EmiratesGBC

BUILDING EFFICIENCY ACCELERATOR PROJECT REPORT

ENERGY AND WATER PERFORMANCE BENCHMARKING IN HOTELS, SCHOOLS, & MALLS

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EmiratesGBC
مجلس الامارات للابنية الخضراء
Emirates Green Building Council

IN PARTNERSHIP WITH

المجلس الأعلى للطاقة
Supreme Council of Energy

Building Efficiency Accelerator

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ACCELERATOR

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Sustainable Energy for All Building Efficiency Accelerator

In 2014, at the Climate Summit, Sustainable Energy for All (SEforALL) announced a partnership of businesses and governments called the Global Energy Efficiency Accelerator Platform. The Platform consists of six individual Accelerators that work in the buildings, lighting, appliances, district energy systems, industry and transportation sectors to create targeted support for energy efficiency.

The Building Efficiency Accelerator (BEA) is a public-private collaboration that turns global expertise into action to accelerate local government implementation of building efficiency policies and programs.

The BEA global partnership is designed to complement existing networks of cities by facilitating access to global expertise in building efficiency topics and providing a venue for engagement with private sector partners. The BEA process of engagement in a city includes guidance and technical advice to:

- Assess and prioritize locally-appropriate building efficiency policies and actions
- Implement actions, matching city needs with available expertise, technical resources and tools
- Track action and documenting progress, and share lessons learned
- Increase ambition for improving the overall efficiency of the building stock

The BEA engages with cities based on the needs of the city and the activities that the partnership can provide in each location. Cities will prioritize policies and activities, and the partnership will connect them to technical resources and engagement opportunities around those priorities.

Cities and subnational governments that join the Accelerator are asked to make three specific commitments to be implemented with assistance from the partnership:

- Implement one enabling policy
- Implement one demonstration project
- Create a baseline of building energy performance, track and report annual progress, and share experiences and best-practices with other governments

Emirates Green Building Council is a business forum based in the United Arab Emirates formed in 2006 with the goal of advancing green building principles. The Council gathers member companies and partners representing a diverse range of stakeholders from within the building industry, government, and academia. EmiratesGBC functions as a common platform for all stakeholders whereby they can meet, discuss, interact, and exchange groundbreaking ideas which help to promote a sustainable built environment in the UAE and the surrounding region.

Since its formation, EmiratesGBC has initiated several programs and events related to improving the operational efficiency of existing buildings. Membership is open to all stakeholders willing to influence a positive change in the country's built environment. The Council facilitates open engagement with its members and conducts quarterly review with its Board Members to devise work plans and programs which promote the Council's mission.

FOREWORD

FROM DUBAI SUPREME COUNCIL OF ENERGY

> “We recognize that preserving our energy resources will be one of the greatest challenges in our drive towards sustainable development. This, however, will not materialize unless the different facets of our society adopt energy conservation principles in theIr core values. The future generations will be the chief beneficiary of our achievements and the best judge of what we accomplish in this field.”
>
> HH Sheikh Mohammed Bin Rashid Al Maktoum

Energy sustainability has come to the top of the agenda of the Dubai Government, driven by the visionary leadership of HH Sheikh Mohammed Bin Rashid Al Maktoum, The Ruler of Dubai.

Successful energy sustainability policy outcomes arew most likely in an effective and robust system of governance and regulations. In Dubai, we have developed a response to the overarching need to change trends in energy generation and use, and deliver the results needed to align ourselves with the international requirements to limit effects on the environment, under the banner of limiting the average temperature rise to under 2°C in the long term. In line with this, new policies are being developed around the world, new technologies are being integrated on the demand side and on the supply side, with renewables taking a fast-growing role, and targets worldwide are becoming more and more ambitious.

In order to find a solution for these challenges and align the work of various stakeholders with global benchmarks of excellence and energy efficiency, the Dubai Supreme Council of Energy has joined the UNEP Sustainable Energy for All initiative called Building Efficiency Accelerator. We respectively want to share knowledge with other countries as well as learn from them and build our own foresight and the Dubai policy stand on energy supply and especially demand.

Benchmarking is one of the drivers to changing of our behavior and raising our awareness. It enables us to measure ourselves with others in terms of energy usage and determine whether we are performing well or if there is a good case for improvements. This can be done at a personal level, building level and among cities and countries.

Benchmarking of select key groups of buildings – schools, hotels and shopping malls -done in this report we see as a great opportunity for improvement – those who are performing well can become aware of it and teach others, while those who have room to improve know what they should aim for. In light of this, we are sure that this publication will serve a great purpose and drive further action towards more efficient schools, shopping malls and hotels, which is our main goal.

Our great society has managed to create a place where so many nations live and work together, enabling better lives not just for residents of Dubai and UAE, but also for hundreds of thousands of families abroad. I am therefore passionately connected to sustainability, both professionally in the Supreme Council of Energy and in personal life.

We thank the Emirates Green Building Council for working with us both on meeting our goals within the Accelerator. One of the results of this work is initiation of several initiatives within the government, and this publication comes as one of the key deliverables with a broad application to work of the government but also for the private sector.
We have made very good progress within this decade and will keep doing so – to reduce our CO2 emissions, create new green jobs, improve quality of life for all and progress the idea of personal happiness as the ultimate goal of developing a harmonious and sustainable society. We look forward to having you work with us on this endeavour.

H.E. Ahmad Buti Al Muhairbi
Secretary General
Dubai Supreme Council of Energy

FOREWORD
FROM THE CHAIRMAN OF EMIRATESGBC

In 2015, world leaders gathered in Paris to make a commitment to address climate change and to propose a roadmap for curbing carbon emissions and the warming of our planet. Today, we are at a critical crossroads and we must collectively take decisive decision to deploy the actions needed to save our planet and humanity.

Many elements must come together that will allow for the success of the Paris Agreement, and the built environment, which accounts for almost 40% of global carbon emissions, industry is a key component that can make a significant influence to limiting climate change and achieving 100 per cent net zero carbon buildings by 2050.
Benchmarking is an important step for industry experts to understand the performance of their buildings and to evaluate energy and water usage. This will enable them to make decisions backed by solid data on how to improve their consumption rates and track their progress.

This report summarises Emirates Green Building Council's (EmiratesGBC) work done for the Building Efficiency Accelerator (BEA) Benchmarking Project dedicated to the evaluation of the Dubai hotels, schools and malls performance.

The BEA project is one of the six tools under the Sustainable Energy for All programme of the United Nations that aims to double the global rate of building energy efficiency by 2030. We are thankful to the Dubai Supreme Council of Energy, the BEA City Representative, for appointing us as the BEA City Liaison, enabling us to undertake this landmark venture. We look forward to continued collaboration on the journey to achieve the vision of His Highness Sheikh Mohammed Bin Rashid Al Maktoum's Vision for Dubai to be the City with the lowest carbon footprint in the world by 2050.

Energy and water management are inherently embedded in sustainable practices and the BEA Benchmarking Project is a major step towards mapping the energy use efficiency of existing buildings in Dubai. The findings will help in undertaking relevant retrofitting measures to achieve net zero carbon emissions in existing buildings, and also support policy making in relation to sustainable building practices and implementing the BEA policy of labelling the energy performance of existing building in Dubai.

We launched the Hotels Benchmarking report in 2016, and it was a substantial step forward in raising awareness by establishing the first ever benchmarks for the hospitality sector in the UAE and the Middle East. The lessons learnt from report meant that EmiratesGBC is equipped to lead the BEA Benchmarking Project and support Dubai's commitment to sustainable development.

I thank the Leadership Team, which have shown their commitment to improve the energy efficiency of their properties and provided multiple case studies for the BEA Benchmarking Project.
The commitment of numerous properties has also been critical to the success of the BEA Benchmarking Project, and I thank them for the support.

I extend my appreciation to the Advisory Committee members who have contributed their expertise and knowledge to review and support the development of the BEA methodology and report.

I hope this report will give you new insights on benchmarking buildings for energy efficiency and assist you in supporting the green vision of our nation – and in turn, contribute to the global efforts to combat global warming and drive energy and water efficient practices.

Saeed Al Abbar
Chairman
Emirates Green Building Council

Table of Contents

Abbreviations........ 8

Executive Summary........ 9

Introduction........ 11

Background Information........ 12

- Global Trends........ 12
- Energy Efficiency of Buildings in Dubai........ 12
- Benchmarking........ 13

BEA Benchmarking Project & Methodology........ 14

- Data Collection........ 14
- Data Verification........ 14
- Data Analysis........ 14

Hotels........ 18

- Overview of Participating Hotels........ 19
- Energy Performance Results........ 19
- Water Performance Results........ 24
- Conclusions and Summary........ 27

Schools........ 28

- Overview of Participating Schools........ 29
- Energy Performance Results........ 30
- Water Performance Results........ 32
- Conclusions and Summary........ 35

Malls........ 36

- Overview of Participating Malls........ 37
- Energy Performance Results........ 38
- Water Performance Results........ 41
- Summary and Recommendations........ 45

Limitations........ 47

Next Steps & Recommendations........ 49

Bibliography........ 50

Appendix A Information Requested from Participating Properties for the BEA Benchmarking........ 51

Appendix B Site to Source Calculation........ 53

Abbreviations

BEA – Building Efficiency Accelerator

CHW – Chilled Water

DC – District Cooling

DIES 2030 – Dubai Integrated Energy Strategy 2030

DM – Dubai Municipality

DSCE – Dubai Supreme Council of Energy

DSM 2030 – Dubai Clean Energy Strategy 2050

EeMAP – Energy Efficient Mortgages Action Plan

EMF-ECBC – European Mortgage Federation - European Covered Bond Council

EmiratesGBC – Emirates Green Building Council

EPA – Environmental Protection Agency

EPBD – Energy Performance of Buildings Directive

ESCO – Energy Service Company

EUI – Energy Use Intensity

GCFA – Gross Conditioned Floor Area

HHV – High Heating Value

HVAC – Heating, Ventilation, and Air Conditioning

KPI – Key Performance Indicators

kWh – Kilowatt Hour

IEA – International Energy Agency

IG – Imperial Gallons

INDC – Intended Nationally Determined Contribution

KHDA – Knowledge and Human Development Authority

LPG – Liquid Petroleum Gas

RSB – Regulatory & Supervisory Bureau

SEforALL – Sustainable Energy for All

SNG – Synesthetic Natural Gas

SSC – Site-to-Source Conversion

UN – United Nations

UNEP – United Nations Environment Program

UNFCCC – United Nations Framework Convention on Climate Change

WRI – World Resources Institute

WUI – Water Use Intensity

Executive Summary

This report presents the results and findings of the energy and water benchmarking study conducted by Emirates Green Building Council as part of Dubai's Building Efficiency Accelerator (BEA) demonstration project. The BEA is a public-private collaboration that turns global expertise into action to accelerate local implementation of building efficiency policies and programs. This benchmarking report forms part of Dubai's commitment under the BEA program of undertaking a demonstrable project to accelerate the uptake of energy efficiency in the Emirate by assessing and benchmarking the performance of hotel, school and shopping mall buildings.

A total of 121 properties from the UAE submitted data for the project with 103 properties located in Dubai. The energy and water data, along with general building characteristics, used for the benchmarking results was obtained directly from the properties. The annual energy and water use intensities (EUIs and WUIs) per gross conditioned floor area (all), per guest-night (hotels), per student (schools) and per footfall (malls), were calculated for each property along with other typology specific metrics. Correlation factors were also calculated to evaluate the impact of certain characteristics (building age, hotels' star rating and schools' KHDA rating) on the performance.

The participating Dubai properties represent 10% of the total number of hotel establishments, 9% of the total mall and shopping centres and 10% of the total number of private schools in Dubai with a cumulative Gross Conditioned Floor Area of 5.6 km^2. The results of the benchmarks (best performers, median, average and worst performers) are presented in the Summary Tables below.

Hotel Properties					
KPI	Range	Best Performers	Median	Average	Worst Performers
Energy Use per GCFA *kWh/m²/year*	All:104 - 648 Hotels:104 - 648 Resorts:181 - 483	All: < 174 Hotels: < 171 Resorts: < 193	All: 252 Hotels: 249 Resorts: 334	All: 275 Hotels: 271 Resorts: 308	All: > 416 Hotels: > 414 Resorts: > 444
Energy Use per guest-night *kWh/guest-night/year*	All:19 - 260 Hotels:19 - 219 Resorts:65 - 260	All: < 24 Hotels: < 23 Resorts: < 71	All: 74 Hotels: 69 Resorts: 148	All: 83 Hotels: 74 Resorts: 158	All: > 204 Hotels: > 168 Resorts: > 249
Water Use per GCFA *litres/m²/year*	All:850 - 5,474 Hotels:850 - 3,106 Resorts:1,054 - 5,474	All: < 928 Hotels: < 915 Resorts: < 1,093	All: 1,487 Hotels: 1,486 Resorts: 1,676	All: 1,704 Hotels: 1,606 Resorts: 2,490	All: > 3,104 Hotels: > 2,632 Resorts: > 4,927
Water Use per guest-night *litres/guest-night/year*	All: 144 - 1,159 Hotels: 144 - 1,159 Resorts: 492 - 1,027	All: < 155 Hotels: < 155 Resorts: < 568	All: 439 Hotels: 363 Resorts: 855	All: 468 Hotels: 430 Resorts: 822	All: > 927 Hotels: > 915 Resorts: > 997

School Properties					
KPI	Range	Best Performers	Median	Average	Worst Performers
Energy Use per GCFA kWh/m²/year	85 - 290	< 92	134	149	> 233
Energy Use per student kWh/student/year	307 - 8,422	Excl. outliers: < 1,681	Excl. outliers: 2,423	Excl. outliers: 2,765	Excl. outliers: > 4,364
Water Use per GCFA *litres/m²/year*	383 - 2,848	< 413	852	1,218	> 2,608
Water Use per student *litres/student/year*	9 - 147	Excl. outliers: < 23	Excl. outliers: 48	Excl. outliers: 50	Excl. outliers: > 89

Mall Properties					
KPI	Range	Lowest Consumer	Median	Average	Higest Consumer
Energy Use per GCFA *kWh/m²/year*	378 - 580	378	465	462	580
Energy Use per footfall *kWh/footfall/year*	1.84 - 5.03	1.84	4.06	3.81	5.03
Water Use per GCFA *litres/m²/year*	658 - 1,586	658	1,300	1,260	1,586
Water Use per footfall *litres/footfall/year*	5.17 - 15.74	5.17	12.94	10.76	15.74

Summary Tables of Energy and Water Use Intensities per Gross Floor Conditioned Area (GCFA) for Dubai hotels, schools and malls. The GCFA is the sum of the conditioned floor area of all floors of the property and excludes all parking spaces and non-conditioned area. Some of the typology specfic performance metrics are also shown; the other performance metrics are reported under the relevant sections within the report.

Hotels:

- Overall, best performers consume **58%** less **energy** per area than worst performers.
- Best hotel performers consume **65%** less **water** per area than worst performers.
- Best resorts performers consume **78%** less **water** per area than worst performers.

Schools:

- The best performers consume **61%** less **energy** per area compared to the worst performers.
- The best performers consume **84%** less **water** per area compared to the worst performers.

Malls:

- The lowest consumer consumes **35%** less **energy** per area compared to the highest consumer.
- The lowest consumer consumes **58%** less **water** per area compared to the highest consumer.

The results show that there is a performance disparity amongst all the participating properties with a large gap between the best and worst performers. This indicates a large opportunity to implement best practices of the market leaders across the sector to drive resource efficiency. Remedial actions can include energy management, energy audits, training and capacity building, behavioural changes and retrofits.

Pearson's correlation coefficients reveal that older hotel properties are likely to consume more energy (negative weak correlation of -0.34) and water (negative moderate correlation of -0.43) per unit area highlighting the importance of retrofitting older buildings. Additionally, higher star-rated hotel properties are likely to consume slightly more energy (positive weak correlation of 0.32) and water (positive weak correlation of 0.31) per unit area.

The correlation coefficients for schools indicated that newer schools are likely to consume more energy and water (weak positive correlation of 0.18 and 0.2, respectively) per unit area. Findings also indicated that higher KHDA rated schools were likely to consume less energy per unit area (weak negative correlation of -0.22).

Introduction

Building Efficiency Accelerator (BEA) Initiative

In 2011, United Nations Secretary-General Ban Ki-moon launched the Sustainable Energy for All (SEforALL) Initiative to mobilize action towards three core targets of the Sustainable development Goal 7, Affordable and Clean Energy, which are: universal access to modern energy, doubling the rate of energy efficiency improvement, and doubling the share of renewable energy in the global mix by 2030. To achieve the energy efficiency targets, the Global Energy Efficiency Accelerator Platform was created as a public-private collaboration focused on six sector-specific energy efficiency opportunities:

1) Appliances and Equipment
2) Building Efficiency
3) District Energy
4) Lighting
5) Transport and Fuel Efficiency
6) Industrial Energy Efficiency

According to the UNEP's Global Status Report 2017 [1], buildings and construction sector together account for 35% of global final energy use and 40% of energy-related carbon dioxide (CO_2) emissions. The report also highlights that there will be massive increase in urban expansion over the next 40 years, and therefore retrofits/ renovations of existing buildings are needed as 65% of the total expected building stock in 2060 is already built today.

To address this, the Building Efficiency Accelerator (BEA) was launched in 2014 at the UN Climate Summit, which invited cities to make a commitment to double the rate of building energy efficiency by 2030.

The BEA Initiative is managed by the World Resources Institute, and at the time of this report, includes 45 global organizations committed to support the BEA cities around the world.

In 2016, Dubai, with the Dubai Supreme Council of Energy (DSCE) as the BEA City Representative, became the first city in the Middle East to sign and commit to the BEA among 35 other cities.

Cities that sign up to the BEA agree to:

- Implement one enabling policy
- Implement one demonstration project
- Create a baseline of building energy performance, track and report annual progress, and share experiences and best-practices with other governments.

Emirates Green Building Council (EmiratesGBC) was appointed as the BEA City Liaison by DSCE to provide support for the BEA objectives and lead the selected demonstration project.

To initiate Dubai's BEA efforts, an online survey was issued in October 2016 to over 50 key stakeholders which included federal and city governments, building owners and managers, technical and financial building service providers and utility companies to aid in identifying and prioritizing effective energy efficiency policies and projects for buildings. A stakeholder consultation workshop followed in December 2016 [2] to engage business and government industry stakeholders, identify policy focus areas and share strategic directions that align with the city's sustainability vision in connection to buildings.

