wastage of water

UFW Control

Network Management

Strict Legislation

Measures To Control UFW

Leakage Control

Accurate Metering

% OF TOTAL OUTPUT

YEAR

Water Conservation Strategy

Water for All: Conserve, Value, Enjoy
**Water Pricing Policy**

- Restructured in 1997 based on marginal cost pricing
- Water Conservation Tax applied from the first $m^3$ of water consumed
- Full cost recovery

<table>
<thead>
<tr>
<th>Tariff category</th>
<th>Consumption block (m$^3$ per mth)</th>
<th>Tariff (¢/m$^3$)</th>
<th>WCT (%)</th>
<th>Total (¢/m$^3$)</th>
<th>WBF (¢/m$^3$)</th>
<th>Tariff (¢/m$^3$)</th>
<th>WCT (%)</th>
<th>Total (¢/m$^3$)</th>
<th>WBF (¢/m$^3$)</th>
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<tr>
<td>Domestic</td>
<td>1 to 20</td>
<td>56</td>
<td>0</td>
<td>56.0</td>
<td>10</td>
<td>117</td>
<td>30</td>
<td>152.1</td>
<td>30</td>
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<td></td>
<td>20 to 40</td>
<td>80</td>
<td>15</td>
<td>92.0</td>
<td>10</td>
<td>117</td>
<td>30</td>
<td>152.1</td>
<td>30</td>
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<tr>
<td></td>
<td>Above 40</td>
<td>117</td>
<td>15</td>
<td>134.6</td>
<td>10</td>
<td>140</td>
<td>45</td>
<td>203.0</td>
<td>30</td>
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<tr>
<td>Non-domestic</td>
<td>All units</td>
<td>117</td>
<td>20</td>
<td>140.4</td>
<td>22</td>
<td>117</td>
<td>30</td>
<td>152.1</td>
<td>60</td>
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</table>

1: Water Conservation Tax – Tax on consumption to reinforce the water conservation message  
2: Waterborne Fee – Volume-based used water fee  
3: Sanitary Appliance Fee – Fixed used water fee based on the number of sanitary appliances
Water Conservation Measures & Consumption

- 1991: WCT Introduced. Applicable for consumption over 20m3
- 1992: All new and upgraded HDB flats installed with LCFCs
- 1994: Mandatory LCFCs at all premises
- 1995: Save Water Campaign
- 1996: Save Water Campaign
- 1997: WCT restructured to be levied from first drop. Water tariff increase.
- 1998: Save Water Campaign
- 2003: Introduction of Water Efficient Homes Programme
- 2006: 10 Litre Challenge introduced
Water Demand Management

• Sustained public education
  – Public exhibitions
  – Educating the young

• Use of water saving devices
  – Water Efficient Homes and Buildings
  – Water Efficiency Labelling Scheme (WELS)

• 10-Litre Challenge (domestic sector)
  – 147 lppd by 2020
  – 140 lppd by 2030

• 10% Challenge (non-domestic sector)
  – Pilot testing of dual flush LCFCs in HDB estates

More than 500 products labelled under WELS

Water Detective Programme launched in about 140 primary schools
Connecting with the Community

• Engaging the community to participate and take ownership

Friends of Water
>1200 individuals & organisations contribute towards water cause

Our Waters Programme
49 adopters to help take care of waters

Water Volunteer Groups
61 groups formed in various constituencies

Water Network – partnership panel to reflect 3P sectors’ views & suggestions

ABC Waters - Public Awareness
Engaging the Community

Our Waters Programme
- Community adoption programme for waterways

Recreational Activities in Reservoirs
- Wakeboard World Cup
- Queen’s Baton Race
- Kayaking, Dragon-boating, Canoeing
Active Beautiful Clean (ABC) Waters Programme

Long-term strategic initiative

- To transform our utilitarian drains, canals and reservoirs into vibrant, aesthetically pleasing and clean flowing streams, rivers and lakes

- To bring people closer to the water so that they will cherish and take ownership

- To create a seamless blue-green network well integrated with the adjacent developments

“...Turn Singapore into a City of Gardens and Water”
– PM Lee, ABC Waters Public Exhibition - Feb 2007
Project Implementation

- 3 completed pilot projects with more activities and good community support

ABC Waters @ Kolam Ayer ABC Waterfront

ABC Waters @ Bedok Reservoir

ABC Waters @ MacRitchie Reservoir

Water for All: Conserve, Value, Enjoy
Ongoing ABC Waters Projects

- 12 ABC Waters projects under construction

Sungei Punggol - Sengkang Floating Wetland

- Features
  - Floating Wetland
  - Fruit themed pavilions
  - Viewing Gallery
ABC Waters Projects – under construction

Lower Seletar Reservoir (Family & Rowers’ Bay)

- **Features**
  - Performance stage
  - Heritage bridge
  - Rain Garden
  - Viewing deck
ABC Waters Projects – under construction

Alexandra Canal

- **Features**
  - Constructed Wetlands
  - Canal edge plantings
  - Community plaza
ABC Waters Projects – under construction

Jurong Lake

– Features
  • Geyser
  • Boardwalk
  • Wetlands
  • Viewing Plaza
ABC Waters Projects – under construction

Kallang River – Bishan Park

– Features
  • Cleansing biotopes
  • Amphitheatre
  • Water playground
  • Alfresco dining by the river
  • Water cascade
Artist Impression of other ongoing ABC Waters projects
Growing the Water Industry

~ Companies throughout the water value chain

- Keppel Seghers
- Hyflux
- SembEnviro
- Veolia Water
- Darco
- Dayen

System Integrators
- Desalination
- Wastewater treatment
- Liquid separation
- Membrane systems

Consultancy/Engrg Svcs
- Feasibility studies
- Technical consultancy
- Project Management

Municipal wastewater treatment

Utilities Companies
- Govt bodies
- BOO contractors
- Multi-utilities

Financing

Industrial wastewater treatment

Equipment Suppliers
- Filtration equipment
- Disinfection equipment
- Control system providers

Membranes Suppliers
- Zenon
- Hyflux
- Memcor / Siemens Water
- Hydranuatics
- Toray

Water Treatment Chemicals
- Nalco
- BioLab
- Chemitreat

Water Treatment

Materials

F&B
- Ultra-Pure Water

Testing & Analysis Services
- CAWT
- Setsco
- NUS
- NTU

Township devt
- CH2MHiII
- Black & Veatch
- CDM
- MWH
- CPG

• Siemens
• GE Water
• Veolia Water
• Pall
• Chemitreat
• GrahamTek

Water for All: Conserve, Value, Enjoy
4 - 8 July 2011

Sustainable Water Solutions for a Changing Urban Environment

• The global platform for water solutions
• Brings together policymakers, industry leaders, experts and practitioners
• Address challenges, showcase technologies, discover opportunities & celebrate achievements

• Key highlights include Lee Kuan Yew Water Prize, Water Leaders Summit (by invitation only), Water Convention, Water Expo & Business Forums

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of attendees</th>
<th>No. of countries participated</th>
<th>Value of deals, tenders &amp; investments announced</th>
<th>No. of co-located events</th>
<th>No. of participating companies in Water Expo</th>
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<td>2008</td>
<td>8,500</td>
<td>79</td>
<td>$$380m</td>
<td>42</td>
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<td>2009</td>
<td>10,000</td>
<td>82</td>
<td>$$2.2b</td>
<td>76</td>
<td>420</td>
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<td>2010</td>
<td>14,000</td>
<td>112</td>
<td>$$2.8b</td>
<td>120</td>
<td>514</td>
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Thank you