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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, PO 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 CO2eq cumulatively can be achieved.

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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...
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.

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.
Thermal desalination is divided into; Multi-Stage Flash (MSF) and Multi-Effect Distillation (MED) with 75% and 18% respectively of total desalination capacity. Only 7% of the Abu Dhabi’s desalination capacity in 2011 came from RO plants [12].

Abu Dhabi is heavily reliant on MSF; it is preferable due to its large capacity, high reliability, as well as relatively affordable consumption of energy to desalinate the highly concentrated total dissolved solids (TDS) of the Gulf seawater, and most importantly the ability to cogenerate with power production. The energy used for water desalination varies with the ratio of water to power production. The water demand in Abu Dhabi is almost constant throughout the year, whereas electricity demand, dominated by air conditioning load, usually increases during summer months, and drops significantly during winter months. For the case of Abu Dhabi, the ratio of water to power varies from 320 to 1170 (m³/d) per MW of cogeneration plant capacity [13]. The CO₂ emissions allocated for electricity and water production in Abu Dhabi varies from one season to another, according to EAD GHG report [14] the annual average in 2010 was 13.76 Kg CO₂eq/m³ for water production, and 0.51 Kg CO₂eq/kWh for electricity production.

Most of the desalinated plants in Abu Dhabi are located along the coastline of the Arabian Gulf, primarily to desalinate the seawater as well as utilizing the seawater for cooling purposes. The quality of seawater is essential for the effectiveness of the desalination process. Any oil spill from oil containers in an area witnessing very active movement of oil containers all over the year, may cause a complete shutdown of the plant if the oil spill reaches the seawater intake [15]. This would put the water security at stake. The quality of seawater is essential for the effectiveness of the desalination process. Any oil spill from oil containers in an area witnessing very active movement of oil containers all over the year, may cause a complete shutdown of the plant if the oil spill reaches the seawater intake [15]. This would put the water security at stake.

2.2.2. Energy requirements for wastewater treatment

There is no available data on the level of energy used for wastewater treatment in Abu Dhabi; the international studies estimate the energy intensity for primary treatment within the range of 0.1–0.3 kWh/m³ and 0.275–0.59 kWh/m³ for secondary treatment, which includes sludge [2].

According to Abu Dhabi Environmental Statistics [6]; the total quantity of wastewater inflow in Abu Dhabi exceeded 259 Million m³ in 2011; out of which 243 million m³ were treated and 133 million m³ were only used mainly for irrigation of the landscape areas.

2.3. End use energy and water consumption

The electricity demand for the Abu Dhabi Emirate reached the level of 43.2 TWh in 2011. As shown in Fig. 3, the domestic sector is the major electricity consumer which accounted for 31% of the total electricity consumed in 2011, followed by commercial and governmental sectors with 29% and 25% respectively [12].

In the water side, Abu Dhabi consumed 961.5 Million m³ of water in 2011, 54% of which went to domestic, followed by governmental and commercial sectors with 22% and 16% respectively as shown in Fig. 4.

As it can be noticed from Figs. 3 and 4; buildings’ sector—which constitutes; residential, commercial and governmental buildings—is the foremost consumer of the entire electricity and water use with 84.6% and 92.2% respectively.

The growth in the building sector was enormous during the past few years in Abu Dhabi and will continue with the same pattern for the upcoming 20 years. According to Abu Dhabi Economic Vision 2030 [17], residential units are projected to grow more than 3.5 times from 2007 to 2030, while the growth of office space and retail space is projected to rise 4 and 5 times respectively over the same period. Those planned buildings once occupied will require large amounts of energy and water and will be responsible for producing a huge amount of GHG emissions as well.

Abu Dhabi and in its efforts to optimize the urban growth challenges, has developed the Abu Dhabi 2030 urban master plan that addresses sustainability as a core principle. As a result, in 2010 the Estidama initiative was launched; the first program of its kind that is tailored to Abu Dhabi and the Middle East region.

The pearl rating system is a central component of Estidama program; it is a building design methodology for constructing and operating buildings and communities more sustainably. The minimum standard (one Pearl) is the entry level and five Pearls is the highest level that can be achieved. Starting from 2011, all new community developments, new villas and new private buildings are required to achieve at least one pearl rating as per Estidama standards. New governmental projects; including schools, mosques and governmental buildings, are required to achieve a minimum rating of two Pearls.