Based on the survey results and input from the stakeholder workshop, Dubai committed to adopting an energy performance labelling scheme of existing buildings as the BEA policy [3] and benchmarking the energy performance of 100 buildings (hotels, schools and malls) in Dubai was chosen as the BEA demonstration project [4].

This report presents the results from the BEA Benchmarking project carried out by Emirates Green Building Council for the city of Dubai.

Background Information

Global Trends

As the world population continues to rise, resource consumption also increases with buildings-related CO_2 emissions increasing by 1% per year since 2010 [1]. Several reports and studies have concluded accelerated actions are needed to achieve the Paris Agreement and limit global warming to 1.5°C before the end of the century [1], [5], [6], [7]. Improving the energy efficiency of new and existing building prevents locking emerging economy cities into a high carbon, low efficiency-built environment.

Globally, many regions and cities have realized the energy and carbon saving potential of buildings and there has been a growing trend towards energy efficient buildings. This is largely backed with improvements of buildings codes and regulations such as Europe's Energy Performance of Buildings Directive (EPBD) 2010/31/EU, British Columbia's Energy Step Code and Carbon Neutral Adelaide, to name just a few.

In response to the accelerated actions required from the public and private sectors to mitigate climate change through gradual transition to net zero buildings and/or cities, the WorldGBC launched Net Zero Carbon Buildings Commitment as part of The Climate Group's global EP100 initiative. The Commitment calls for companies, cities, states and regions to reach Net Zero operating emissions in their portfolios by 2030, and to advocate for all buildings to be Net Zero Carbon in operation by 2050.

Other global trends enabling improvement of energy efficiency of the built environment include a suite of policies and/or financial incentives. For instance, the Energy Efficient Mortgages Action Plan (EeMAP) is a project coordinated by the European Mortgage Federation (EMF-ECBC), to create a private bank financing mechanism to increase energy-efficient investment in EU residential buildings.

Energy efficiency trends, however, are not just limited to the ones above, as seen in IEA's 2018 Energy Efficiency Market Report [8], which shows that efficiency in the building sector is also driven by market transitions towards smart technologies such as digitalization and controls, as well as better performance equipment such HVAC systems, insulation, pumps and lighting.

The overall effect of the governmental drivers, financing mechanisms and private sector market transitions encourages and enables property owners to shift towards retrofitting existing building stock. This is evident as the global energy service company (ESCO) market expanded 8% to USD 29 billion in 2017 and is expected to continue growing [8].

Energy Efficiency of Buildings in Dubai

The UAE was one of the first countries in the region to ratify the Paris Agreement through the submission of its Intended Nationally Determined Contribution (INDC) to the United Nations Framework Convention on Climate Change (UNFCCC), despite being categorized as a non-Annex 1 country [9].

Dubai has demonstrated its commitment to tackle climate change by aligning with the federal strategies, such as the Green Economy for Sustainable Development, UAE Vision 2021 and the UAE Green Agenda 2015 - 2030, through the Dubai Plan 2021 which aims to position Dubai as a leader in sustainability.

THE DUBAI DEMAND SIDE MANAGEMENT 2030 (DSM 2030) STRATEGY AIMS TO REDUCE THE EMIRATE'S ENERGY AND WATER CONSUMPTION BY 30% BY 2030

The Emirate of Dubai has demonstrated its commitment to tackle climate change by aligning with the federal strategies, such as the Green Economy for Sustainable Development, UAE Vision 2021 and the UAE Green Agenda 2015 - 2030, through the Dubai Plan 2021 which aims to position Dubai as a leader in sustainability. These are further supported by the Dubai Integrated Energy Strategy 2030 (DIES 2030) and the Dubai Clean Energy Strategy 2050 [10].

Under DIES 2030, the Dubai Demand Side Management 2030 (DSM 2030) strategy aims to reduce the Emirate's energy and water consumption by 30% by 2030. Buildings have received priority in DSM 2030, where one entire program is dedicated to periodically improving the building regulations to increase energy and water savings. This is expected to generate the biggest percentage DSM share of savings for both energy and water consumption (26.75% and 32.30%, respectively) [11]. Accordingly, Dubai Municipality (DM) introduced the Al Sa'fat Rating System in September 2016, with four certification levels to strengthen the sustainable built environment of the city.

Another key program of the DSM 2030 Strategy is retrofitting existing buildings. The program is being managed by Etihad ESCO, which was established in 2013, with the goal to create a viable performance contracting market for energy service companies (ESCOs) in Dubai. Along with other ESCOs, they aim to retrofit about 30,000 buildings by 2030 and generate 1.68 TWh energy savings, 5.64 BIG water savings and 1M tons CO2 emissions' reduction by 2030 [10]. This is expected to contribute 8.77% and 12.19% of energy and water savings, respectively, of the DSM 2030 Strategy [11].

Benchmarking

Establishing baselines through building benchmarks can be very influential in directing building owners' attention towards energy efficiency. Indeed, this has also been recommended by the WRI as one of the actions for accelerating building efficiency [12]. Building owners and managers can make better energy management decisions if they have reasonable and convenient access to data on energy consumption and building characteristics. Additionally, benchmarks can help support policy makers in developing strategies and polices.

The first ever industry benchmark in the UAE was established by the EmiratesGBC's 2016 Energy and Water Benchmarking for UAE Hotels Report [13]. This was an important step in advocating for the improved energy and water performance of existing hotels in the UAE, given that the UAE is one of the top most visited tourist destinations in the world.

Building benchmarks for other typologies, however, had still not been established prior to this report, thus making it difficult to evaluate the actual energy and water performance of the building sector. The BEA benchmarking project and the baselines presented in this report provide new and much needed information to help drive improved building efficiency in Dubai and support the development of policy and energy efficiency initiatives.

ESTABLISHING BASELINES THROUGH BUILDING BENCHMARKS CAN BE VERY INFLUENTIAL IN DIRECTING BUILDING OWNERS' ATTENTION TOWARDS ENERGY EFFICIENCY

BEA Benchmarking Project & Methodology

Given the instrumental support that benchmarking can provide to policy development, the benchmarking of 100 buildings of different typologies, hotels, schools and malls, was chosen by the city of Dubai as its BEA demonstration project to support its chosen policy commitment to the BEA - labelling the energy performance of existing buildings.

This section details the methodology for the BEA Benchmarking Project.

Data Collection

The data collection process took place from January to May 2018. During this period, over 400 properties were contacted and invited to contribute and participate in the project. The data for the BEA Benchmarking Project was obtained using questionnaires distributed to building owners, operators and/or managers. The data requested included general, physical and operational characteristics[1] as well as:

- Total electricity consumption data (in kWh) for the years 2013 – 2017,
- Electricity consumption data (in kWh) for common areas for the years 2013 – 2017 (for malls),
- Chilled water consumption (in Refrigerant ton) for years 2013 – 2015 for properties connected to district cooling network,
- Fuel consumption (in kg) for the years 2013 – 2017 (LPG, SNG, Natural gas and Diesel),
- Solar power generation (in kWh) for years 2015 – 2017 for properties with photovoltaic systems installed on-site (for malls),
- Total Water consumption data (in Imperial Gallons – IG) for the years 2013 – 2017,
- Water consumption data (in Imperial Gallons – IG) for common areas for the years 2015 – 2017 (for malls),
- Makeup water consumption data (in Imperial Gallons – IG) for water cooled-chiller plants for the years 2015 – 2017 (for malls),
- Guest-night and occupancy data for the years 2013 – 2017 (for hotels),
- Total number of students enrolled for the years 2013 – 2017 (for schools),
- Footfall data for years 2013 – 2017 (for malls).

1 For the details of data requested, refer to Appendix A.

Out of the total number of properties that were invited, 85 hotels, 27 schools and 9 malls in the UAE submitted data to EmiratesGBC for the BEA Benchmarking project, of which 70 hotels, 24 schools and 9 malls were in the Emirate of Dubai.

Data Verification

Data was provided by the properties directly and did not include on site verification by EmiratesGBC. A two-step review, however, was conducted internally to spot obvious discrepancies and errors to be corrected by the participating properties. In cases where the properties reported data with different units, the values were converted using the conversion metrics from the IEA Energy Statistics Manual [14].

Some of the properties were excluded from the benchmarking analysis as they were unable to provide one full year's data, were missing data, were not based in Dubai or were not able to provide the clarifications requested. In some cases, properties and/or data was excluded after verifications as they were not baseline values (due to closures, expansions or retrofits) or were considered outliers and were removed to avoid skewing the results of the statistics. In all cases, excluded properties were informed of their omission from the study due to the reasons mentioned above.

Data Analysis

Extensive research from various studies and global benchmarks was undertaken to identify the Key Performance Indicators (KPIs) to best represent the energy and water performance of the properties. A methodology for each of specific typologies was developed, reviewed and refined with the help of feedback received from an Advisory Committee, which consisted of representatives from government, consultancies and ESCOs. The methodologies were again re-assessed based on the available data and observations made during the data collection phase.

Table 1, *Table 2* and *Table 3* show the KPIs used for the properties based on the building typology. The Energy Use Intensity 1 (EUI-1) and Water Use Intensity 1 (WUI-1) are used to evaluate the spatial efficiency of the properties and are commonly used as benchmarking metrics globally such as EPA's Energy Star Portfolio Manager [15].

EUI 1 represents the total annual energy consumption as the sum of the electricity in kWh, the electrical equivalent of the Chilled Water (CHW) consumption of district cooling in kWh, and the High Heating Value (HHV) of the fuel used onsite in kWh divided by the Gross Conditioned Floor Area in m^2 (GCFA). The GCFA is the sum of the floor area of all floors of the property that is conditioned and therefore excludes all parking spaces and non-conditioned area.

Similarly, WUI-1 represents the total annual water consumption of the property divided by the GCFA. Make-up water was excluded for all water analysis for malls to ensure a fair comparison between participating malls (given that some malls used air-cooled chillers or district cooling).

The other EUIs and WUIs are typology specific and were used to better evaluate the operational performance of the property.

Participating properties were also separated, and their performance compared against each other based on their specific classification; for instance, whether it was a resort or hotel.

A Site-to-Source Conversion (SSC) factor of 3.21 was used for EUI-H2 to convert the final energy consumed onsite to primary or source energy as it incorporates the heat and electricity requirements of the building back to the raw fuel input, thereby accounting for any losses such as transmission and distribution losses [16]. The factor of 3.21 was calculated using the values obtained using IEA 2015 data for the UAE [17][2].

As the operations of malls are complex and data availability is unique to each mall property,

Hotel Properties	
KPI	Formula
EUI-H1 (Site Energy) *kWh/m²/year*	$= \dfrac{Electricity\ in\ kWh + 0.92\dfrac{kW}{ton} \times CHW\ in\ RTh + Fuel\ in\ kg \times HHV\ of\ fuel}{Gross\ Conditioned\ Floor\ Area}$
EUI-H2 (Source Energy) *kWh/m²/year*	$= \dfrac{SSC \times \left(Electricity\ in\ kWh + 0.92\dfrac{kW}{ton} \times CHW\ in\ RTh\right) + Fuel\ in\ kg \times HHV\ of\ fuel}{Gross\ Conditioned\ Floor\ Area}$
EUI-H3 *kWh/guest-night/year*	$= \dfrac{Electricity\ in\ kWh + 0.92\dfrac{kW}{ton} \times CHW\ in\ RTh + Fuel\ in\ kg \times HHV\ of\ fuel}{Annual\ Guestnight}$
EUI-H4 *Wh/m²/guest-night/year*	$= \dfrac{\left(Electricity\ in\ kWh + 0.92\dfrac{kW}{ton} \times CW\ in\ RTh + Fuel\ in\ kg \times HHV\ of\ fuel\right) \times 1000}{Gross\ Conditioned\ Floor\ Area \times Annual\ Guestnight}$
WUI-H1 *litres/m²/year*	$= \dfrac{Water\ in\ litres}{Gross\ Conditioned\ Floor\ Area}$
WUI-H2 *litres/guest-night/year*	$= \dfrac{Water\ in\ litres}{Annual\ Guestnight}$

Table 1 KPIs and formulas used for Hotels (denoted with the letter H)

2 For details on the calculation used, refer to Appendix B.

School Properties	
KPI	Formula
EUI-S1 *kWh/m²/year*	$= \dfrac{Electricity\ in\ kWh + 0.92\dfrac{kW}{ton} \times CHW\ in\ RTh}{Gross\ Conditioned\ Floor\ Area}$
EUI-S2 *kWh/student/year*	$= \dfrac{Electricity\ in\ kWh + 0.92\dfrac{kW}{ton} \times CHW\ in\ RTh}{\sum Students}$
WUI-S1 *litres/m²/year*	$= \dfrac{Water\ in\ litres}{Gross\ Conditioned\ Floor\ Area}$
WUI-S2 *litres/student/day*	$= \dfrac{Water\ in\ litres}{\sum Students \times 365}$

Table 2 KPIs and formulas used for Schools (denoted with the letter S)

Mall Properties	
KPI	Formula
EUI-M1 Net Energy Use per GCFA *kWh/m²/year*	$= \dfrac{Net\ Grid\ Electricity\ in\ kWh + 0.92\dfrac{kW}{ton} \times CHW\ in\ RTh}{Gross\ Conditioned\ Floor\ Area}$
EUI-M2 Net Energy Use per footfall *kWh/footfall/year*	$= \dfrac{Net\ Grid\ Electricity\ in\ kWh + 0.92\dfrac{kW}{ton} \times CHW\ in\ RTh}{Annual\ footfall}$
EUI-M3 Landlord Energy Use *kWh/m²/year*	$= \dfrac{Common\ Space\ Electricity\ in\ kWh}{Common\ Space\ Area} + \dfrac{Electricty\ consumption\ of\ onsite\ chiller\ plants\ in\ kWh + 0.92\dfrac{kW}{ton} \times CHW\ in\ RTh}{Gross\ Conditioned\ Floor\ Area}$
EUI-M4 Common Services Energy Use *kWh/m²/year*	$= \dfrac{Common\ Space\ Electricity\ in\ kWh + Electricty\ consumption\ of\ onsite\ chiller\ plants\ in\ kWh + 0.92\dfrac{kW}{ton} \times CHW\ in\ RTh}{Common\ Space\ Area}$
WUI-M1 Water Use per GFCA *litres/m²/year*	$= \dfrac{Total\ Water\ in\ litres - Makeup\ Water\ for\ onsite\ watercooled\ chiller\ in\ litres}{Gross\ Conditioned\ Floor\ Area}$
WUI-M2 Water Use per footfall *litres/footfall/year*	$= \dfrac{Total\ Water\ in\ litres - Makeup\ Water\ for\ onsite\ watercooled\ chiller\ in\ litres}{Annual\ footfall}$
WUI-M3 Common Services Water Use *litres/m²/year*	$= \dfrac{Common\ Space\ Water\ in\ litres - Makeup\ Water\ for\ onsite\ watercooled\ chiller\ in\ litres}{Common\ Space\ Area}$

Table 3 KPIs and formulas used for Malls (denoted with the letter M)

four types of KPIs were used to evaluate the performance of malls (see Table 3), whereby EUI-M1 and EUI-M2 examined the overall performance of the malls, and EUI-M3 and EUI-M4 evaluated the energy performance of common spaces/shared service areas (i.e. landlord-controlled areas).

Net Grid Electricity was used for EUI-M1 and EUI-M2, instead of total electricity consumption, as one of the malls generated solar energy on-site; for malls which were able to separate the annual chiller electricity consumption from the common space electricity consumption, EUI-M3 was used. For mall properties that were unable to do so, EUI-M4, a performance metric used for few of the malls in the region and in a study of shopping malls in the Gulf Coast [18], [19], was used.

Fuels consumed by hotel properties, such as LPG, diesel and Natural Gas, were converted into kWh equivalent using the high calorific values for the fuels from the IEA Energy Statistics Manual [14]. For Synthetic Natural Gas (SNG), however, the composition and Gross Calorific Value of SNG was provided directly from the property which used SNG. The High Heating Value (or Gross calorific value) was used as it includes all the heat released from the fuel, including any carried away in the water formed during combustion and was used for conversion of fuels as per EPA's Final Rule for Mandatory Reporting of Greenhouse Gases [20].

It should be noted that fuel consumption was not considered for schools and malls (see Table 2 and Table 3) as some of the participating properties did not have any fuel usage or did not provide the fuel data. Two of the schools used LPG for the science laboratories but their usage was minimal and therefore was not considered.

Chilled water (CHW) from District Cooling was converted into kWh equivalent using the average efficiency of district cooling plants in Dubai (0.92 kW/Ton) as per RSB Dubai Cooling Study [21].

Similar to the 2016 Benchmarking Report for UAE Hotels [13], the hotel and school properties in this study were classified based on percentile ranges of the respective KPIs, shown in Table 4.

Classification	Percentile
Best Performers	Less than 5th
Excellent	Between 5th and 25th
Good	Between 25th and 35th
Average	Between 35th and 65th
Fair	Between 65th and 75th
Unsatisfactory	Between 75th and 95th
Worst Performers	Greater than 95th

Table 4 Classification of properties based on their percentile values

Properties with values less than the 5th percentile were classified as "best performers", while properties with values more than the 95th percentile were classified as "worst performers". The ratio between the worst and best performers shows the potential savings that can be achieved through operational improvements and/or retrofits. Caution must be exercised, however, when interpreting these results as not all the properties provide the same services as the others. Thus, best performers are not necessarily the most efficient but may provide lower energy or water intense services compared to others.

Correlation factors were calculated using the Pearson product-moment correlation coefficients[3] to measure the impact of numerical factors such as the star-rating and the property age on the energy and water performance. To describe the strength of a correlation, Evans method [22] was used, whereby the level of correlation is evaluated based on the ranges of the absolute value of "r" as mentioned below:

- 0.00 <|r|< 0.19 - very weak correlation
- 0.20 <|r|< 0.39 - weak correlation
- 0.40 <|r|< 0.59 - moderate correlation
- 0.60 <|r|< 0.79 - strong correlation
- 0.80 <|r|< 1.0 - very strong correlation

THE ENERGY USE INTENSITY 1 (EUI-1) AND WATER USE INTENSITY 1 (WUI-1) ARE USED TO EVALUATE THE SPATIAL EFFICIENCY OF THE PROPERTIES. THE OTHER EUIS AND WUIS ARE TYPOLOGY SPECIFIC AND WERE USED TO BETTER EVALUATE THE OPERATIONAL PERFORMANCE.

