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Potential of energy and water efficiency improvement in Abu Dhabi's building sector – Analysis of Estidama pearl rating system

Sameer Assaf [a, b], Mutasim Nour [b, *]

[a] Department of Energy and Climate Change of UAE's Ministry of Foreign Affairs, Abu Dhabi, United Arab Emirates
[b] School of Engineering and Physical Sciences, Heriot – Watt University Dubai Campus, Dubai International Academic City, P O Box: 294345, Dubai, United Arab Emirates

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ABSTRACT

Energy and water infrastructure in Abu Dhabi provides a strong example of the interconnection between energy and water, where the majority of its electricity and water demand is jointly produced from cogeneration plants. The total cost of fuel used for cogeneration plants are heavily depending on the efficiency level of end-use energy and water consumption. Buildings are the major electricity and water consumers with 84.6% and 92.2% respectively from the entire demand. The aim of this study is to analyze the energy and water consumption reduction by implementing Estidama pearl regulations and compare it with Business as Usual -the normal execution of things as they always do-for three sample buildings (villa, multistory residential and office building). For energy assessment, eQUEST software was used to examine the energy performance of the chosen buildings and to evaluate the energy saving potential after applying Estidama requirements. While for water assessment; Estidama and LEED calculation tools were used to do the same. The results of energy simulation and water analysis of the chosen buildings showed a potential of electricity reduction between 31% and 38% and a potential of water reduction between 22% and 36% depending on building type and other parameters. Also, a total monetary savings of 19 Billion AED can be achieved cumulatively over ten years period (2011–2020) after Estidama regulations have been applied. In addition, a reduction of 31.4 Million ton of CO_2eq cumulatively can be achieved.

1. Introduction

Water and energy are vital resources that affect all aspects of life and support human welfare. They are essential for economic growth and sustainable development; and recognized as fundamental inputs for the modern economies [1]. The rapid global population growth and fast economic development are key drivers for increasing the global demand on water and energy resources.

The concept of water and energy nexus has been acknowledged in the United States in mid nineties of the last century, and has received increased attention all over the world during the past five years [2].

Historically, energy and water resources have been treated independently, and their policies have been developed in isolation from each other. However, due to the recent growing concerns of the issues relevant to energy and water accessibility, environmental impacts and prices instability [3], many countries have started integrating both systems to obtain better planning and policy directions.

According to Middle East and North Africa (MENA) Energy Investment Outlook [4] titled: Capturing the Full Scope and Scale of the Power Sector, the MENA region would need 124 GW incremental power capacity over the next five years, with an average growth of 7.8% annually. The growth of electricity consumption is strongly correlated to economic development, high population growth and harsh climate conditions, which all countries in the region experience, especially the Gulf Cooperation Council (GCC) states. The share of GCC states alone exceeds 42% (US$105 billion) of the total required expenditure.

In 2011, the total installed power capacity in United Arab Emirates (UAE) was 26132 MW; which has increased significantly over the past few years due to commissioning of several new plants. As for water capacity, although UAE has relatively large volume of underground and surface water reserves, only 3% of the available water is fresh according to UAE water conservation strategy [5], the remaining 97% is saline water. Furthermore, desalinated water

* Corresponding author. Tel.: +971 44358717; fax: +971 44477350.
E-mail addresses: sameerassaf@yahoo.com (S. Assaf), mutasim.nour@hw.ac.uk (M. Nour).

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accounts for 92% of the total water used for domestic and industrial activities [5].

Abu Dhabi is the largest emirate among the seven emirates of the UAE, and has one of the highest per capita rates of electricity and water consumption in the world. According to Abu Dhabi Energy and Environmental Statistics [6] electricity consumption per capita in Abu Dhabi was 20.39 MWh/year in 2011, almost seven times the global average (2.89 MWh/year) [7]. The urban water per capita use in Abu Dhabi was 1250 l/day in 2011, 54% of which (i.e 675 l/day) are used for domestic activities [6], which is much higher than the rate of most of the developing countries where their daily average does not exceed half of Abu Dhabi's daily per capita rate. Buildings are the major electricity and water consumer in Abu Dhabi with 84.6% and 92.2% respectively of total electricity and water consumption.

With this regard, the Abu Dhabi government has stressed the importance of adopting new regulations to increase sustainability in the construction sector. The Urban Planning Council (UPC) – through its Pearl Rating System, that was put in place in 2011 – commands all new buildings to achieve specific benchmarks in order to minimize the energy and water use as well as reducing construction waste and recycling building materials.

2. Background

Energy and water are two closely linked and interdependent resources where energy production requires a large amount of water. Likewise, a huge amount of energy is needed to extract, treat, desalinate, transport and distribute water. Fig. 1 shows the interlinkages between the two resources.

