

Wastewater reclamation and reuse network Singapore

water scarcity impact

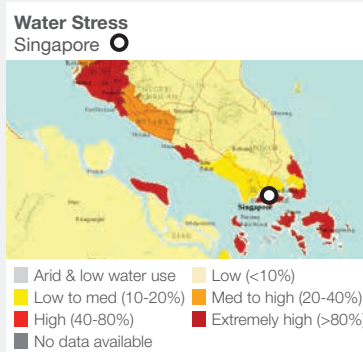


Reduced withdrawal	●
Reduced consumption	
Improved water quality	
Increased productivity	●
Net basin benefit	●

volumetric impact
127 750 000m³/yr

capital cost
confidential

estimated unit cost of water
not available



Water Stress Map:
Gassert, F., M. Landis, M. Luck, P. Reig, and T. Shiao. 2013. "Aqueduct Global Maps 2.0."

Confidence level
● Low ● Medium ● High

Water Scarcity Impact Key
● Main ● Minor

Credits
We wish to acknowledge the input of PUB, Singapore's national water agency, in the preparation of this case study.

Project Overview

Singapore has a population of over five million people with a demand of 1 700 000m³/day, this is forecast to double within 50 years with 70% of demand being from the non-domestic sector. Although rainfall averages 254mm/yr, Singapore has limited natural water resources due to its small land area of 700km²; as a result it has historically relied on imported water. In the late 1990s Singapore initiated a programme to become increasingly self-sufficient in water supply. One component of the programme, called NEWater, involves the collection of treated wastewater flows that would have otherwise been discharged to the ocean, followed by treatment using dual membrane and ultraviolet technologies to produce potable standard water. This is currently used to supply 350 000m³/day mainly for non-potable industrial use and cooling. This is equivalent to 30% of Singapore's daily water demand and forecast to rise to 50% of demand by 2030.

Key Elements

- Collection and advanced treatment of treated wastewater flows that would have been discharged into the ocean.
- Four NEWater plants established between 2002 and 2010 with a capacity of over 500 000m³/day. Two early plants were funded by the Public Utilities Board (PUB) and the other two were on Design Build Own Operate contracts.
- An extensive water sampling and testing programme to demonstrate the safety of reclaimed water.
- Distribution of bottled reclaimed water to publicly demonstrate its safety.

Key Outcomes

- Growing public acceptance of NEWater as a source of supply.
- Growth in use of NEWater from 27 000m³/day in 2003 to 350 000m³/day in 2012 offsetting the withdrawals required from existing freshwater resources
- NEWater is mainly used for non-potable industrial and commercial uses, in cooling systems and supplementing Singapore's potable water supply via indirect potable use.
- NEWater currently meets 30% of Singapore's total water demand and is projected to meet up to 55% of Singapore's water demand by 2060.



Singapore

Intervention Features

- Wastewater recycling for potable use
- Wastewater recycling for industrial use
- Stakeholder engagement

Project Levers

(1) Treated Wastewater collection:

The sewerage network collects used water from domestic and non-domestic sources.

The used water is channelled through a combination of gravity sewers and pumping stations, to wastewater treatment plants where it is treated to acceptable international standards. The treated effluent is either reclaimed via NEWater plants or disposed to the sea.

(2) Water Recycling and purification:

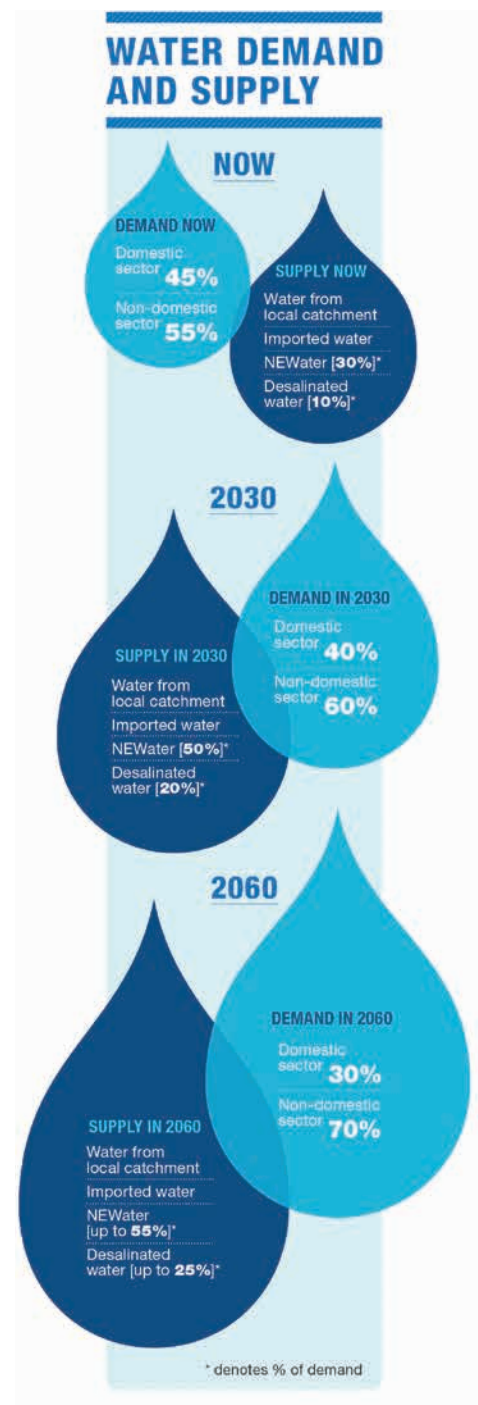
NEWater is made by purifying treated used water through a rigorous three-stage process. Initially, unwanted substances such as suspended solids, minute particles, disease-causing bacteria and viruses are filtered out by membranes.

Following this, the water passes through a reverse osmosis stage. This ensures that contaminants such as bacteria, viruses, heavy metals, disinfection by-products are removed. The end result is high-grade water that is free from viruses and bacteria and contains very low levels of salts and organic matters.

As an added safety measure, the water undergoes ultraviolet disinfection. Alkaline chemicals are then added to restore the pH balance of the water.

(3) Public Engagement:

To gain public confidence in NEWater, the water utility has been distributing NEWater bottles to the public, institutions and community organisations for public sampling. To date, more than 23 million bottles of NEWater have been given out. A visitor centre has also been established which serves as a focal point to educate the public and demonstrate the benefits of the programme.



Above: Singapore water demand and supply (© Singapore Public Utilities Board)

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Outcomes and Challenges

The implementation of the NEWater plants is part of a wider programme called the Four National Taps strategy to deliver a diversified and robust water supply for Singapore.

Currently, Singapore has four operational NEWater plants at Bedok (82 000m³/d), Kranji (77 000m³/d), Ulu Pandan (148 000m³/d) and Changi (228 000m³/d). The plants at Ulu Pandan and Changi were built under Design Build Own Operate agreements for 20 and 25 years respectively. A fifth plant at Seletar (2004) was decommissioned in 2011 in order to centralise used water treatment at Changi and produce cost efficiencies.

NEWater is supplied and used for:

- Non-potable industrial and commercial uses in wafer fabrication plants, electronics factories and power generation plants.
- Air-conditioning cooling systems of commercial and institutional complexes.
- Supplementing Singapore's potable water supply via indirect potable use (blending with reservoir water). In 2011, this was estimated to be 2.5% of total potable water consumption.