3 Pearson product-moment correlation coefficients is a measure of the linear correlation between two variables X and Y, which is the covariance of the two variables divided by the product of their standard deviations.

Hotels

Overview of Participating Hotels

The participating hotel properties[4] for the BEA Benchmarking project represent 3.67 km^2 of Gross Conditioned Floor Area. 82% of the hotel properties were 4-5 star rated, with the remainder rated as 3 stars and below. More than half the properties provided laundry services (to either staff or guests or both). 42% of the hotels had some form of eco-certification or environmental management system (Green Key, Green Globe, Earth Check, ISO 14001) and only 15% of hotels had some form of renewable energy generation on-site.

More than four-fifths of the participating properties used onsite fuel, though their end-use varied significantly as some hotels used fuel just for cooking, whereas others used fuel for hot water or steam generation. The type of fuel used depended primarily on the end-use and location, with a majority using Liquid Petroleum Gas (LPG) for cooking and diesel being primarily being used for the testing of emergency power generation systems. Due to the presence of a Synthetic Natural Gas (SNG) network within the Palm, all participating Palm hotels used SNG. In 2017, the fuel consumption of participating hotel properties accounted for 12%, on average, of the overall site energy consumption.

One-third of the participating properties were connected to district cooling which, on average, accounts for 30% of the overall participating hotel properties' site energy consumption and can reach to a maximum of 42%.

Energy Performance Results

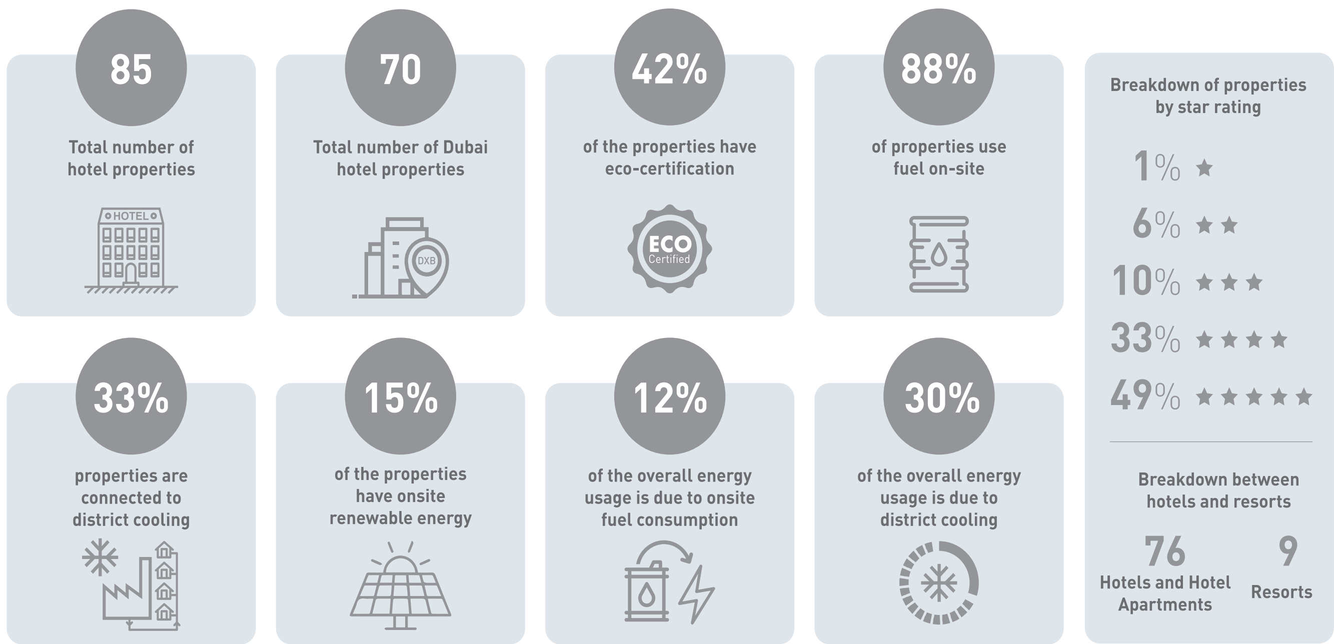
The following sections evaluate the energy performance of the hotel properties based on the KPIs established in Table 1. It should be noted that after the property exclusions, the final number of hotels that were used to calculate the energy performance was 62, representing 10% of the total number of Dubai hotel establishments [23].

EUI-H1

The Energy Use Intensity-H1 (EUI-H1 in Table 1) is the total site energy use of the hotel (including electrical, district cooling & fuel) per gross conditioned floor area and is commonly used to evaluate a building's energy performance level [12], [13]. The results for 2017 EUI-H1 show that:

- Participating hotel properties in Dubai consumed between 104 kWh/m^2/year and 648 kWh/m^2/year.
- A median participating hotel property in Dubai consumes 252 kWh/m^2/year. The average EUI of the participating properties is 275 kWh/m^2/year.
- Best performing hotel properties consumed less than 174 kWh/m^2/year. Worst performers consumed more than 416 kWh/m^2/year.

The results for all Dubai hotel properties for the year of 2017 are presented in Figure 1 where it can be seen that the median and average values



4 Hotel properties refer to all hotels including hotels, hotel apartments and resorts.

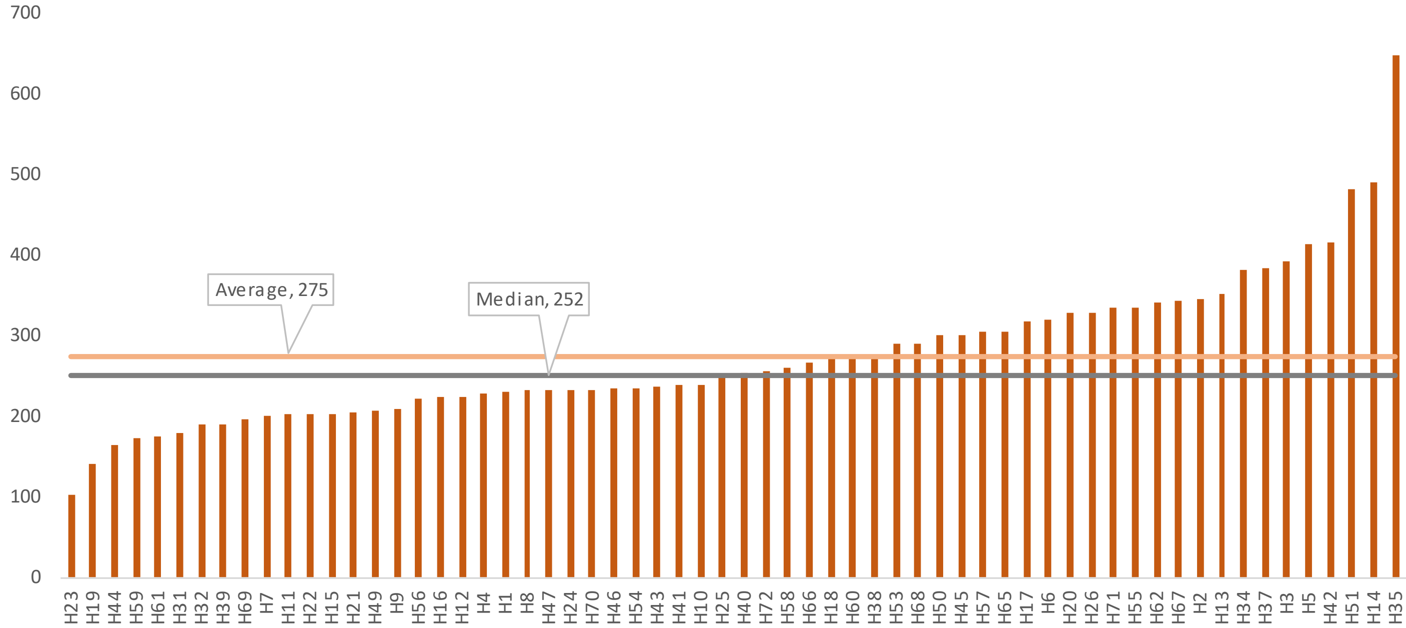


Figure 1 Energy Use Intensity-H1 (kWh/m²/year) for all participating Dubai hotel properties

are quite close, showing that the distribution of the data is spread close to the mean value.

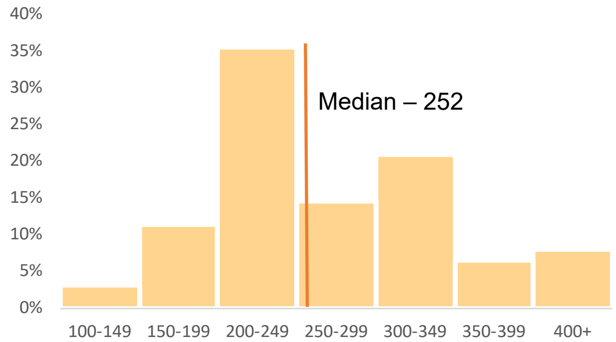


Figure 2 Frequency distribution for the 2017 EUI-H1 of hotel properties

The frequency distribution of EUI-H1 is presented in Figure 2 shows the percentage of properties arranged into frequency bins of 50 kWh/m2/year, with the lower bound of 100 and maximum bound of above 400. Closer examination of Figure 2 shows a bimodal distribution due to the presence of two peaks. The larger peak of 35% has an EUI within the 200 - 250 range, whereas the second peak of 21% corresponds to the 300-350 EUI range.

Impact of Hotel Age and Star Rating

EUI-H1 shows a negative weak correlation (-0.34) with the building age and a positive weak correlation (0.32) with the star rating.

The correlations are consistent with the 2016 EmiratesGBC benchmarking report [13], and is anticipated given that older hotels (unless retrofitted) have less efficient equipment and systems, whereas, higher star rated hotels often offer more amenities/services as compared to lower star rated hotels.

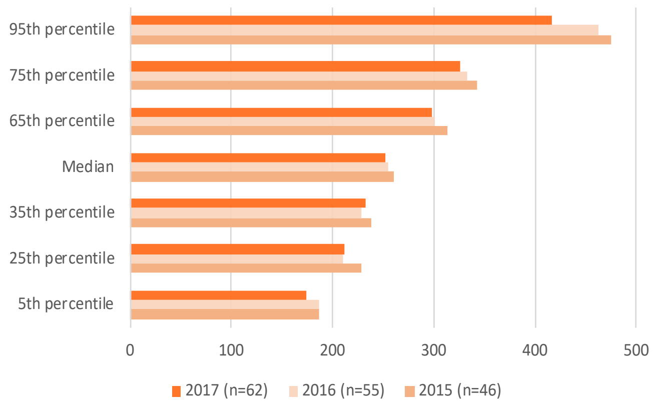


Figure 3 Percentile values of EUI-H1. Note: the number of properties (denoted with the letter n) used to calculate the values varies year from year.

Best vs Worst Consumers

The EUI-H1 percentile values for the years 2015-2017 is illustrated in Figure 3. It should be noted that not all properties were able to provide the data for those given years or were excluded as the data were not baseline values (due to renovations, expansions, closures or repairs).

Figure 3 shows there is gradual reduction in EUI 1 within all percentiles from 2015 – 2017, with an overall reduction of 4% in the median values.

The ratio between the 95th percentile and the 5th percentile (worst performers vs. best performers) is 2.4, highlighting that the worst performers consume as much as two and half times more energy than the best performers.

Figure 3 also shows that there is broad range of EUI-H1 results for any given year, highlighting the unequal performance between the hotel properties across Dubai.

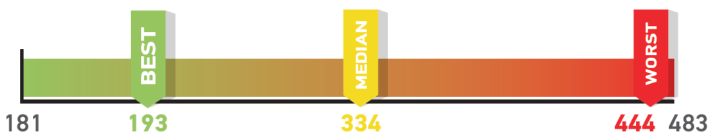
Hotels vs Resorts

To better understand the impact of the hotel type on the energy and water performance, the participating properties were separated according to hotel types. At first, hotels and hotel apartments were grouped separately, but the median of EUI and Water Use Intensity (WUI) values were not significantly different as compared to hotels and resorts. Thus, hotel apartments and hotels were combined into one group. The 2017 EUI-H1 results for the participating properties, after segregation, show:

- A median hotel or hotel apartment in Dubai consumes 249 kWh/m²/year.
- Best performing hotels and hotel apartments consumed less than 171 kWh/m²/year. Worst performers consumed more than 414 kWh/m²/year.

EUI-H1 of Hotel and Hotel Apartments
kWh/m²/year

- A median resort in Dubai consumes 334 kWh/m²/year.
- Best performing resorts consumed less than 193 kWh/m²/year. Worst performers consumed more than 444 kWh/m²/year.



EUI-H1 of Resorts
kWh/m²/year

Both results show the median and average lies close to each other, highlighting the even spread around the average values. These findings also agree with the Cornell Hotel Sustainability (CHR) Hotel Sustainability Benchmarking Index 2016 Report where it was reported that resorts have higher energy and water usage per square meter across all climate zones [24].

EUI-H2

During verification, it was noted that participating hotel properties have varying operational equipment with differing efficiencies; for instance, some hotel properties have electric boilers, whereas other properties have fuel-powered boilers. As a result, comparison between such properties is not fair and thus it becomes necessary to evaluate the energy performance of these properties using source energy instead.

This is what is evaluated through the Energy Intensity Use-H2 (EUI-H2 in Table 1), which converts the on-site electricity and the electrical equivalent of district cooling into source energy using the Site to-Source Conversion (SSC) factor of 3.21.

The results for the 2017 EUI-H2 show that:

- Participating hotel properties in Dubai consumed between 334 primary-kWh/m²/year and 1,728 primary-kWh/m²/year.
- A median hotel property in Dubai consumes 727 primary-kWh/m²/year. The average EUI of the participating properties is 809 primary-kWh/m²/year.
- Best performing hotel properties consumed less than 523 primary-kWh/m²/year. Worst performers consumed more than primary-1,235 kWh/m²/year.

The results for the Dubai hotel properties are illustrated in Figure 4 which shows that while the some of the properties have increased energy consumption, the overall performance of the properties does not change significantly. This is evident when examining Figure 1 in conjunction,

A MEDIAN HOTEL OR HOTEL APARTMENT IN DUBAI CONSUMES 249 kWh/m²/year. A MEDIAN RESORT IN DUBAI CONSUMES 334 kWh/m²/year.

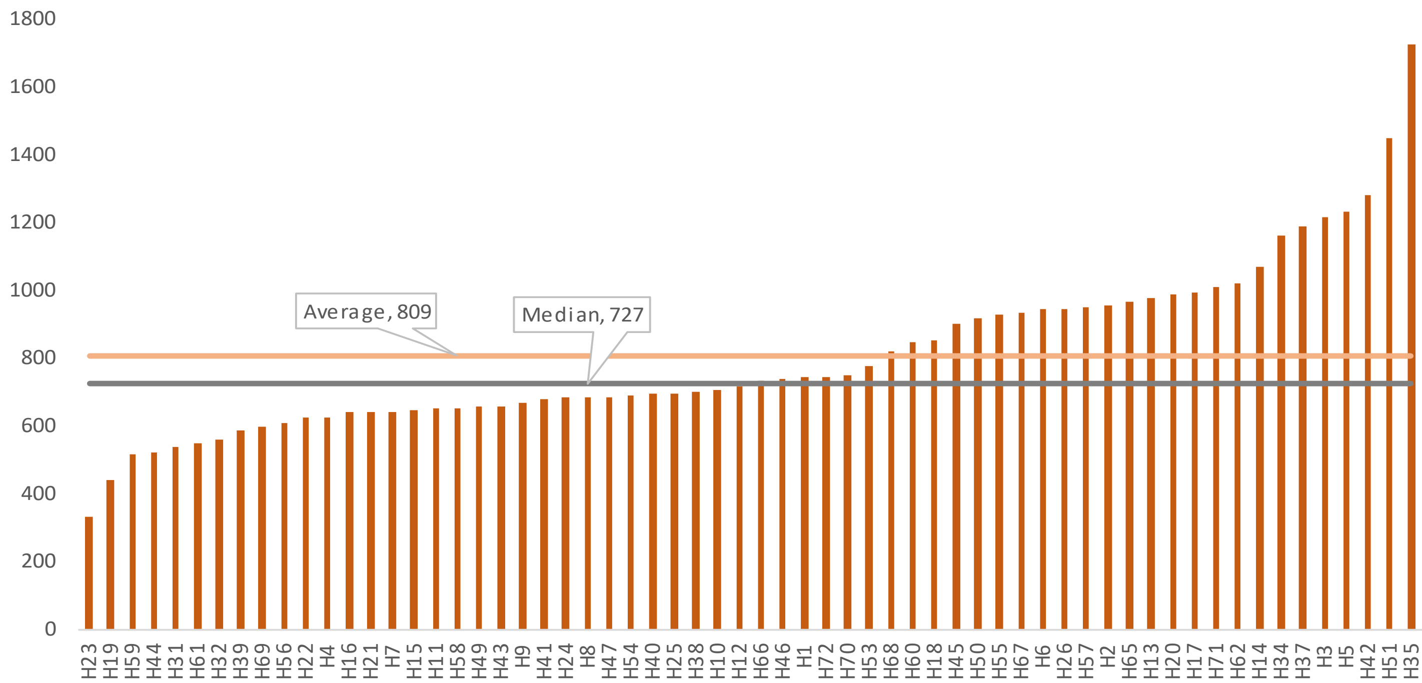


Figure 4 Energy Use Intensity-H2 (primary-kWh/m²/year) for all participating Dubai hotel properties

where the best performers of 2017 EUI-H1 are also the best performers of EUI-H2.

Best vs Poor Consumers

Similar to the results from EUI-H1, there is a performance disparity between the best performers and the worst performers, whereby the worst performers consume almost two and half times more than the best performers.