In Abu Dhabi as well as for the most of hot climate countries; cooling load is the largest energy element in any building, where more than 50% of the entire building’s annual electricity consumption goes to cover cooling load. Achieving only the minimum thermal insulation requirements of pearl rating system could reduce the annual cooling load by 37.2% compared to “as built” typical villa building in Abu Dhabi [18]. Thus, significant reduction in the building’s electricity bill can be achieved.

3. Methodology

Detailed energy and water analysis on representative buildings are carried to estimate the potential of energy and water reduction in buildings’ sector, mainly to identify the current level of energy and water consumption in typical buildings in Abu Dhabi, and to
project how it is going to be in the future if the Business As Usual is sustained, as well as after applying the Estidama pearl rating system.

As shown in Fig. 5, the first step for conducting this research work is collecting all statistical data relevant to water and energy sector in Abu Dhabi for supply and demand side, focusing on the building sector and its related environmental and economic data. The analysis part is commenced by carrying out quantitative investigation on the water requirements for electricity production, and energy needs for water desalination and treatment in Abu Dhabi.

A comprehensive assessment of the levels of water and energy consumption at the end-use segment is followed, through conducting energy simulation and water use analysis for selected representative buildings in Abu Dhabi. The purpose of these analyses is to estimate the current level of consumption in existing buildings and how it will become after adopting Estidama pearl rating system. Afterward, an evaluation is carried out to project the future water and electricity demand in Abu Dhabi and to quantify the potential water and energy savings from adopting Estidama by 2020. Lastly, a detailed environmental and economic benefits analysis is performed to reflect the estimated reduction in end-use water and energy consumption on the primary side and quantify the potential of cost savings and carbon emissions reduction.

The obtained data has been divided into two main categories; the supply side and the demand side. In the supply side; all data relevant to electricity and water annual production and consumption, generation types, technologies used for water desalination, quantity of treated waste water, fuel and CO₂ allocation for water and electricity production and water to power ratio in cogeneration plants have been obtained. On the demand side, hundreds of data points were collected in the fields of; electricity and water use by sector, buildings' types and numbers, energy and water intensities for selected buildings, water and electricity costs, buildings' codes and standards, as well as LEED and Estidama guidelines for the building sector.

Several factors, approaches and assumptions have been considered throughout this research work, which can be summarized below:

- Three sample buildings was chosen for the end-use energy and water analysis, (villa, multistory residential and office building). For energy assessment, eQUEST simulation 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.
- Year 2011 was selected as base-year for this research work; most of the used data is actual and solid for this particular year.
- The water consumption in villa segment varies from one type to another depending upon the availability and size of landscape area, type of plants and irrigation used. The wide range of water intensity in villa segment – according to available references – could reach up to six times the minimum value. This makes baseline water calculation very complicated to be estimated and has been verified by adjusting the figures used in the calculation to match with the average of the revealed water intensity range in this segment.
- No building code was applied in Abu Dhabi prior to 2011. All buildings had been built in Abu Dhabi before 2011 had no obligations to use insulations or efficient glazing on its building envelope. Furthermore, there were no clear records on the efficiency level of the building envelope of existing building. For simulating the energy consumption of existing building (baseline case), we assumed that no insulation was used on the building’s envelope, the results of energy simulation were compared to the revealed energy intensity level for similar building type and size, to make sure that the set assumption was accurate.
- For estimating the impact of end-use energy and water reduction on the supply side, two scenarios were assessed; the business as usual (BAU) scenario and Estidama scenario. The BAU scenario assumes that the buildings will be constructed after 2011 will consume the same level of energy and water of buildings that have been constructed before 2011. The Estidama scenario assumes that all buildings that will be constructed after 2011 should be built in accordance to Estidama requirements and thus should achieve the mandatory credits of minimum energy and water performance.
- The year 2020 was selected as a reference year to estimate the cumulative potential of generated savings after adopting the Estidama pearl rating system compared to BAU, and to reflect its impact on the supply side. The projected water and electricity consumption in Abu Dhabi by 2020 is estimated with a potential annual growth rate of 8% in electricity and 5% for water consumption. These projected figures have been chosen depending on the historical growth records and the announced future plans.
- The water to power ratio in the cogeneration plants in Abu Dhabi varies during the summer and winter depending on

![Fig. 5. Steps of conducting this research work.](image)
4. End use energy simulation and water calculation

A detailed water and energy analysis is carried out for representative buildings in Abu Dhabi; three types of buildings have been chosen, namely; villa, multistory residential building, and office building.

