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A study to assess alternative water sources for reducing energy consumption in a medical facility case study, Abu Dhabi

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Abstract

This paper presents the case for water and energy conservation in a desert type climate healthcare environment, which is based on the need for Abu Dhabi to decrease potable water and energy consumption to reduce environmental impact. The work documented in this paper is part of the first author's Professional Doctorate change project in Sustainable Built Environment (D.SBE) at Cardiff Metropolitan University with a medical facility case study in the United Arab Emirates (UAE) in use since 2015. The project is investigating the impact of alternative water sources energy consumption versus public network seawater desalinated potable water for outdoor use. The context is a 364 beds hospital in Abu Dhabi with a 21,600m² building footprint area surrounded by a 36,310m² vegetated open space. The hospital includes a treated air cooling condensate water system suitable for use as irrigation water and water feature use. The condensate water has been tested in 2016 and 2017 to verify compliance for reuse. Whilst, the water test results demonstrate suitability for outdoor reuse in a healthcare setting, additional alternative water sources such as fire test pump water (450m³/year) have been tested in March 2017, which shows that a tertiary treatment system is needed for its reuse. It was also found that onsite alternative water sources are less energy intensive for irrigation (0.22kWh/m³) and water feature use (39.09kWh/m³) than offsite produced desalinated potable water (55.68kWh/m³ average). The next steps are to quantify the treated condensate water from the air cooling system for 12 months through the newly installed flow meters at the raw condensate water tanks to confirm the 2013 theoretical model and calculate yearly water energy consumption. To date (March 2017) 26 days of data have been recorded (February to March 2017) which align with the model by data extrapolation. This study will help understand how alternative water sources for outdoor use, impact on building systems energy consumption, greenhouse gas emission, operation and maintenance cost and the environment. This study may be beneficial to local competent authorities for making and adjusting standards for energy and water conservation strategies in healthcare settings.

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Keywords: Sustainable medical facility buildings, non-clinical processed water reuse; water energy nexus; Middle East.

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1. Introduction

The work documented in this paper is part of the first author's Professional Doctorate change project in Abu Dhabi, at a newly built medical facility in use since April 2015. The medical facility is in Abu Dhabi capital city of the United Arab Emirates (UAE), a hot desert type climate [1, 2] and a Middle East Country laying between latitude 22º 29 N and 24º 53 N and longitude 56º 10 E and 51º 37 E [3]. The facility landscape is greater than its building footprint representing more than 50% of the site or a 36,310-square meter (m^2) vegetated open space including decorative water features. The project is investigating energy to non-potable water consumption versus energy to public network desalinated potable water and how alternatives water sources can help reduce energy consumption for irrigation and water features water use. The water irrigation demand has been estimated at 386 cubic meter (m^3) per day at peak by the landscape contractor, and 1,352m^3/month for the combined water features capacity, which is discussed in this paper at Section three. The design of the 364 beds hospital includes an existing Air Handling Unit (AHU) Air Conditioning (A/C) condensate water treatment system, which is intended to treat condensate water from the air cooling system to a quality suitable for use as landscape irrigation and water features. The short fall in condensate water availability during the winter months in Abu Dhabi (December-February) is proposed to be met by soil improvement and by sourcing additional alternative water sources such as fire pump test water.

The aim of this D.SBE action research project designed, developed and implemented by the first author is to provide an account of water and energy conservation strategies for outdoor landscape for sites located in arid climates, such as the Emirates of Abu Dhabi (UAE). The anticipated outcome of this research project is to demonstrate how alternative water sources for outdoor use can help decrease potable water use and improve overall energy consumption and associated carbon emissions of a building, such as the medical facility. The strategy is to encourage the local authority to amend their water standard so that hospitals with irrigated outdoor space optimize their water need and increase the use of treated non-potable water use. Thus, impacts upon the environment, operation and maintenance cost and practices, greenhouse gas emissions, and building systems energy and water consumption can be minimized.

2. The Context of Water Energy Nexus in Abu Dhabi

The Middle East region including the UAE has the lowest fresh water resource endowment in the world. The water regional availability is as little as <100m^3 per capita per year [4]. The UAE depends heavily on non-renewable groundwater and augments supplies by desalination of sea water to produce freshwater. The overall water need is supplied by groundwater supplemented by desalination and wastewater treatment plants [3]. 72% of the groundwater is used for agriculture, 29% of the desalinated water is used for commercial and residential need while wastewater accounts for 4% of the overall water demand [5]. Since rainfall is very small (<100mm/year) and the recharge of the groundwater is less than 4% per year, Abu Dhabi has no choice, but to supply municipal water from seawater desalination (ibid.). Water systems can save energy by reducing the amount of water that must be withdrawn, treated, and distributed [6] especially in place like Abu Dhabi where the technique of desalination is high energy intensive, such as Reverse Osmosis technologies that also has a very high cost (0.5-1 USD/m^3) in comparison to conventional sources (0.05 USD/m^3) [4]. To overcome this challenge and to align with the Abu Dhabi Vision 2030, the Regulation Supervision Bureau (RSB) released a plan in 2013 [7] "*to ensure non-conventional generation, including renewable technologies, is developed and integrated in coming years*" [7]. From 2020, fuel sources are intended to be diversified comprising of <58% Gas, >2% Renewable Energy, 20% Liquefied Gas and 20% Nuclear. Most of the Emirate's water capacity production is powered by co-generation plants, with waste steam emanating from this process is used for thermal desalination. The desalination plant of the future will use a mix of reverse osmosis and standalone thermal, which will account for 20%+ in 2030 as opposed to 6%+ until 2017 and 10%+ in 2020 of the overall based production for financial and operational reasons. Co-generation thermal plant technology is planned to be utilized for 70%+ of the overall production of water desalination in compare to 94% (2017) and 84% in 2020 [ibid]. In comparison Reverse Osmosis energy consumption ranges from 1.6kWh/m^3 to 3.0kWh/m^3, stand-alone thermal 0.8kWh/m^3 to 4.5kWh/m^3 and 0.8kWh/m^3 to 1.2kWh/m^3 for co-generation technologies [8]. A Stand-alone system requires more heat than a combined cycle gas turbine coupled with thermal desalination [9]. The latter process requires less energy because it incorporates multiple stages or effects utilizing