Hotels vs Resorts

Given the results from EUI-H1, it was anticipated that the resorts would have a higher EUI-H2 as compared to hotels and hotel apartments. Indeed, the results for 2017 EUI-H2 reveal:

- A median hotel or hotel apartment in Dubai consumes 721 primary-kWh/m^2/year.
- A median resort in Dubai consumes 936 primary-kWh/m^2/year

EUI-H3

The third KPI is the total energy consumption of the hotel per annual guest-night and is a hotel specific performance metric. The use of this KPI is much easier to quantify and benchmark whereas using average occupancy rates can lead to considerable precision errors. It is also cited by the Global Sustainable Tourism Council [25] as a suggested performance indicator and was used for the 2016 Benchmarking Report for UAE hotels [13].

EUI-H3 results, illustrated in Figure 5, show:

- Participating hotel properties in Dubai consumed between 19 and 260 kWh/guest-night/year.
- A median hotel property in Dubai consumes 74 kWh/guest night/year. The average EUI per guest-night is 83 kWh/guest-night/year.
- Best performing hotel properties consumed less than 24 kWh/guest-night/year. Worst performers consumed more than 204 kWh/guest-night/year.

Closer examination of Figure 1 and Figure 5, shows that the best performers in EUI-H1, with the exception of H19, do not correspond to the same properties in EUI-H3. Therefore, in terms of operations, the best performers are not necessarily the most spatially energy efficient hotels (although this is a major contributing factor). It was also noted that the top performers of EUI-H3 are all three-star rated properties.

However, it should be noted the results from this KPI might not be completely accurate for hotels with many food and beverage (F&B) outlets. This is because F&B outlets usually have high energy consumption, and is factored into the overall energy consumption, but the visitors to these outlets are not accounted for in the guest-night values (as they are not staying at the hotel).

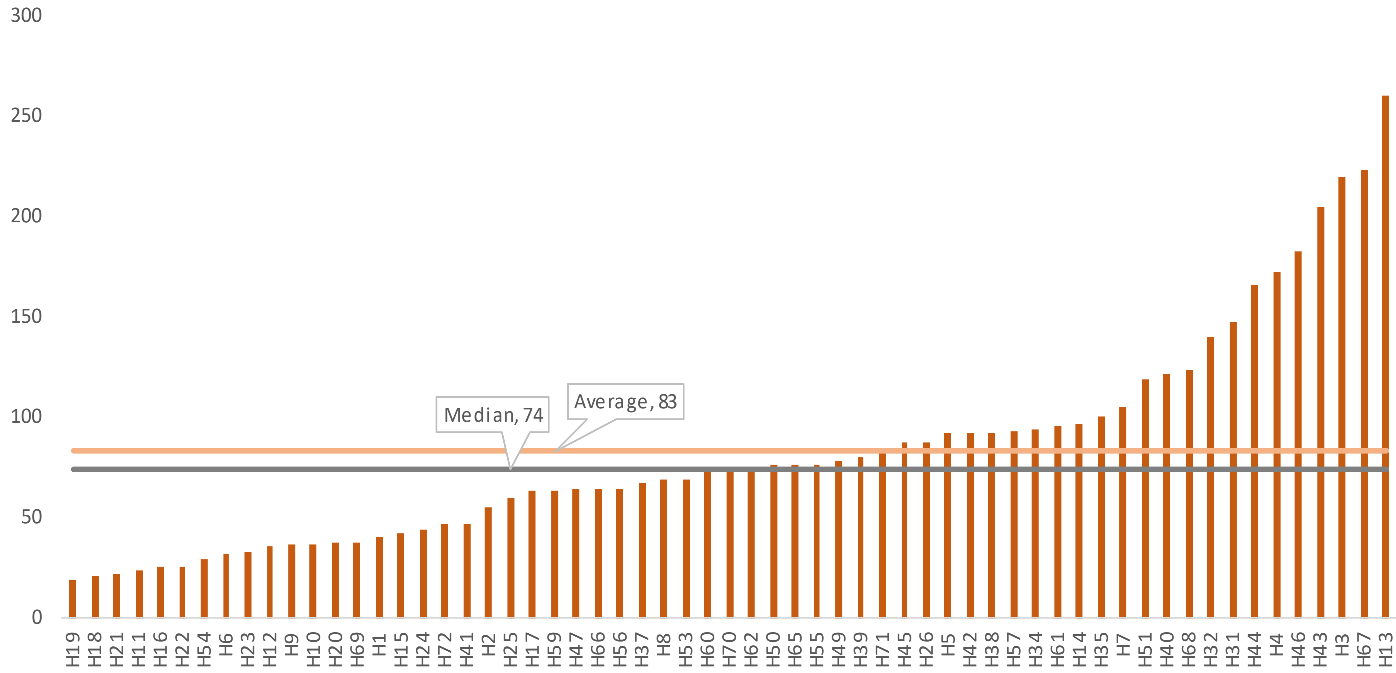


Figure 5 Energy Use Intensity-H3 (kWh/guest-night/year) for all participating Dubai hotel properties

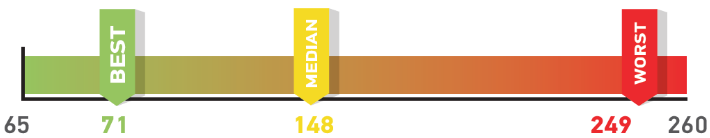
Hotels vs Resorts

The difference in consumption patterns between resorts and hotels and hotel apartments is much more pronounced when using EUI-H3. For the participating hotel properties, the 2017 EUI-H3 findings reveal:

- A median hotel or hotel apartment in Dubai consumes 69 kWh/guest-night/year.

EUI-H3 of Hotel and Hotel Apartments
kWh/guest-night/year

- A median resort in Dubai consumes 148 kWh/guest-night/year.



EUI-H3 of Resorts
kWh/guest-night/year

The difference between hotels and hotel apartments/serviced apartments was negligible and therefore were grouped together. The results therefore show that, on average, participating resorts consume twice as much energy per guest night compared to hotels and hotel apartments.

EUI-H4

The final KPI used to evaluate the energy performance of hotels is the total energy consumption of the hotel per gross conditioned floor area per annual guest-night (EUI-H4 in Table 1). This EUI was used in the 2016 Benchmarking Report for UAE Hotels [13] and was chosen as the metric for the energy classification considering both spatial and operational efficiencies.

EUI-H4 results, shown in Figure 6, reveal that:

- The values ranged from 0.62 to 6.97 Wh/m^2/guest-night/year.
- The median was 1.81 Wh/m^2/guest-night/year.
- The average was 2.32 Wh/m^2/guest-night/year.

Like EUI-H1 and EUI-H3, the best performers of EUI-H4 were not the best performers in the other metrics. Interestingly, the best performers of EUI-H4 were a mixture of hotel star ratings.

THE DIFFERENCE BETWEEN HOTELS AND HOTEL APARTMENTS/SERVICED APARTMENTS WAS NEGLIGIBLE AND THEREFORE WERE GROUPED TOGETHER

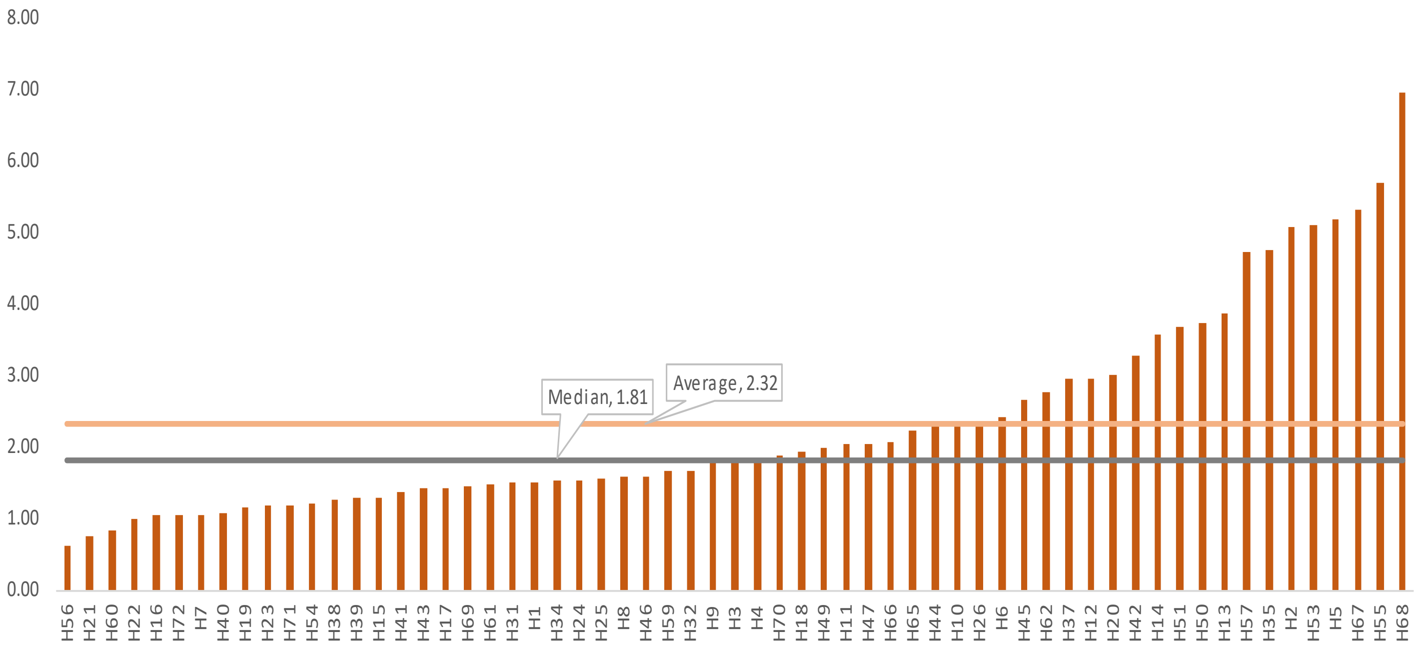


Figure 6 Energy Use Intensity-H4 (Wh/m²/guest-night/year) for all participating Dubai hotel properties

Water Performance Results

The following sections evaluate the water performance of the hotel properties based on the KPIs established in Table 1.

WUI H1

The Water Use Intensity-H1 (WUI-H1 in Table 1 is the total water use of the hotel per gross conditioned floor area.

Figure 7 shows that for 2017 WUI-H1:

- Participating hotel properties in Dubai consumed between 850 to 5,474 litres/m²/year.
- A median hotel property in Dubai consumes 1,487 litres/m²/year.
- The average WUI-H1 of the participating hotel properties was 1,704 litres/m²/year.
- Best performing hotel properties consumed less than 928 litres/m²/year. Worst performers consumed more than 3,104 litres/m²/year.

The wide range of values show that the water performance of the hotel properties varies greatly and is also supported as the median and average values do not lie close to each other.

One of the reasons for this is because water consumption in hotel properties varies greatly and is dependent on the operations and services that the property provides. For instance, one of the properties, H13, as seen in Figure 7, has a very high WUI-H1 value compared to the rest of the data set. Upon further clarification, it was discovered that this was due to the large irrigated landscape area, and the presence of multiple swimming pools and F&B outlets. But these operational characteristics were not requested from all the hotel properties and this case was only examined as this property was an outlier.

Impact of Hotel Age and Star Rating

The results indicate that there is a moderate negative correlation (-0.43) and a weak positive correlation (0.31) between the age of the building and star rating, respectively, with WUI-H1.

These correlations agree with the correlations from the 2016 Benchmarking Report [13], as older properties suffer from aging infrastructure, whereas newer properties benefit from newer technologies, efficient design and more stringent regulations. The correlation with star rating is also expected as higher star rated properties generally offer more services.

Hotels vs Resorts

The difference in the 2017 WUI-H1 values between participating hotel and hotel apartments with resorts is quite substantial as:

- For Hotels and Hotel Apartments:
  - The median was 1,486 litres/m²/year

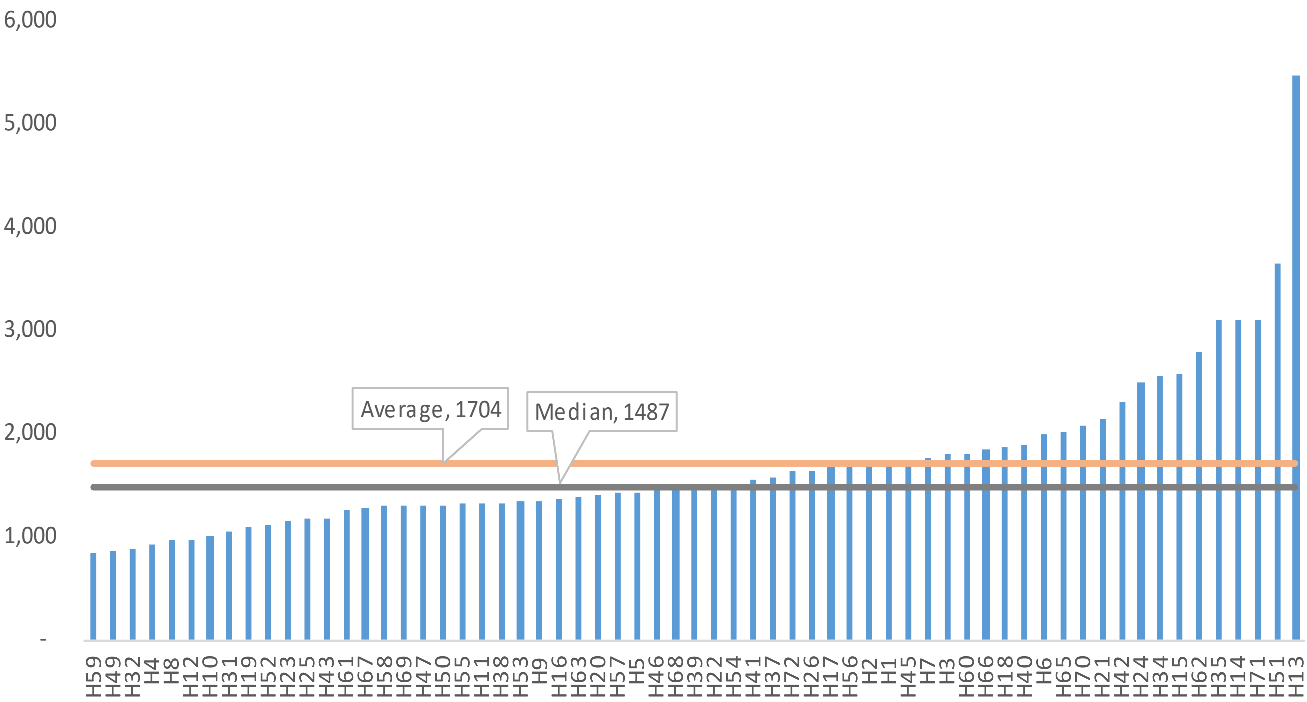
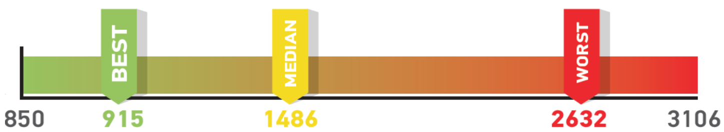


Figure 7 Water Use Intensity-H1 (litres/m²/year) for all participating Dubai hotel properties

- The average was 1,606 litres/m²/year

WUI-H1 of Hotels and Hotel Apartemtns
litres/m²/year

- For resorts:
  - The median was 1,676 litres/m²/year
  - The average was 2,490 litres/m²/year



WUI-H1 of Resorts
litres/m²/year

These results show that resorts have much higher mean and median values compared to hotels and hotel apartments. They also have a much higher spread of values showing that within the same segment, the worst performing resorts consume as much as 4.5 times the amount of water per square meter than the best performers. In contrast, the difference between the worst and best performers for the other segment (hotels and hotel apartments) is 2.9. A possible explanation for this is that resorts have large irrigated landscape areas and generally have higher number of pools and F&B outlets than the other hotel typologies.

WUI-H2

The second KPI used is the total water use of the hotel per guest-night. Figure 8 shows that for 2017 WUI-H2:

- Participating hotel properties in Dubai consumed between 144 and 1,159 litres/guest-night/year.
- A median hotel property in Dubai consumes 439 litres/guest-night/year.
- The average of the participating hotel properties was 468 litres/guest-night/year.
- Best performing hotel properties consumed less than 155 litres/guest night/year. Worst performers consumed more than 927 litres/guest-night/year.

It is important to note that one of the properties (H13) was excluded from the WUI-H2 analysis as it had a value which was three times greater than the maximum value reported above.

As seen previously in the evaluation of EUI-H1 and

A MEDIAN HOTEL OR HOTEL APARTMENT IN DUBAI CONSUMES 1,486 litres/m²/year. A MEDIAN RESORT IN DUBAI CONSUMES 1,676 litres/m²/year.