4.1. Energy analysis

In order to assess the energy performance of the selected representative buildings, both the baseline case (existing building) and proposed case (new building- Estidama compliance) are virtually simulated using eQUEST version 3.64 energy modeling software.

Buildings that have been constructed before 2011 are considered as baseline case, where no building code was applied in Abu Dhabi. The proposed case is applied to those buildings which are built after 2011; new buildings need to fulfill the Estidama pearl rating system requirements that have been put in place in 2011.

Identifying the design parameters of the existing buildings was difficult due to inadequate information of the energy efficiency level of various building systems, and the lack of insulation regulation in Abu Dhabi before 2011. As a result, the baseline building model was simulated to reflect the limited available data and using some assumptions to match with the current level of energy intensity of the chosen buildings in Abu Dhabi. Table 1 summarizes the input parameters that were used for baseline case and proposed case energy simulation of the three selected buildings.

4.1.1. Case study 1: villa building

Villa is one of the key building segments in Abu Dhabi; Medium-size villa with two stories and total built-up area of 465 m² (5000 ft²) was selected for this analysis as shown in Fig. 6.

The results of the two energy simulations of baseline and proposed case showed that a considerable amount of energy can be reduced after achieving the minimum energy performance of Estidama requirements as shown in Fig. 7.

A potential energy reduction of 31% is likely attainable, mostly from cooling load reduction due efficiency enhancement; through using better insulation of the various elements of building envelope as well as utilizing efficient cooling units. The remaining savings came from using more efficient lighting system and supply part of the hot water demand from renewable energy source.

4.1.2. Case study 2: multistory residential building

For simulation purposes, a typical 10 stories residential building with a total built-up area of 126.33 m² (135,977 ft²) is used as shown in Fig. 8.

Fig. 9 demonstrates the potential of energy reduction in multi-story residential building after meeting the requirements of minimum energy performance of the Estidama pearl building rating system.

4.1.3. Case study 3: office building

Typical 10 stories office building with a total built-up area of 7820 m² (84173 ft²) was selected in this simulation analysis. Fig. 10 shows the potential of energy reduction in the office building after meeting the requirements of minimum energy performance of the Estidama pearl rating system.

