First Stage of Tseung Kwan O Desalination Plant - Innovations and Features

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Introduction

Hong Kong, home to about 7.5 million people, is one of the world's most densely populated cities. There are several challenges within Hong Kong's water supply such as continuously growing demand arising from economic and population growth, water resources competition in the Pearl River Delta as well as climate change resulting in extreme weather patterns and prolonged droughts.

To cater for these challenges, the Water Supplies Department (WSD) of the Government of the Hong Kong Special Administrative Region (HKSARG) is building resilience through the Tseung Kwan O (TKO) Desalination Plant, the first membrane-based desalination plant to supply municipal potable water in the HKSAR upon its commissioning in 2023. TKO Desalination Plant is developed in two stages. The first stage will supply up to 50 million m^3 (MCM) of fresh water per year to complement the existing fresh water supply.

Currently in the construction stage, the Plant design incorporates unique and sustainable design elements and considerations with the aim to minimising environmental impacts and facilitating an effective and reliable plant operation for production of quality fresh water. The requisites and constraints of the Plant are presented together with the design features and solutions to achieve a highly efficient and sustainable plant.

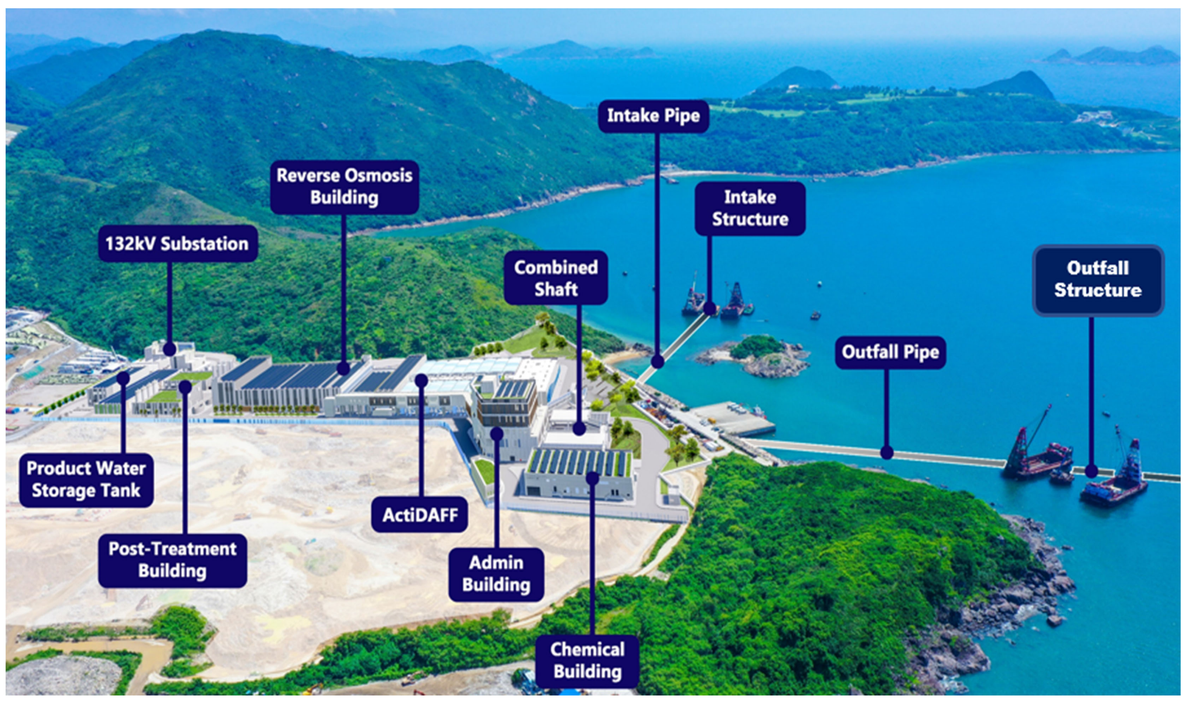

Figure 1: First Stage TKO Desalination Plant

Design of the Plant

The design of the TKO Desalination Plant incorporates several distinctive features and innovative elements to achieve:

- flexibility to treat a wide range seawater feed quality
- efficiency in energy consumption and operation
- compliance with stringent water quality standard
- adaptability for varying water demand
- ease of operation and maintenance

Marine Works

As desalination plants need to be located close to the sea and because land is a scarce commodity in Hong Kong, a distinctive combined shaft that combines the intake and outfall chambers into a single structure is designed. This represents an important layout optimisation and minimises potential environmental impact on the sea coast.