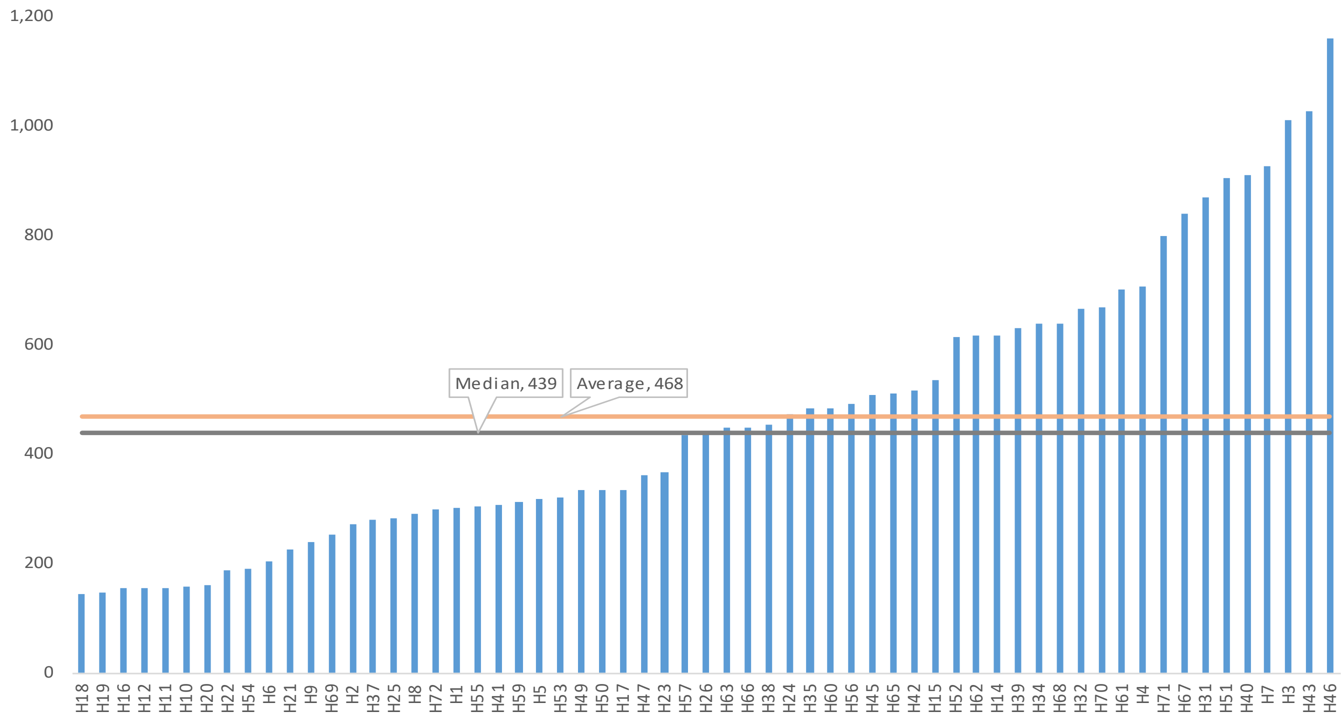


Figure 8 Water Use Intensity-H2 (litres/guest-night/year) for all participating Dubai hotel properties

EUI-H3, the best performers of WUI-H1 are not the best performers of WUI-H2. Similar to EUI-H3, the best performers of WUI-H2 of the hotels are all three-star rated but, given the limitations mentioned previously, it is difficult to evaluate whether these properties are truly water efficient or whether they simply do not have the same water intensive amenities as the other properties. This is emphasized even more as there is a large ratio of 6 between the best performers and the worst performers, highlighting that the worst performers consume six times more water per guest-night than best performers. It is worthwhile to mention that, like EUI-H3, this KPI does not evaluate the impact of existing F&B outlets, laundry services, pools and other water consuming services and their usage by non-guests and as a result leads to the wide variations seen above.

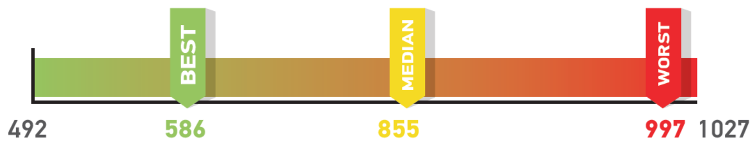
Hotels vs Resorts

Segregation of the properties into different typologies and examining the 2017 WUI-H2 values shows that:

- For Hotels and Hotel Apartments:
  - The median was 363 litres/guest-night/year.
  - The average was 430 litres/guest-night/year.

WUI-H2 for Hotels and Hotel Apartments
litres/guest-night/year

- For resorts:
  - The median was 855 litres/guest-night/year.
  - The average was 822 litres/guest-night/year.



WUI-H2 for Resorts
litres/guest-night/year

As anticipated, resorts have higher median and average values and therefore consume more water per guest-night compared to hotels and hotel apartments.

THESE RESULTS SHOW THAT RESORTS HAVE MUCH HIGHER MEAN AND MEDIAN VALUES COMPARED TO HOTELS AND HOTEL APARTMENTS

Conclusions and Summary

Hotel Properties					
KPI	Range	Best Performers	Median	Average	Worst Performers
EUI-H1 *kWh/m²/year*	All:104 - 648 Hotels:104 - 648 Resorts:181 - 483	All: < 174 Hotels: < 171 Resorts: < 193	All: 252 Hotels: 249 Resorts: 334	All: 275 Hotels: 271 Resorts: 308	All: > 416 Hotels: > 414 Resorts: > 444
EUI-H2 *Primary-kWh/m²/year*	All: 334 - 1,728 Hotels: 334 - 1,728 Resorts: 540 - 1,451	All: < 523 Hotels: < 521 Resorts: < 560	All: 727 Hotels: 721 Resorts: 936	All: 809 Hotels: 799 Resorts: 883	All: > 1,235 Hotels: > 1,221 Resorts: > 1,319
EUI-H3 *kWh/guest-night/year*	All: 19 - 260 Hotels: 19 - 219 Resorts: 65 - 260	All: < 24 Hotels: < 23 Resorts: < 71	All: 74 Hotels: 69 Resorts: 148	All: 83 Hotels: 74 Resorts: 158	All: > 204 Hotels: > 168 Resorts: > 249
EUI-H4 *Wh/m²/guest-night/year*	All: 0.62 - 6.97 Hotels: 0.76 - 6.97 Resorts: 0.62 - 5.31	All: < 1.00 Hotels: < 1.03 Resorts: < 0.79	All: 1.81 Hotels: 1.82 Resorts: 1.51	All: 2.32 Hotels: 2.30 Resorts: 2.52	All: > 5.19 Hotels: > 5.14 Resorts: > 4.88
WUI-H1 *litres/m²/year*	All:850 - 5,474 Hotels:850 - 3,106 Resorts:1,054 - 5,474	All: < 928 Hotels: < 915 Resorts: < 1,093	All: 1,487 Hotels: 1,486 Resorts: 1,676	All: 1,704 Hotels: 1,606 Resorts: 2,490	All: > 3,104 Hotels: > 2,632 Resorts: > 4,927
WUI-H2 *litres/guest-night/year*	All: 144 - 1,159 Hotels: 144 - 1,159 Resorts: 492 - 1,027	All: < 155 Hotels: < 155 Resorts: < 568	All: 439 Hotels: 363 Resorts: 855	All: 468 Hotels: 430 Resorts: 822	All: > 927 Hotels: > 915 Resorts: > 997

Table 5 Summary of results for all participating Dubai hotel properties. Total number of properties included 55 hotels and hotel apartments and 7 resorts

Table 5 summarizes the range, median and average values from the BEA Benchmarking for the hotel properties, as well as the best and worst performance thresholds for each KPI. Examination of the summary results highlights the wide spread of EUI and WUI values of the hotel properties. It was evident from the results that the best performing hotels in EUI-H1 are not the best performing hotels in EUI-H3 and EUI-H4. The same argument also applies for WUI-H1 and WUI-H2. It was noted, however, that 3-star rated hotels were the best performers of both EUI-H3 and WUI-H2.

It was also noted that resorts and hotels have different consumption patterns with hotels and hotel apartments consuming 12% less energy and 36% less water, on average, per area than resorts. A median hotel property in Dubai, however, still has an 8% higher site EUI-H1 than median hotels in the United States [15].

The variations between energy and water performance of all properties demonstrates the unequal performance amongst the properties, with the ratios between the best and worst performers indicating a significant potential for energy and water savings. For instance, best hotel and hotel apartment performers consume 58% less energy and 65% less water per unit area than worst hotel and hotel apartment performers.

Best vs Worst Performers

Overall, best performers consume
58% less energy
per area than worst performer

Best hotel performers consume
65% less water
per area than worst performer

Best resorts performers consume
78% less water
per area than worst performer

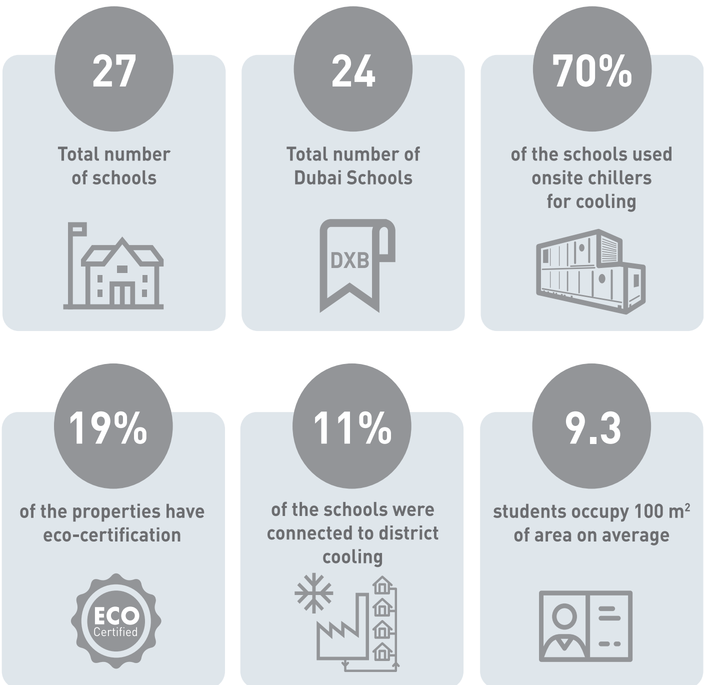
Schools

Overview of Participating Schools

The 27 participating school properties for the BEA Benchmarking project represent 0.49 km^2 of Gross Conditioned Floor Area (GCFA) with a total number of 30,793 students enrolled and 3,434 full time staff (as of 2017). All the participating schools were private schools, with 63% of the schools managed by an education provider. 70% of the participating schools used chillers for cooling, 19% used on-site air conditioning units (split, ducted or window units) and remainder connected to district cooling.

74% of the participating schools were K-12 schools, followed by pre-school and primary - 19% and 7%, respectively. 19% of these schools were eco-certified as LEED projects (which looks at building design and/or operation) or as FEE's Eco-Schools (which looks at eco-literacy).

A majority of 38% of the Dubai participating schools had a KHDA Rating of Good, with 17% rated as Very Good and 13% rates as Outstanding. The breakdown of the participating school KHDA



Ratings are presented in Figure 9, which shows that over a quarter of the properties did not have a KHDA Rating, as they were not yet inspected.

It was noted during the analysis that there was a large variation in the student density of the

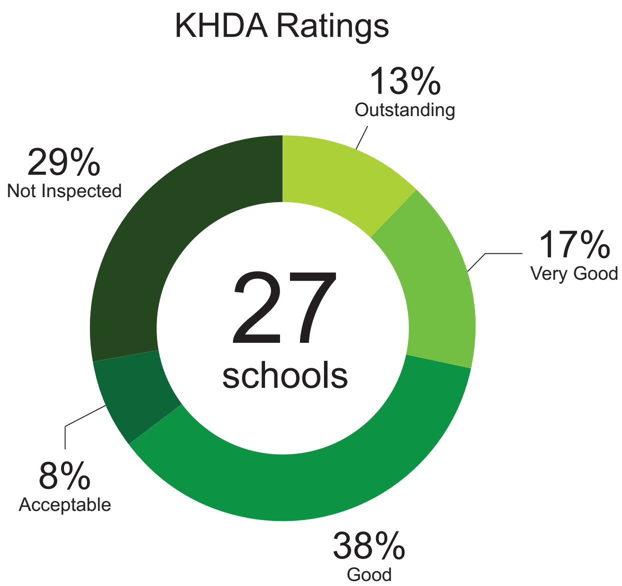


Figure 9 KHDA Ratings of the Dubai participating school properties

participating schools, which ranged from 1.6 to 39.1 student per 100 m^2 GCFA. This is presented graphically in Figure 10, which reveals the average student density per 100 m^2 of GCFA was 9.3. However, it should be mentioned that some of the school properties, such as S2, S14 and S21, were not at full capacity as they had only recently been opened.

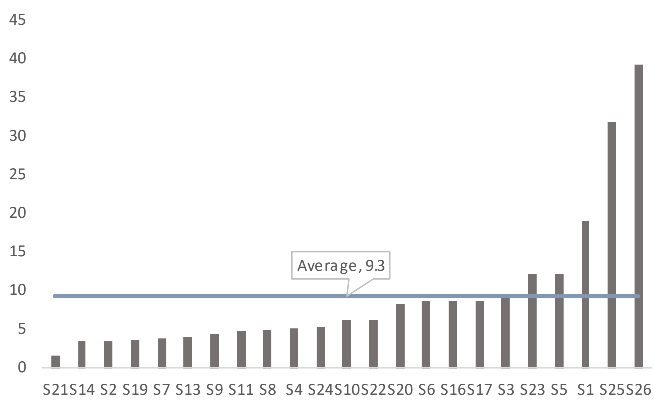


Figure 10 Student density per 100 m^2 of Gross Conditioned Floor Area

As one full year's worth of performance data is required for benchmarking, the data from 2018 was aggregated into the 2017 data for five of the school properties as they were only operational mid-2017. Thus, the consumption data for the missing months in 2017 was completed using the real performance data from the months in 2018.

After property exclusions, the final number of Dubai schools whose energy and water performance were evaluated was 18, which represents 10% of the private schools in Dubai [26].

Energy Performance Results

The following sections evaluate the energy performance of the school properties based on the KPIs established in Table 2.

EUI-S1

The Energy Use Intensity-S1 (EUI-S1 in Table 2) is the total site energy use of a school (including electricity and district cooling and excluding fuel consumed onsite) per gross conditioned floor area.

The results for the 2017 EUI-S1 shown in Figure 11 suggest:

- Participating school properties in Dubai consumed between 85 kWh/m^2/year and 290 kWh/m^2/year.
- A median participating school property in Dubai consumes 134 kWh/m^2/year.
- The average EUI-S1 of the participating properties is 149 kWh/m^2/year.

One of the properties was removed from the analysis as it was an outlier property with a value of 41 kWh/m^2/year.

While the energy data was verified, the GCFA required onsite verification and therefore the property was subsequently removed from the EUI-S1 analysis.

There was no discernible difference between the EUI-S1 values for the different types of schools and therefore was not reported. This, however, does not suggest that all types of schools perform equally as it could be likely that was an insufficient sample size of the other groups to detect any noticeable trends.

Impact of School Age and KHDA Ratings

EUI-S1 shows a weak positive correlation of 0.18 with the building age, which is anticipated given that there are several studies which have concluded that newly built schools consume more electricity than older schools as they have a higher reliance on digital methods of teaching [27], [28], [29], [30], [31]. However, it could also be possible that the older schools do not have the energy intensive ventilation systems that new code compliant schools do.

Given that some of the properties had not been inspected, they were excluded from the KHDA correlation calculation in order to make the results valid. Doing so showed that EUI-S1 had a weak negative correlation of -0.22 with the KHDA rating.

A MEDIAN PARTICIPATING SCHOOL PROPERTY IN DUBAI CONSUMES 134 kWh/m^2/year

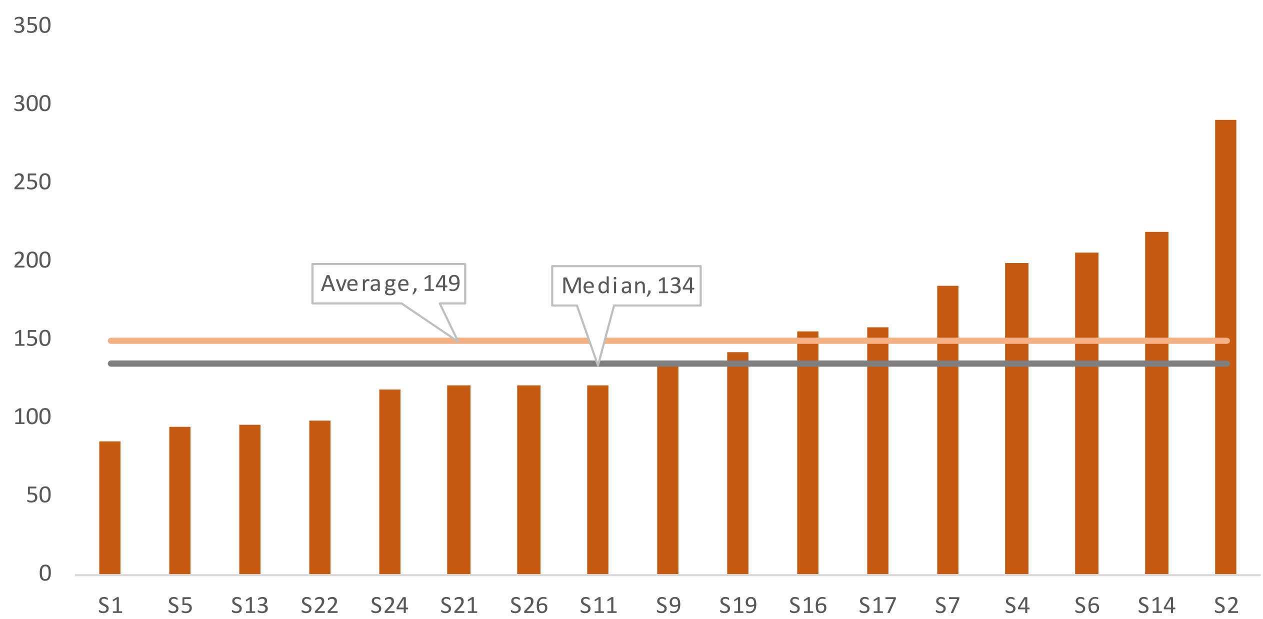


Figure 11 Energy Use Intensity-S1 (kWh/m^2/year) for Dubai school properties

Given that the KHDA ratings are based on the schools' quality of teaching and their ability to enhance students' overall achievements and wellbeing [32], [33] and the fact that it is unknown whether higher rated schools offer fewer or extra amenities and facilities, it is not possible to conclude the cause for the negative correlation.

Best vs Worst Consumers

Calculation of the 5th and 95th percentile values revealed:

- Best performers consumed less than 92 kWh/m²/year.
- Worst performers consumed more than 233 kWh/m²/year.

EUI-S1 of Schools
kWh/m²/year

This, along with the graphical presentation of the EUI-S2 values illustrated in Figure 11, shows that there is a performance disparity between the best performers and the worst performers, whereby the worst performers consume two and half times more energy per area than the best performers.

EUI-S2

The Energy Use Intensity-S2 (EUI-S2 in Table 2) is the total site energy use of the school per student. However, it should be noted that this performance metric is noticeably affected by the school's current student capacity as will be discussed below.

The results for the 2017 EUI-S2 shown in Figure 12 indicate:

- Participating school properties in Dubai consumed between 307 kWh/student/year and 8,422 kWh/student/year.

Examination of Figure 12 reveals that the first four properties, S26, S1, S3 and S5, and the last three properties, S14, S21 and S2, are outliers when compared to the rest of the dataset. These properties were not excluded from Figure 12 as the first four properties have the highest student densities amongst all the participating school properties (39, 19, 9 & 12 students per 100 m², respectively), whereas the last three properties had the lowest student densities (3, 2 & 3 students per 100 m², respectively.