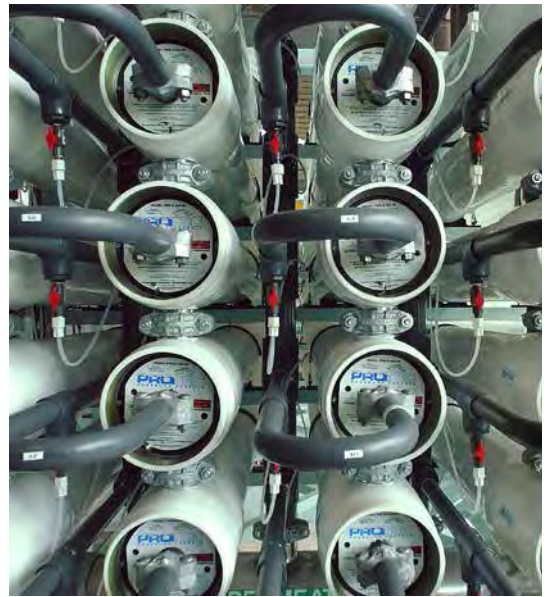
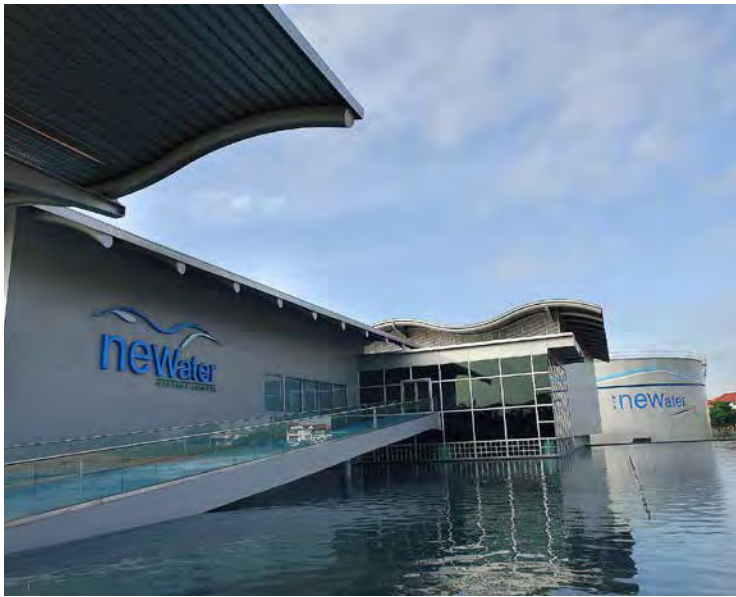
The demand for NEWater has grown from 13-fold from 27 000m³/d in 2003 to 350 000m³/d today. NEWater now meets 30% of Singapore's total water demand and is expected to meet 50% by 2030. Looking further forward, by 2060, NEWater is projected to meet up to 55% of Singapore's future water demand.

Capital costs of the scheme are not readily available; however for the purpose of this catalogue the capital cost for the latest 228 000m³/d plant at Changi has been estimated at \$165m. The production of NEWater is funded through the NEWater tariff. It currently stands at approximately \$0.8/m³ before Goods and Service Tax (GST) and is cheaper than the normal water tariff of \$0.94/m³ before GST.

In addition, NEWater does not attract the Water Conservation Tax (WCT). WCT was introduced in 1991 to reinforce the message of conserving water and is imposed as a percentage of the total water consumption. The WCT rate starts at 30% for a domestic water consumption of up to 40m³ per month, rising to 45% for higher water consumption.

As a comparison, the first year price for the production of NEWater at Changi under the Design Build Own Operate agreement was \$0.24/m³ (2010), inflated thereafter. The price excludes the cost of pumping into distribution and the cost of providing and maintaining the NEWater distribution network.

A comprehensive water sampling and analysis programme was conducted from 2000 to 2002 and the quality of NEWater was benchmarked against international standards. An independent expert panel was formed to provide advice on the study and to evaluate and make recommendations on the results of the study. The panel concluded that NEWater was safe for potable use but recommended indirect potable use instead of directly supplying NEWater for potable use.



Left to right clockwise: nEWater Visitor centre (© Singapore Public Utilities Board); Reverse osmosis (© Singapore Public Utilities Board); Singapore skyline (© Kelvintt | Dreamstime.com)