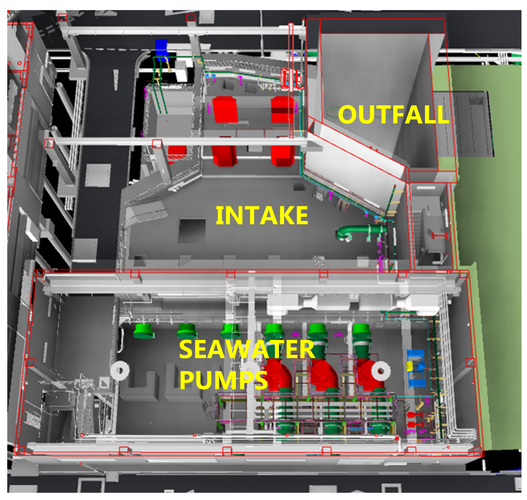

Figure 2: Combined Shaft for Intake and Outfall

Pre-Treatment

As global temperature increases due to climate change, the warmer sea will increase the recurrence of harmful algae blooms, which will affect the operation of desalination plants. The pre-treatment of the TKO Desalination Plant includes a Dissolved Air Flotation and Filtration (DAFF), called ActiDAFF©. This treatment unit provides flotation at the same velocity of normal filtration, so that the benefits of filtration will not be compromised. The flotation part provides enhanced protection against algae blooms as an additional separation stage. This will ensure a reliable and flexible design for the future operation of the plant. By placing dissolved air flotation on top of media filters, the footprint can be greatly reduced.

Post-Treatment

As drinking water quality requirements and the expectations from consumers are ever-increasing, desalination plants are not outside this continuous improvement circle. The TKO Desalination Plant features two innovations in this area. The first one is the use of ultrafiltration in the preparation of lime for remineralisation; this will ensure that the turbidity of the product water is at all times controlled effectively, avoiding any potential turbidity spike. This novel solution is a first-of-kind application for desalination remineralisation.

A second innovation is the use of an On-Site Chlorine Generation (OSCG) plant for disinfection with a view to minimising risks in transportation, storage, handling and application of liquid chlorine. There is an increased awareness of the need to limit the disinfection by-products levels including chlorates in potable water. Direct chlorine gas dosing instead of hypochlorite solution dosing will minimise any potential chlorate formation. The OSCG plant will achieve those requirements and ensure the desalination plant is ready for future more stringent standards.

Reverse Osmosis

Energy consumption constitutes a substantial part of the total operation cost of the plant. The design includes provisions for flexible pressure adjustment to compensate the changes in salinity due to Pearl River's influence of the salinity of the seawater feed. Splitting the high pressure required for RO operation into two pumping banks will increase efficiency and avoid energy penalty for variable-frequency drives on the larger pumps. The use of positive displacement energy recovery device in the first pass RO and incorporating additional energy recovery turbine in the second pass to generate electricity from residual pressure of second pass reject maximise the energy regain from the process.

WSD has done testing for disinfection by-product (DBP) formation and determined the potential for formation of brominated DBPs. To minimise the formation of these DBPs, the plant was designed to achieve 0.2 ppm bromide in the product water, which determined the capacity of the second pass. The Partial Split RO design was adopted for the two-pass design. It reduces and optimises the size of the second pass RO with a pressure centre designed in order to achieve pump efficiencies (>90%) comparable to plants many times the production capacity of this plant.

The RO system is configured in two floors to allow ease of access and maintenance to RO membranes and its associated equipment. An inspection corridor from the administration and control building designed to allow clear view of the system will facilitate quick operation and maintenance inspection within a protected environment.

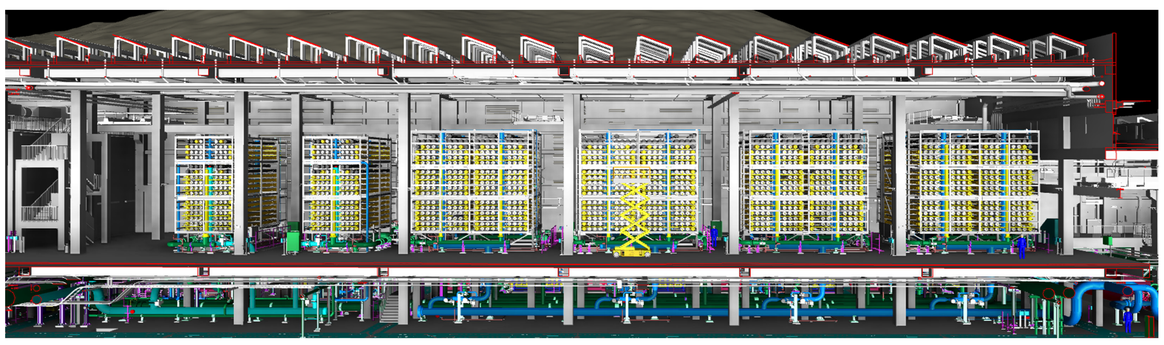

Figure 3: Two Floor RO System Building

Conclusions

The TKO Desalination Plant is currently in the construction stage and is planned to begin operation in 2023. This plant, with the target of low energy consumption of 3.1 to 3.4 kWh/m3 (excluding product water pumping to network) of water production, incorporates unique and sustainable design elements to address local site constraints and reduces environmental impacts and carbon footprint. The novel application of post treatment technology ensures consistent production of fresh water that meets the stringent water quality standards adopted in Hong Kong. As a new fresh water source, the product water supply from the desalination plant is impervious to prolonged droughts. This will build resilience in Hong Kong's fresh water supply, thereby supporting sustainable population and economic growth in Hong Kong.

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