The energy and student data of these properties were confirmed multiple times throughout the analysis. However, during verifications it was found that the first four properties were at maximum student capacity whereas the last three properties were at only half or lower capacity.

Thus, in order to establish valid and comparable statistical values, these outlier properties were excluded from other analysis. After exclusion of these properties, it can be seen that:

- A median participating school property in Dubai consumes 2,423 kWh/student/year.
- The average EUI of the participating properties is 2,765 kWh/student/year.

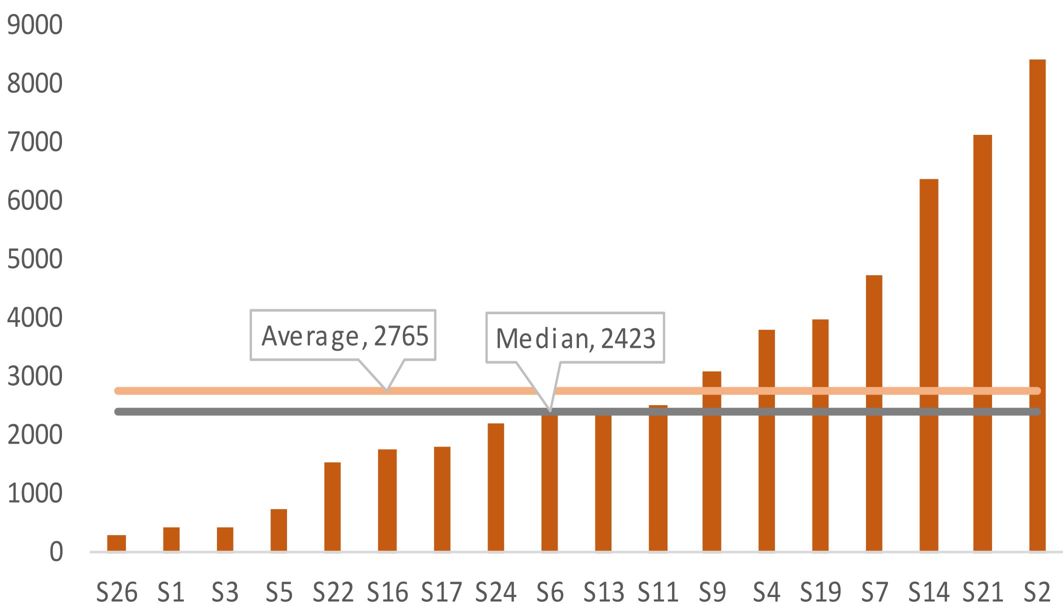


Figure 12 Energy Use Intensity-S2 (kWh/student/year) for Dubai school properties.
Note: Average and Median values exclude the outliers (the first four and last three) properties.

Impact of School Age and KHDA Ratings

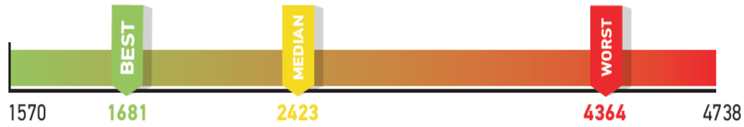
EUI-S2 has a moderate positive correlation of 0.52 with the school age, which supports the findings from the verifications, given that newer schools are less likely to be at high or full student capacity. The strength of the correlation is further amplified given that newer schools generally have a higher electricity consumption [27], [28], [29], [30], [31].

Similar to EUI-S1, the properties which were not inspected by KHDA were removed from the KHDA ratings correlation calculation. As a result, EUI-S2 was also found to have a moderate negative correlation of -0.44 with the KHDA ratings. Given that EUI-S2 is influenced by the number of students enrolled, a probable explanation of the correlation could be due to the fact that higher rated schools attract a greater number of students as compared to lower rated schools. This is supported by examination of the recent trends and overview of KHDA inspections' report [33], where it was reported that a greater number of students attended higher rated schools in 2017 as compared to previous years.

Best vs Worst Consumers

Examination of the EUI-S2 values shows:

- Best performing school properties consumed less than 1,681 kWh/student/year.
- Worst performers consumed more than 4,364 kWh/student/year.



EUI-S2 of Schools
kWh/student/year

The percentiles were calculated with the exclusion of the outlier properties, where it can be seen that, among the participating school properties, the worst performers consume 2.6 times more energy per student than the best performers.

Water Performance Results

The following sections evaluate the water performance of the school properties based on the KPIs established in Table 2.

Given that the irrigated landscape area, the presence of swimming pools and other water-intensive facilities and activities were not requested from all the properties, caution must be exercised when evaluating and comparing the water performance and correlations of participating school properties amongst each other as well as international benchmarks.

WUI-S1

The Water Use Intensity-S1 (WUI-S1 in Table 2) is the total water use of the school per gross conditioned floor area.

The 2017 WUI-S1 values presented in Figure 13 show:

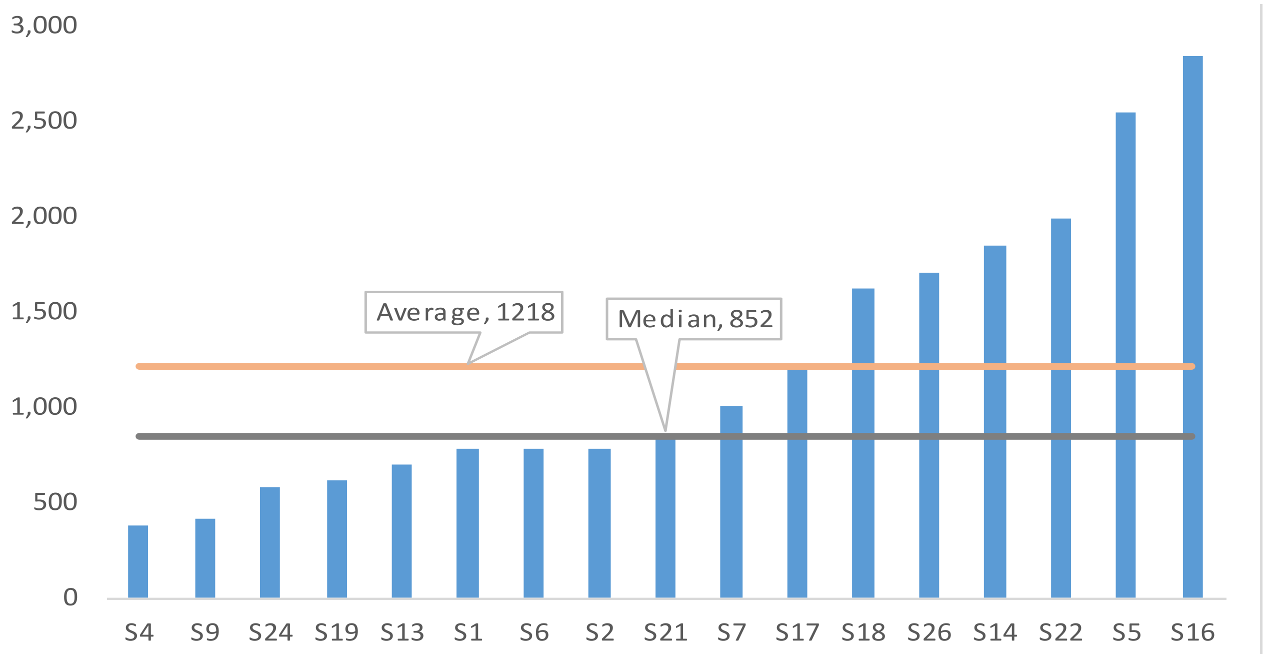


Figure 13 Water Use Intensity S1 (litres/m^2/year) for Dubai school properties.

- Participating school properties in Dubai consumed between 383 to 2,848 litres/m²/ year.

- A median school property in Dubai consumes 852 litres/m²/year.
- The average WUI-S1 of the participating school properties was 1,218 litres/m²/year.

Examination of the results presented in Figure 13 shows that there is a wide disparity between the water performance of the participating school properties, which is supported by the large difference between the median and average values.

One of the pre-school properties did not provide water data and was thus removed from analysis. Additionally, it was observed that two of three participating pre-school properties had a higher water performance as compared to the other school types - primary and K-12 schools. This observation was investigated directly with the participating properties, where the high-water consumption was clarified by the fact that the pre-school had water intensive activities for the children. However, given the limited number of participating pre-school properties, it is not possible to conclude that pre-schools in Dubai are more water intensive than primary or K-12 schools.

Impact of School Age and KHDA Ratings

WUI-S1 shows a weak positive correlation of 0.20 with the age of the school which suggests that newer schools are more water intensive than older schools. This could possibly be related to additional facilities provided by newer schools but given that operational characteristics such as the irrigated area, the type of facilities and the presence of showers and swimming pools were not requested from all the properties, there is no definitive explanation for the correlation.

The KHDA ratings had a very weak positive correlation of 0.03, after exclusion of uninspected properties, with the WUI-S1 values.

Best vs Worst Consumers

Comparison of the participating best and worst performers shows:

- Best performing school properties consumed less than 413 litres/m²/year.
- Worst performers consumed more than 2,608 litres/m²/year.

WUI-S1 of Schools
litres/student/day

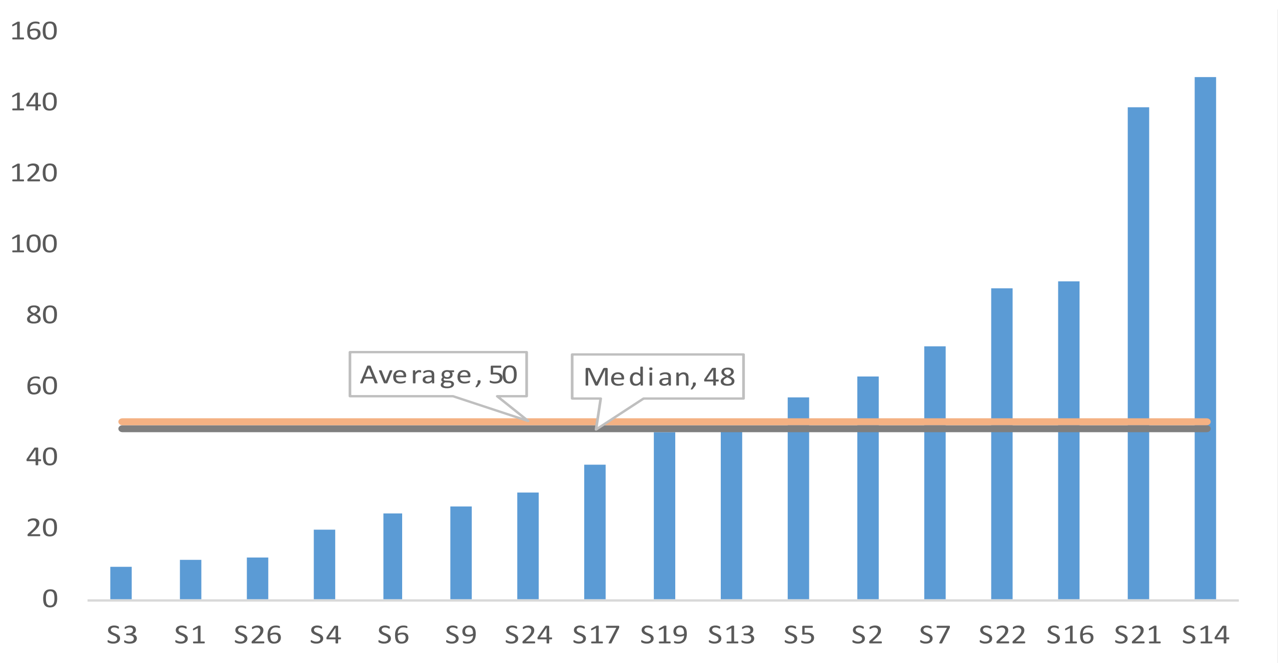


Figure 14 Water Use Intensity-S2 (litres/student/day) for Dubai school properties.
Note: Average and Median values exclude the outliers (the first three and last two) properties.

Based on the results, it can be ascertained that worst performers consume 6.3 times more water per area than the best performers.

WUI-S2

The Water Use Intensity-S2 (WUI-S2 in Table 2) is the total annual water use of the school per student per day. Per day figures were calculated by dividing the annual water use per student by 365.

Similar to EUI-S2, the WUI-S2 values are greatly influenced by the number of students in the school, with the result that schools with a higher number of students or higher capacities relative to the maximum capacities or otherwise, are expected to perform better under this metric.

The results of the 2017 WUI-S2 values show:

- Participating school properties in Dubai consumed between 9 litres/student/day and 147 litres/student/day.

The outliers shown in Figure 14 (S3, S1, S26, S21 & S14) were excluded from the calculation of the median and average for WUI-S2. This was done to establish valid benchmarks for the reasons explained earlier for EUI-S2. After exclusions, the results reveal:

- A median participating school property in Dubai consumes 48 litres/student/day.
- The average EUI of the participating properties is 50 litres/student/day.

Impact of School Age and KHDA Ratings

WUI-S2 has a strong positive correlation of 0.69 with the age of the buildings. Analogous to the explanation provided for age correlation with EUI-S2, this is most probably due to the fact that newer schools are unlikely to have higher capacities than older schools.

Conversely, WUI-S2 has a weak negative correlation of -0.28 with the KHDA rating.

Best vs Worst Consumers

Examination of the WUI-S2 values, after exclusion of outliers, shows:

- Best performing school properties consumed less than 23 litres/student/day.
- Worst performers consumed more than 89 litres/student/day.

WUI-S2 of Schools
litres/student/day

By excluding the outlier properties, it can be seen that among the participating school properties, the worst performers consume 3.9 times more water per student per day than the best performers.

GIVEN THE LIMITED NUMBER OF PARTICIPATING PRE-SCHOOL PROPERTIES, IT IS NOT POSSIBLE TO CONCLUDE THAT PRE-SCHOOLS IN DUBAI ARE MORE WATER INTENSIVE THAN PRIMARY OR K-12 SCHOOLS

Conclusions and Summary

School Properties					
KPI	Range	Best Performers	Median	Average	Worst Performers
EUI-S1 *kWh/m^2/year*	85 - 290	< 92	134	149	> 233
EUI-S2 *kWh/student/year*	307 - 8,422	Excl. outliers: < 1,681	Excl. outliers: 2,423	Excl. outliers: 2,765	Excl. outliers: > 4,364
WUI-S3 *litres/ m^2/year*	383 - 2,848	< 413	852	1,218	> 2,608
WUI-S4 *litres/student/day*	9 - 147	Excl. outliers: < 23	Excl. outliers: 48	Excl. outliers: 50	Excl. outliers: > 89

Table 6 Summary of results for all participating Dubai school properties. The ranges shown are for all properties; for EUI-S2 and WUI-S2 the median, average, best and worst performers exclude outliers.

The range, median and average values as well as the best performing and worWst performing threshold values for participating school properties are summarized in Table 6.

Amongst all the participating properties, obtaining the data from schools was the most challenging as not all schools had onsite facility management or did not have additional human resources to specifically assign the task of gathering the required data and completing the questionnaire.

It is evident from the ranges shown in Table 6 that there is an unequal performance amongst the participating schools with the worst performers consuming two to three times as much, depending on the performance metric, as the best performers. This performance gap was the largest for the water usage per area. This highlights the urgent need for schools to make efficiency one of the main areas of focus.

It was also noted that most schools do not track their energy and water consumption but rather only record and track the costs. While this is useful from a financial budget perspective, it does not allow evaluation of the school's operational energy and water efficiency. Therefore, it is recommended that schools should make it a common practice to record and track their consumption data to allow them to at least benchmark against themselves and their peers in the market.

The results from this study support global studies as there is a weak positive correlation with the age of the participating schools and the EUI-S1 and WUI-S1 values, indicating that that newly built schools consume more energy and water per area. Additionally, higher rated KHDA schools consumed less energy per area and per student as compared to lower rated schools.

The student density of the participating schools varied significantly as some of the schools were recently opened. This had a significant impact on the operational performance metrics such as EUI-S2 and WUI-S2, where the schools with the lowest student densities had the worst performance. Furthermore, schools with large capacities performed better under these metrics.

Finally, no noticeable difference in the performance metrics was observed between the different types of schools, with the exception of pre-schools for WUI-S1. However, a higher sample is needed to conclude whether the different types of schools have similar performance.

Best vs Worst Performers

The best performers consume
61% less energy
per area than worst performers

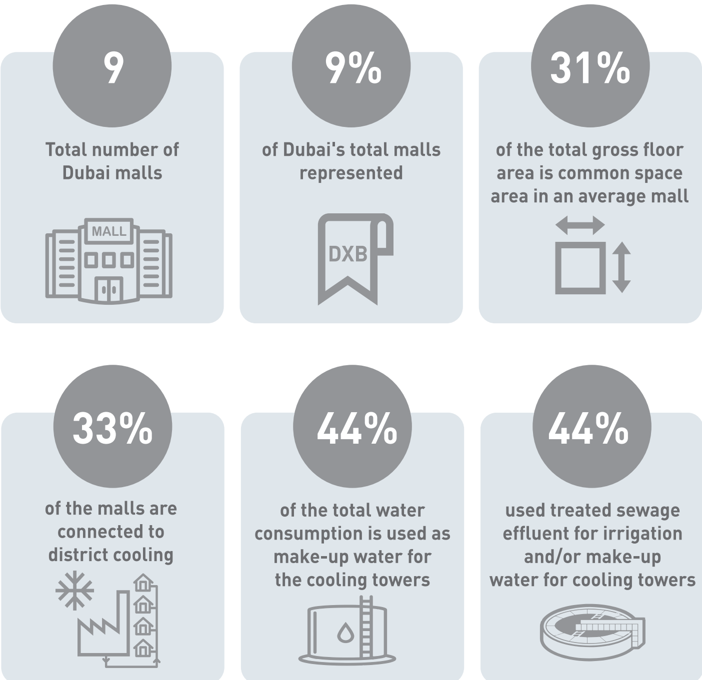
The best performers consume
84% less water
per area than worst performers

Malls

Overview of Participating Malls

The nine participating mall properties for the BEA Benchmarking project represent 1.39 km^2 of Gross Conditioned Floor Area with a 31% average share of common space area, shown in Figure 15. The analysis done as part of this benchmarking project represent 9% of the 96 total mall and shopping centre properties across Dubai [34]. The participating properties had a total footfall of 155 million in 2017, with an average footfall density of 131 footfall/m^2. 33% of the malls were connected to district cooling, with the remainder of the malls having either water-cooled or air-cooled chillers or a combination of both. One only mall property had solar energy generated onsite.