Table 1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Villa Baseline case</th>
<th>Villa Proposed case</th>
<th>Multistory Baseline case</th>
<th>Multistory Proposed case</th>
<th>Office Building Baseline case</th>
<th>Office Building Proposed case</th>
</tr>
</thead>
<tbody>
<tr>
<td>External walls</td>
<td>8 inch concrete block</td>
<td>Estidama minimum energy requirements</td>
<td>8 inch concrete block</td>
<td>Ashrae 90.1, 2007 requirements</td>
<td>8 inch concrete block</td>
<td>Ashrae 90.1, 2007 requirements</td>
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<tr>
<td></td>
<td>U value-2.63 W/m²/K</td>
<td>U value-0.32 W/m²/K</td>
<td>U value-2.63 W/m²/K</td>
<td>U value-0.7 W/m²/K</td>
<td>U value-2.63 W/m²/K</td>
<td>U value-0.7 W/m²/K</td>
</tr>
<tr>
<td>Roof</td>
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<td>Estidama minimum energy requirements</td>
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<td></td>
<td>U value-2.63 W/m²/K</td>
<td>U value-0.14 W/m²/K</td>
<td>U value-2.63 W/m²/K</td>
<td>U value-0.36 W/m²/K</td>
<td>U value-2.63 W/m²/K</td>
<td>U value-0.36 W/m²/K</td>
</tr>
<tr>
<td>Glazing</td>
<td>6 mm single reflective glass</td>
<td>Estidama minimum energy requirements</td>
<td>6 mm single reflective glass</td>
<td>Ashrae 90.1, 2007 requirements</td>
<td>6 mm single reflective glass</td>
<td>Ashrae 90.1, 2007 requirements</td>
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<tr>
<td></td>
<td>U value-5.57 W/m²/K</td>
<td>U value-2.2 W/m²/K</td>
<td>U value-5.57 W/m²/K</td>
<td>U value-6.9 W/m²/K</td>
<td>U value-5.57 W/m²/K</td>
<td>U value-6.9 W/m²/K</td>
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<td>Lighting power density</td>
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<td>6.8 W/m²²</td>
<td>7.5 W/m²²</td>
<td>7.5 W/m²²</td>
<td>11 W/m²²</td>
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</tr>
<tr>
<td>Equipment power density</td>
<td>20 W/m²</td>
<td>20 W/m²</td>
<td>12 W/m²</td>
<td>12 W/m²</td>
<td>12 W/m²</td>
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<td>Occupancy</td>
<td>10 m³/person</td>
<td>10 m³/person</td>
<td>10 m³/person</td>
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<td>HVAC</td>
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<td>DX air cooled units</td>
<td>DX air cooled units</td>
<td>DX air cooled units</td>
<td>DX air cooled units</td>
<td>DX air cooled units</td>
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<tr>
<td>Heating design temperature</td>
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<td>20 °C</td>
<td>20 °C</td>
<td>20 °C</td>
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<td>20 °C</td>
</tr>
<tr>
<td>Cooling design temperature</td>
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<td>23.8 °C</td>
<td>23.8 °C</td>
<td>23.8 °C</td>
<td>23.8 °C</td>
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<tr>
<td>Cooling electric input ratio (EIR)</td>
<td>0.34</td>
<td>0.28</td>
<td>0.39</td>
<td>0.34</td>
<td>0.39</td>
<td>0.34</td>
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<tr>
<td>Ventilation rate</td>
<td>25.5 m³/hr/person</td>
<td>25.5 m³/hr/person</td>
<td>25.5 m³/hr/person</td>
<td>25.5 m³/hr/person</td>
<td>25.5 m³/hr/person</td>
<td>25.5 m³/hr/person</td>
</tr>
<tr>
<td>Infiltration rate</td>
<td>0.35 Air changes/Hr</td>
<td>0.35 Air changes/Hr</td>
<td>0.35 Air changes/Hr</td>
<td>0.35 Air changes/Hr</td>
<td>0.35 Air changes/Hr</td>
<td>0.35 Air changes/Hr</td>
</tr>
</tbody>
</table>
4.2. Water analysis

The water calculation tool of the Estidama pearl rating system is used to estimate the interior water consumption for the three selected buildings. For the purpose of estimating the water consumption for landscape irrigation, which is only applicable for villa building, LEED calculation method is used. For each category, both baseline and proposed case analysis are performed.

For interior water calculation; the flow rates recommended by Energy Policy Act [22] for the various water fixtures are used as shown in Table 2, but with some adjustments to match with the current level of water intensity as per the available data and published studies relevant to buildings sector in Abu Dhabi. For landscape calculation, since Estidama does not provide a calculation tool, the LEED-NC version 2.2 methodology is used.

For verification purposes, the calculated water consumption for the various chosen buildings was compared with available benchmarked values of the RSB water and electricity consumption report [23], which states the water consumption per capita for all types of buildings in Abu Dhabi.
The analysis shows a potential reduction of 35.7%, 21.5% and 33.8% in water consumption can be achieved in villa, residential multi stories and office building respectively after meeting the requirements of minimum interior water use of the pearl building rating system.

5. Outcomes and discussion

The outcomes of energy simulation showed a potential of electricity reduction between 31% and 38%. For the purpose of quantifying the accumulated energy reduction potential by 2020, we assumed that an annual growth rate of 8% in electricity demand during the period from 2011 to 2020 and an energy reduction potential of 30% on all new buildings in Abu Dhabi.

By reflecting the above assumptions on the forecasted electricity demand in Abu Dhabi for business as usual (BAU) as well as for Estidama scenario, it can be noticed that starting from 2012 the consumption of Estidama scenario begins to decline compared to BAU and reaches its maximum reduction by 2020 with 11 TWh below the BAU, as shown in Fig. 11.