2.1. Water requirements for electricity production

In an energy value chain, water is needed for fuel extraction and processing as well as for power generation. The water demand varies depending upon the type of generation and cooling technologies. The ranges of water requirements for various generation and cooling technologies is illustrated in Fig. 2.

This includes water consumption for nuclear, steam turbine, and combined cycle gas turbine (CCGT) power plants respectively, utilizing once-through (OT), closed-loop (CL), and dry cooling technologies. Other technologies included also are integrated gasification combined cycle (IGCC) and pulverized coal (PC). New advanced coal facilities may also include carbon-capture and sequestration (CCS) technologies. Water requirements for renewable energy based generation are also included in the bottom of Fig. 2, which includes wind, solar photovoltaic (PV), concentrating solar power (CSP) and geothermal.

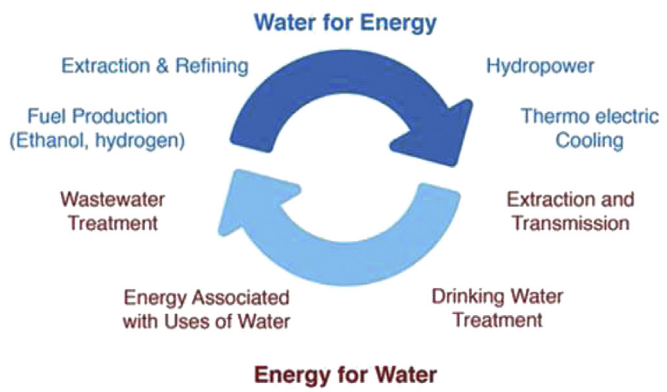

Fig. 1. Water energy nexus [8].

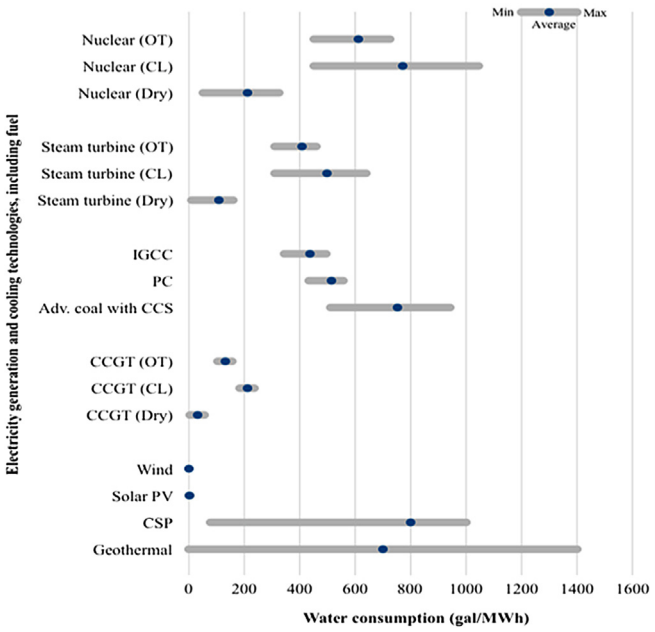

Fig. 2. Water use for electricity production [9].

In this paper, only the water used for electricity generation, which is mainly used for cooling purposes, is covered. For the case of Abu Dhabi; three types of generation are largely used in its power plants: steam turbine (ST), diesel engine (DE) and gas turbine (GT). GT comprises three technologies; simple cycle gas turbine (SCGT), combined cycle gas turbine (CCGT) and gas turbine with heat energy recovery (GT + HER).

For water demand in electricity production, only steam turbines require water for the cooling process whereas gas turbines do not. Most power plants in Abu Dhabi are located along the coastal line, where only seawater is used for cooling due to the limited fresh water resource. The average water usage in energy production for steam turbine is around 315 gal/MWh [2]. Although seawater is considered a stable source compared to fresh water, it continues to use a large amount of seawater – which is eventually discharged into the sea at a very high temperature-would cause thermal pollution and affect the local habitat of fish and other marine species [10].

2.2. Energy requirements for water production

Energy is required for water lifting, desalination, treatment and distribution. The required energy for various types of water processes varies from fractions of KWh to few KWh per cubic meter produced, depending on the process type as well as several geographical, operational and technological factors. This research work focuses on energy used for urban water production, thus covering only water desalination and treatment.

2.2.1. Energy requirements for water desalination

UAE operates 70 desalination plants representing 14% of the overall worldwide capacity, two thirds of which are located in Abu Dhabi [11]. The desalinated water in Abu Dhabi is produced either jointly with electricity as per the thermal cogeneration plants, or separately through independent plants using reverse osmosis (RO) technology. Thermal cogeneration plants represented more than 93% of the entire desalinated capacity in Abu Dhabi in 2011.