Nearly half of the properties used treated sewage effluent (TSE) but its use varied amongst the properties whereby some malls used it for the make-up water contribution and some malls used it exclusively for irrigation.



According to the International Council of Shopping Centres' (ICSC) classifications [35], two malls were classified as Mega-Malls, four malls were classified as super-regional malls and the remaining malls were classified as sub-regional/ community malls. All the malls examined here in this study were enclosed malls.

Not all properties were able to provide the LPG usage data as they either had no access to the

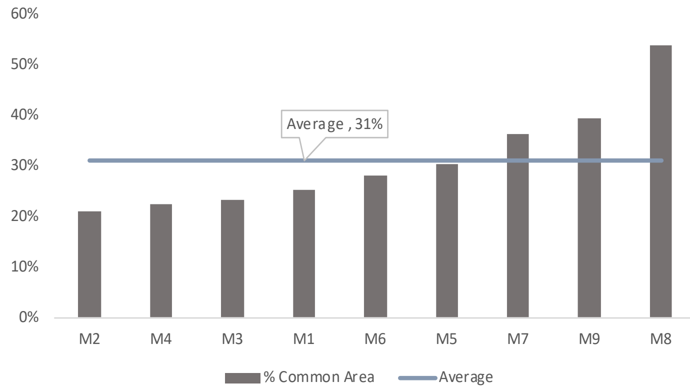


Figure 15 Percentage of common spaces of participating Dubai malls properties

data or the data was difficult to obtain. Therefore, LPG consumption was excluded from the energy analysis for the malls.

As some of the mall properties had undergone expansions in the recent years, it was a considerable challenge to evaluate the baseline year for those given malls. As a result, only the most recent year of data, 2017, was used as a baseline year and is reported in the proceeding sections, with the exception of WUI M1, where 2016 values were also reported.

Additionally, some of the mall properties were unable to provide all the requested data in some cases due to lack of sub-metering or access to the tenants' consumption data or difficulties in obtaining the data. In these cases, the mall properties were excluded from the corresponding KPI analysis.

It should be noted that malls are extremely complex buildings and each individual property needs to be examined based on its own merits. The operational characteristics in terms of equipment, type of tenants and the facilities and services provided are unique to each property and thus peer-to-peer comparisons should be made with caution. As a result, classification of the properties as best or poor performing was not done. Instead, a number of KPIs were used to evaluate multiple aspects of performance.

Additionally, correlation factors were not calculated as the number of mall properties examined was small and thus studying the impacts of different factors on the performance metrics would be invalid.

Energy Performance Results

The following sections evaluate the energy performance of the mall properties based on the KPIs established in Table 3.

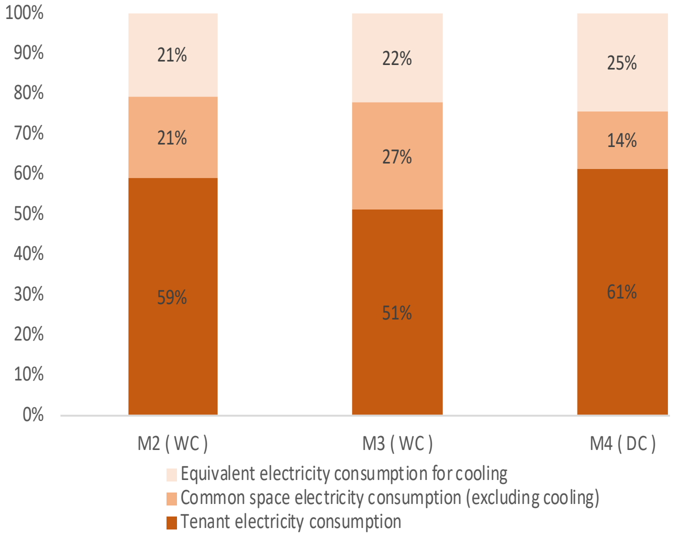


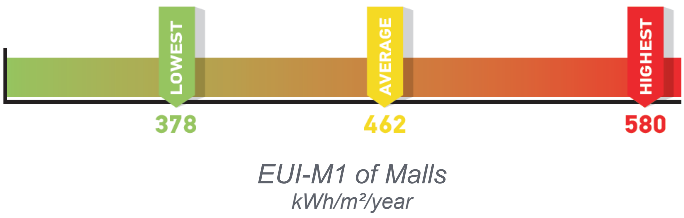
Figure 16 kWh equivalent energy use percentage share of three participating Dubai malls. WC - Water chillers; DC - District Cooling.

Figure 16 represents the energy profile for three of the participating malls which shows that, on average, over half the energy was consumed by the mall tenants with the remaining energy consumption split between the cooling and common areas. The cooling is either electricity consumption of onsite chiller plants or equivalent electricity consumption of District Cooling.

EUI-M1

The Energy Use Intensity-M1 (EUI-M1 in Table 3) is the net site energy use of the mall (including both landlord and tenant electricity and district cooling) per gross conditioned floor area of the mall. The results for 2017 EUI-M1 show that:

- Participating mall properties in Dubai consumed between 378 kWh/m²/year and 580 kWh/m²/year.
- A median participating mall property in Dubai consumes 465 kWh/m²/year.
- The average of the participating properties is 462 kWh/m²/year.



The 2017 EUI-M1 results for the Dubai mall properties are presented in Figure 16. It should be noted that Net Energy Use was used to evaluate the performance as one of the properties used onsite renewable energy generation, which was subtracted from the total electricity usage.

Furthermore, the number of properties evaluated for EUI-M1 is lower than the total number of participating mall properties as some of the malls were unable to provide the total energy consumption data as mentioned earlier. Subsequently, these properties were removed from any of the KPI analysis which required the total energy consumption to be known.

Figure 16 also highlights that the highest consuming mall, M1, uses 53% more energy per area than the lowest consuming mall, M7. This could be due to the different services, types of tenants and/or how efficient the building was designed and operated.

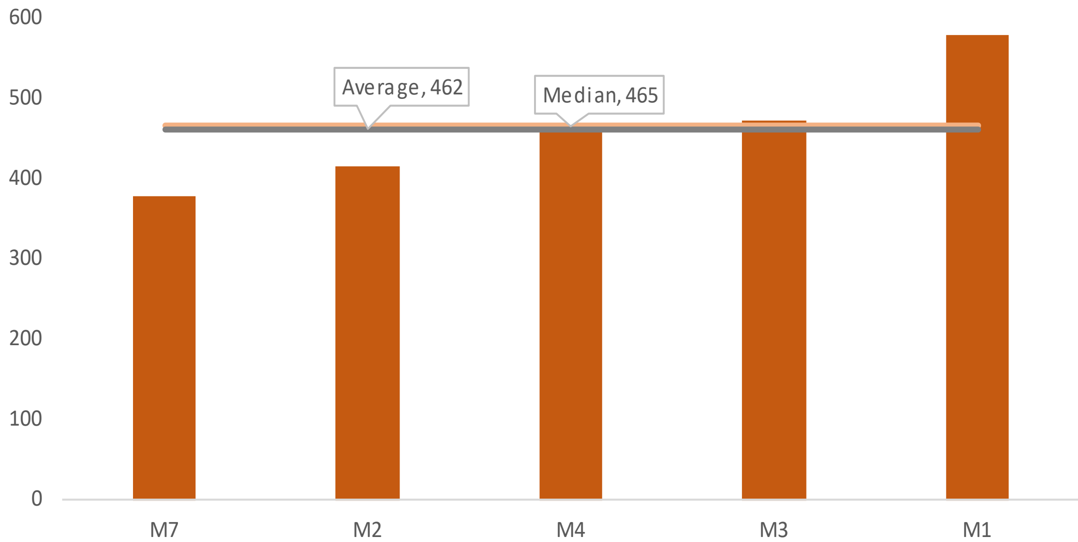


Figure 17 Net Energy Use Intensity-M1 (kWh/m²/year) for participating Dubai mall properties

EUI-M2

EUI-M2 is used to evaluate the net site energy use of the mall (including both landlord and tenant electricity and district cooling) per annual footfall. This metric is mall specific as footfall is commonly used in shopping malls to measure the number of people entering the mall. Net Energy is used again to factor the renewable energy generation of the properties.

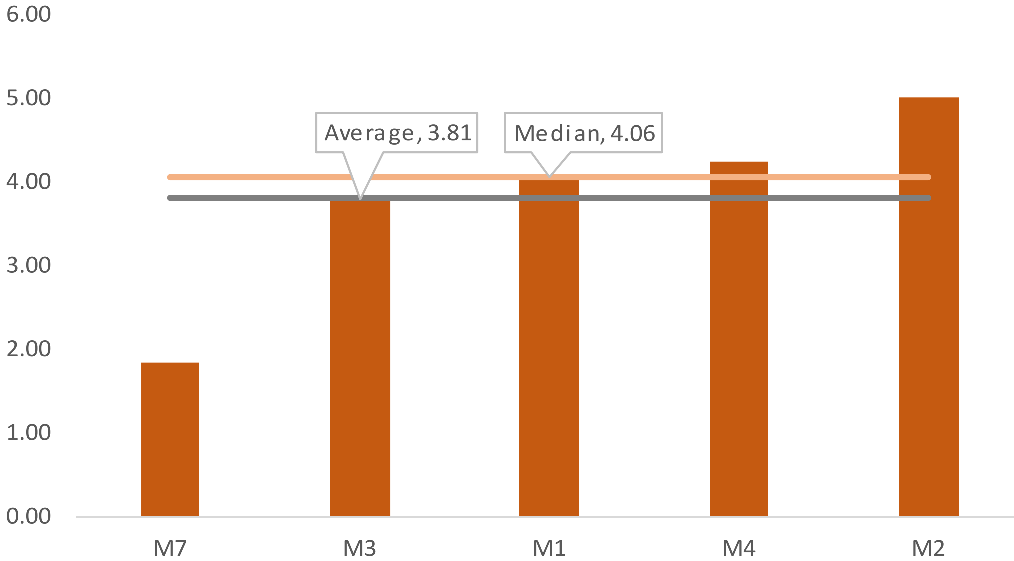


Figure 18 Net Energy Use Intensity EUI-M2 (kWh/footfall/year) for participating Dubai mall properties

The results for 2017 EUI-M2 show:

- Participating mall properties in Dubai consumed between 1.84 kWh/footfall/year and 5.03 kWh/footfall/year.
- A median participating mall property in Dubai consumes 4.06 kWh/footfall/year.
- The average of the participating properties is 3.81 kWh/footfall/year.

EUI-M2 of Malls
kWh/footfall/year

The 2017 EUI-M2 results, illustrated in Figure 18, shows a wide range of the results as it is influenced by the footfall, which, in turn, is dependent on the type, use, size, location and services of the mall. For instance, M7 has an EUI-M2 of 1.84 which is lower than the other examined properties as it has a very high footfall per area as compared to the other properties. Furthermore, this property has a high density of small retail tenants and does not provide many of the services that are commonly associated with shopping malls. When M7 is removed from the analysis, the average 2017 EUI-M2 value changes to 4.30 kWh/footfall/year.

Other than the exception of M7, the mall properties with the lowest EUI-M1 values do not correspond to the same properties for EUI-M2. The reason for this is difficult to establish due to the limited sample size and the large number of unaccounted variables in terms of properties' operational characteristics.

Given that M7 is an outlier property, comparison with the highest consuming property, M2, was done with the second lowest consuming property, M3. The difference shows that M2 consumes 31% more energy per footfall than M3.

EUI-M3

The third KPI (EUI-M3 in Table 3) used to evaluate the energy performance of malls is the Landlord Energy Use, which is the common space electricity and cooling per common space area.

A MEDIAN PARTICIPATING MALL PROPERTY IN DUBAI CONSUMES 4.06 kWh/footfall/year

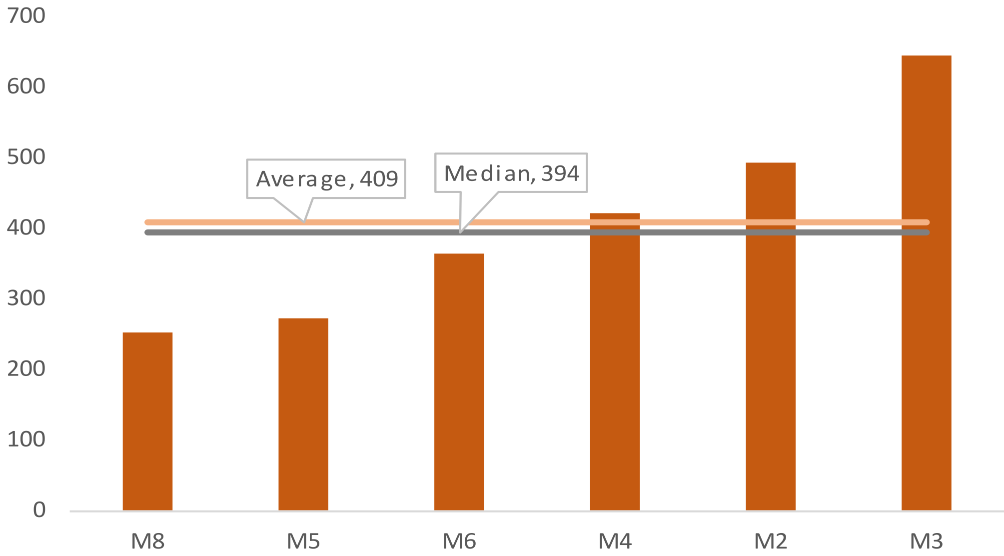
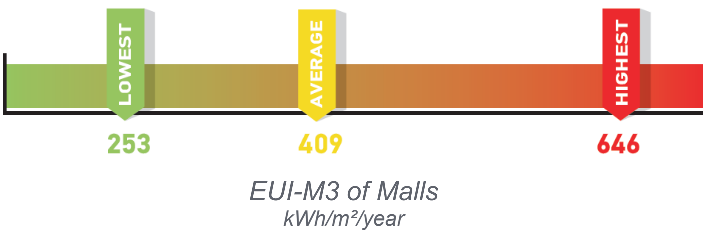


Figure 19 Landlord Energy Use-M3 (kWh/m²/year) for participating Dubai mall properties

The total cooling load was divided by the gross conditioned floor area (Refer to EUI-M3 Equation in Table 3), to provide a reasonable approximation of the cooling intensity as, in most cases, the cooling consumed by common spaces was not separately metered and/or the tenants did not have separate cooling meters, making it impossible to isolate the cooling consumption data for just the common space areas.

The results for 2017 EUI-M3 show that:

- The landlord energy use of the participating mall properties in Dubai varied between 253 kWh/m²/year and 646 kWh/m²/year.
- A median participating mall property in Dubai consumes 394 kWh/m²/year to cool and operate common spaces.
- The average of the participating properties is 409 kWh/m²/year.



The results are presented in Figure 19, where it is apparent that some of the properties which were not evaluated in EUI-M1 and EUI-M2 are analysed in EUI-M3 and vice versa. This is simply due to the data availability of the properties.

Evaluation of the properties under EUI-M3 reveals that the highest consuming mall uses 2.5 times more energy than the lowest consuming mall.

EUI-M4

The final metric (EUI-M4 in Table 3) used to evaluate the energy performance of the participating malls is the Common Services Energy Use, which includes the common space electricity and the total mall cooling load (chiller or district cooling) per common space area.

For several malls, most of the tenants are billed directly by the utility providers for their electricity consumption. For the cooling consumption, the properties do not have exclusive meters for each individual tenant and the common space area. The tenants are usually billed for the cooling consumption per square metre of their leasable area or based on a fixed value agreed upon in the leasing contract. Therefore, in most cases, the total common space electricity and the total chiller electricity consumption data is often combined, making EUI-M4 easy to calculate as the tenants' cooling consumption does not need to be known.

A MEDIAN PARTICIPATING MALL PROPERTY IN DUBAI CONSUMES 394 kWh/m²/year TO COOL AND OPERATE COMMON SPACES

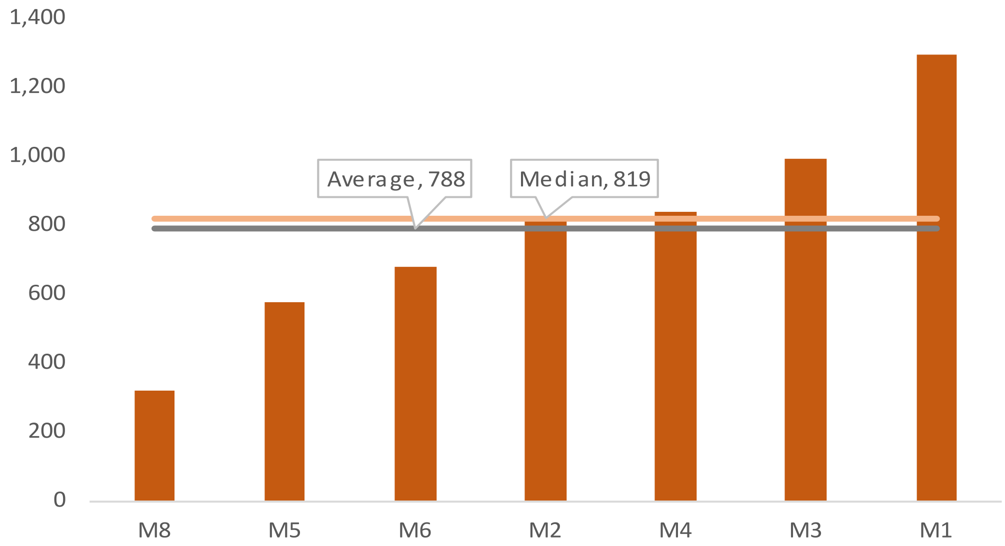


Figure 20 Common Services Energy Use-M4 (kWh/m²/year) for participating Dubai mall properties

The ease of calculation is reflected in the high number of properties evaluated under EUI-M4, which is the most when compared to the other KPIs.