Whereas the potential of water reduction varies from 22% to 36% depending on building type and other parameters, for the purpose of projection the total water reduction by 2020, we assume that an average annual growth rate of 5% in water demand during the period from 2011 to 2020 and a water reduction potential of 20% on all new buildings in Abu Dhabi.

As it can be noticed from Fig. 12, starting from 2012 the consumption of Estidama scenario begins to decline compared to BAU- following the implementation of Estidama system on all new buildings- and reaches its maximum annual reduction by 2020 with 98 Million m$^3$ below the BAU.

The environmental and economic benefits that the Abu Dhabi government can acquire from enhancing buildings performance following the implementation of Estidama pearl building rating system over ten years period (2011–2020) can be summarized as shown in Table 3.

A significant cumulative amount of electricity reduction totaled of 49.3 TWh can be achieved over ten years period of implementing the minimum standard of Estidama program (1 pearl category), which exceeds the entire electricity consumed in Abu Dhabi Emirate in 2011 i.e. 43.3 TWh by 14%. In the water side; a cumulative reduction of 457.1 Million m$^3$ can be achieved in ten years period, which is equivalent to 48% of the entire water demand of Abu Dhabi Emirate in 2011, i.e 961.5 Million m$^3$.

The direct monetary savings from adopting Estidama program could reach up to 19 Billion AED accumulatively over ten years period, based on the current actual unit production cost of electricity and water in Abu Dhabi. The monetary savings are divided between the government of Abu Dhabi and the end-users; the end-users only pay a small portion of the actual cost while the remaining cost is totally covered by the government through its electricity and water subsidy program.

On the environmental side, the entire cumulative carbon reduction of the first ten years of putting Estidama into service is estimated to reach 31.4 Million ton of CO$_2$eq, this is higher than the entire amount of CO$_2$ produced by water and electricity generation sector in Abu Dhabi in 2010- i.e. 30.84 Million ton of CO$_2$eq by 2%.

6. Conclusion

The outcomes of energy simulation and water analysis showed a potential of electricity reduction between 31% and 38% and a potential of water reduction from 22% to 36% depending on building type and energy policies. The implementation of Estidama pearl building rating system results in significant energy and water savings, which contribute to both environmental and economic benefits for Abu Dhabi.
the consumption of water and energy. Subsidy withdrawal, could de-
charges lower for less consumption. Pricing, via taxing or partial
adopt the variable tariff scheme used in other emirates; which
protect the environment and reduce carbon emissions. The
sidies, enhance the market and create new job opportunities,
reduce the government expenditures on energy and water sub-
tions and enhancing its energy and water security. It will also
thus help preserving its natural resources for the coming genera-
reduce water and energy consumption by considerable amounts,
system for all new constructed buildings in Abu Dhabi would

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Summary of the project outcomes.</th>
<th>Annual demand growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative consumption savings in 10 years- TWh/Mm3⁴</td>
<td>49.3</td>
<td>457.1</td>
</tr>
<tr>
<td>Cumulative monetary savings in 10 years-Billion AED</td>
<td>14.2</td>
<td>4.8</td>
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<tr>
<td>Cumulative carbon savings in 10 years-Millions tons of CO2eq</td>
<td>25.1</td>
<td>6.3</td>
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</table>

type and other parameters. Adopting the Estidama pearl rating
system for all new constructed buildings in Abu Dhabi would
reduce water and energy consumption by considerable amounts,
thus help preserving its natural resources for the coming genera-
tions and enhancing its energy and water security. It will also
reduce the government expenditures on energy and water subs-
idades, enhance the market and create new job opportunities,
protect the environment and reduce carbon emissions. The first ten
years of putting Estidama building program into service could
achieve monetary savings up to 19 Billion AED and abate 31.4
Million ton of CO2eq cumulatively. In addition, Abu Dhabi could
adopt the variable tariff scheme used in other emirates; which
charges lower for less consumption. Pricing, via taxing or partial
subsidy withdrawal, could definitely play a huge role in reducing
the consumption of water and energy.

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