The results for 2017 EUI-M4, presented in Figure 20, reveal that:

- The Common Services Energy Use of the participating mall properties in Dubai varied between 318 kWh/m²/year and 1,296 kWh/m²/year.
- A median participating mall property in Dubai consumes 819 kWh/m²/year for common building services.
- The average of the participating properties is 788 kWh/m²/year.

Closer examination of Figure 19 and Figure 20 shows that the properties with the lowest values of EUI-M3 also have the lowest values for EUI-M4. This is expected, given that both metrics evaluate the efficiency of the common spaces and services.

The wider range of values observed are attributable to the two outlier properties, M8 and M1, observed in the dataset. M8 has a very low EUI-M4 value compared to the other properties and might be due to the large percentage share (54%) of the common area. M1, on the other hand, has a combination of air-cooled and water-cooled chillers which contributes significantly to the cooling load of the property.

Water Performance Results

The following sections evaluate the water performance of the mall properties based on the KPIs established in Table 3.

It should be noted that all the KPIs exclude any makeup water required for the water-cooled chillers as well the treated sewage effluent. This is done to allow a fair comparison to be made across the properties as not all of them have the same operations.

The exclusion of makeup water is justified when examining Figure 21, which shows that the makeup water can, on average, contribute to 44% of the total water consumption in malls with water cooled chillers.

Figure 21 also shows that for malls with water cooled chillers, tenants contribute the least to the overall water use, with an average of 21% consumption of the total. Common area water

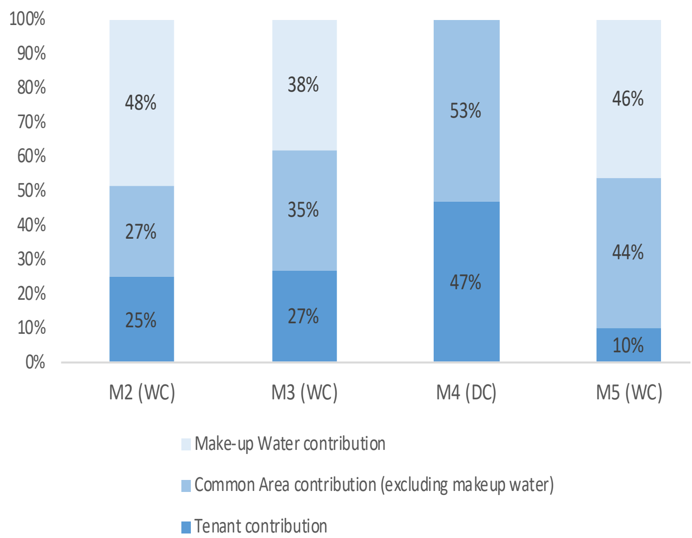


Figure 21 Water use percentage share of four participating Dubai malls. WC - Water chillers; DC - District Cooling.

usage, not limited to but including water use for irrigation and public washrooms, on average accounted for 35% of the total water consumption. It should be noted that the values presented are the average values and are limited to the malls connected to water cooled chillers.

changes within the WUI values over a broader context. Doing so shows that there is some slight water usage variation among the same properties, with the largest variation observed for M5, which showed an 18% increase between 2016 and 2017.

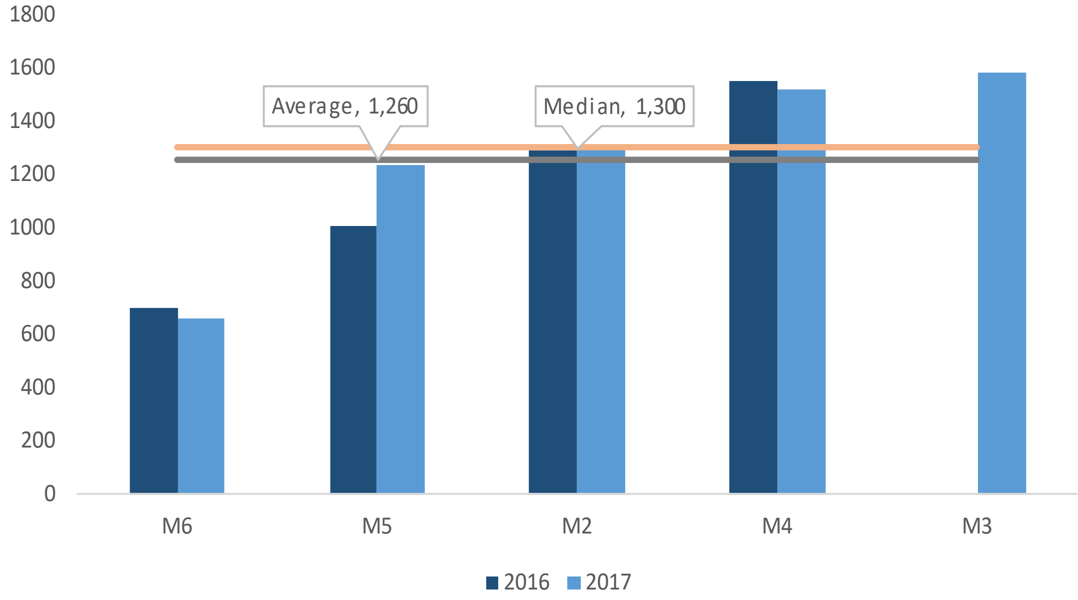


Figure 22 Water Use Intensity M1 (litres/m²/year) for participating Dubai mall properties

WUI-M1

The Water Use Intensity-M1 (WUI-M1 in Table 3) is the total water use (including tenants but excluding makeup water and treated sewage effluent) per gross conditioned floor area.

The results for the 2017 WUI-M1, presented in Figure 22, show:

- Participating mall properties in Dubai consumed between 658 litres/m²/year and 1,586 litres/m²/year.
- A median participating mall property in Dubai consumes 1,300 litres/m²/year.
- The average WUI of the participating properties is 1,260 litres/m²/year.

WUI-M1 of Malls
kWh/m²/year

The 2016 WUI-M1 values are also presented in Figure 22 to highlight the approximate ranges and

Year-on-year variation of footfall compared with the year-on-year variation in WUI-M1 showed that footfall variation was not the direct reason for WUI-M1 differences observed for all properties, which indicates that the water usage of the mall properties is complex as well.

Even though in both 2016 and 2017, M6 has a much lower WUI-M1 value when compared to the rest of the properties, it is still not possible to conclude whether this property is water efficient, given that other operational characteristics such as the irrigated landscape area, fixtures and flow rates, type and size of tenants, and water-related services of the properties are unknown.

WUI-M2

The Water Use Intensity-M2 (WUI-M2 in Table 3) is the total water use (including tenants but excluding makeup water and treated sewage effluent) per footfall.

A MEDIAN PARTICIPATING MALL PROPERTY IN DUBAI CONSUMES 1,300 liters/m²/year

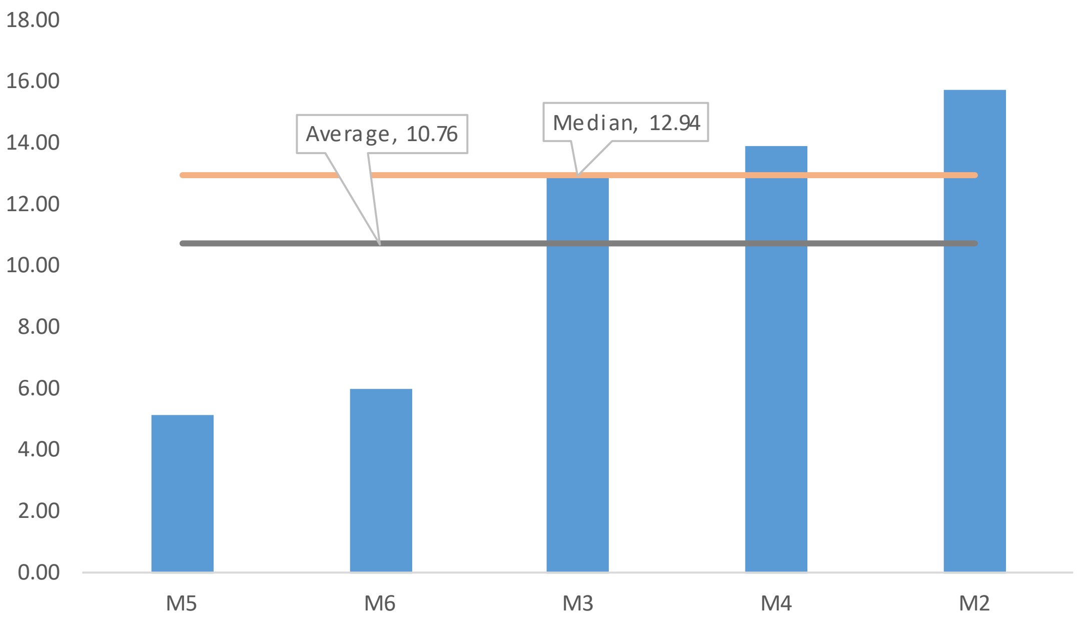
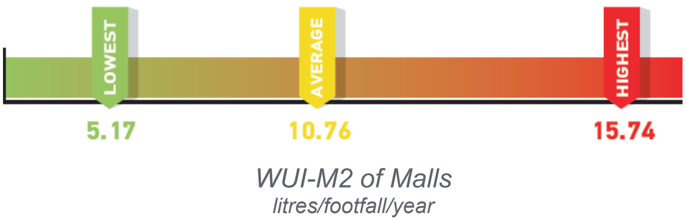


Figure 23 Water Use Intensity M2 (litres/footfall/year) for participating Dubai mall properties

The 2017 WUI-M2 results presented in Figure 23 show:

- Participating mall properties in Dubai consumed between 5.17 litres/footfall/year and 15.74 litres/footfall/year.
- A median participating mall property in Dubai consumes 12.94 litres/footfall/year.
- The average WUI of the participating properties is 10.76 litres/footfall/year.



It is clear from Figure 23 that M5 and M6 have much lower values than the other properties. This is because these two properties have the highest footfall per area amongst the properties. Given that WUI-M2 is considerably influenced by the footfall, it is anticipated that these two properties would also have the lowest WUI-M2 values as well.

Due to the limited sample size and the fact that the average is markedly affected by outlier values, there is a noticeable difference between the median and average WUI-M2 values. This difference is further exasperated by the footfall variation amongst the properties.

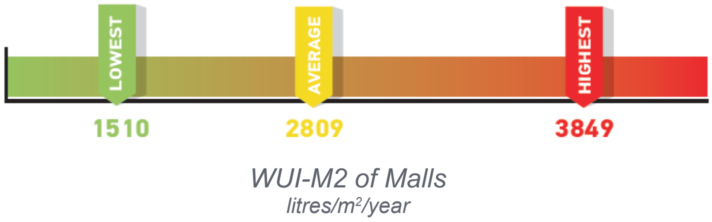
WUI-M3

The last KPI used to evaluate the water performance of malls is the Common Services Water Use (WUI-M3 in Table 3), which looks at the common area water use (excluding makeup water and treated sewage) per common space area, used to evaluate the water performance directly under the control of the mall owner/operator.

This KPI evaluates the most number of properties as compared to the other mall water performance metrics as it does not require the tenant consumption to be known.

The 2017 WUI-M3 results, shown in Figure 24, reveal that:

- The Common Services Water Use in the participating mall properties varied between 1,510 litres/m^2/year and 3,849 litres/m^2/year.
- A median participating mall property in Dubai consumes 3,230 litres/m^2/year for common services.
- The average WUI of the participating properties is 2,809 litres/m^2/year.



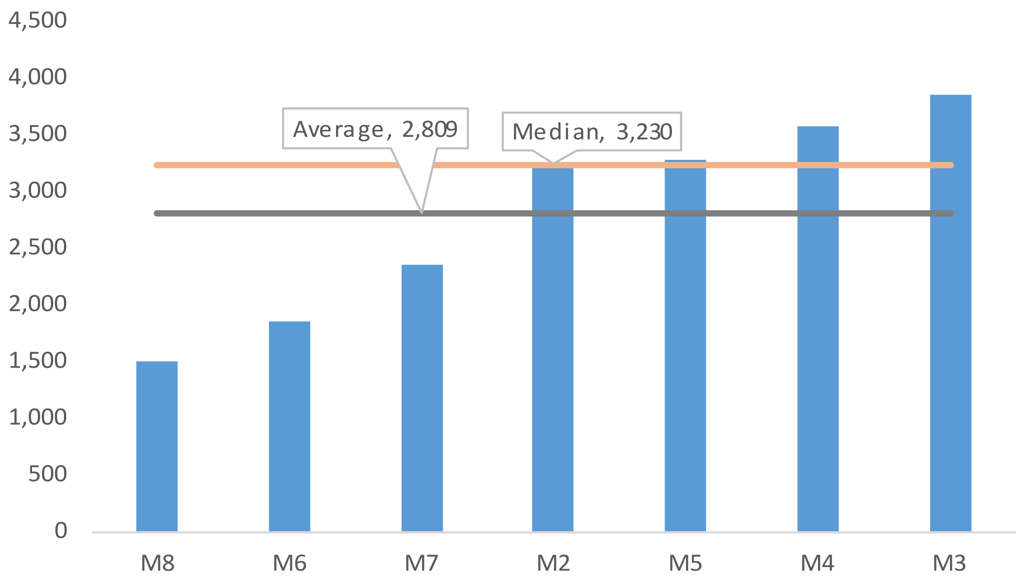


Figure 24 Common Area Water Use-M3 (litres/m²/year) for Dubai mall properties

It should be noted that as WUI-M3 analyzes the common area water use per common space area, the results are invariably affected by the common space area and the density of tenants within the malls; in other words, malls with a high percentage share of common space area are expected to perform better within this metric. This can be seen when examining Figure 24, where M7 and M8 have the lowest values as well as the highest percentage share of common area (36% and 54%, respectively).

A MEDIAN PARTICIPATING MALL PROPERTY IN DUBAI CONSUMES 3,230 litres/m²/year FOR COMMON SERVICES

Nevertheless, it should also be pointed out that water efficiency measures play a vital role in reducing the overall consumption of these properties. While it can be simplistic to categorize the properties with the lowest EUI M3 values as highly water efficient, this should be avoided as, similar to WUI-M1, the details of the malls' operations and efficiency measures are unknown.

Summary and Recommendations

Mall Properties				
KPI	Number of Properties	Range	Median	Average
EUI-M1 Net Energy Use per GCFA *kWh/m²/year*	5	378 - 580	465	462
EUI-M2 Net Energy Use per footfall *kWh/footfall/year*	5	1.84 - 5.03	4.06	3.81
EUI-M3 Landlord Energy Use *kWh/m²/year*	6	253 - 646	394	409
EUI-M4 Common Services Energy Use *kWh/m²/year*	7	318 - 1,296	819	788
WUI-M1 Water Use per GFCA *litres/m²/year*	5	658 - 1,586	1,300	1,260
WUI-M2 Water Use per footfall *litres/footfall/year*	5	5.17 - 15.74	12.94	10.76
WUI-M3 Common Services Water Use *litres/m²/year*	7	1,510 - 3,849	3,230	2,809

Table 7 Summary of results for all participating Dubai mall properties

Table 7 summarizes the range, median and average values from the BEA Benchmarking for all the participating Dubai mall properties. An important point to note is that the number of evaluated properties varied with each KPI, with some properties being analysed only for a few KPIs.

In terms of operations, over half the energy, on average, was consumed by the mall tenants with the remaining energy consumption split between the cooling and common areas (see Figure 16). However, it should be mentioned that the common space area also varied significantly between the malls, which invariably effected the KPIs.

It was also seen that even though water cooled chillers offer a better efficiency compared to air cooled chillers [21], their impact on water consumption is significant. Figure 21 shows that, on average, the makeup water can contribute to 44% of the total water consumption in malls with water cooled chillers.

The variations in the performance metrics suggests that there is an unequal performance amongst the properties. While this might be related to the age, size, footfall and services of the mall, there is a 30% - 60% difference, depending on the performance metric, between the lowest consuming malls and the highest consuming malls. For instance, the lowest consuming mall uses 35% less energy and 58% less water per area than the highest consumer. Comparisons to international benchmarks, however, show that a median enclosed mall in Dubai consumes 57% more energy per unit area than a median enclosed mall in US [15].

Understanding the mall properties data was challenging as malls have complex operations and data obtained from questionnaires was limited. This is further complicated by the fact that some malls do not sub-meter the cooling consumption of all their tenants or do not have access to tenant's consumption figures. A significant amount of time was spent understanding the energy flows of the properties before any analysis could be done.

It is recommended to not only track and register the common services consumption but also the consumption of tenants. The reason for this is to allow the property owners to understand the consumption patterns and enable third party professionals (whether they might be energy and water auditors, ESCOs or facility management personnel) to easily assess the performance.

Given that different mall owners and operators calculate different performance metrics, it is recommended to use the performance metrics used in this study (Table 3) to provide mall owners/operators with an industry baseline and to also harmonize future benchmarks.

Lowest vs Highest Consumers

The lowest consumer uses **35% less energy** per area than the highest consumer

The lowest consumer uses **58% less water** per area than the highest consumer

Limitations

While sizable samples were required for each of the building typologies, higher participation of different types of properties of each of the typologies can improve the established benchmarks. For instance, only a limited sample of resorts is represented within this study as compared to hotels. Similarly, higher number of different school types such as pre-schools and primary schools can also elucidate the energy and water performance difference, if any, between them. However, it should be noted that total sample size of malls is much more limited as compared to the other two typologies as malls cannot be easily grouped into specific types as each mall is unique in terms of their services and characteristics.

The full operational characteristics of the properties were not fully captured within this study as the questionnaires were simplified. As a result, many of the operational characteristics such as the presence and number of energy intensive services and amenities such as restaurants in hotels, food courts in malls, computer and science laboratories in schools, as well as water intensive facilities such as the swimming pools, restaurants, spas, green irrigated areas were not requested from the participating properties. Hence, it becomes difficult to evaluate whether the best performers are indisputably efficient or whether they have no/low number of energy or water intensive amenities. Additionally, it was also not possible to study the impact of these characteristics on the chosen KPIs (except for the building age for hotels and schools, star rating for hotels and KHDA rating for schools).

Attention should be given when comparing the properties performance against the established benchmarks, as not all differences in operational characteristics, services and amenities was not factored into this project's methodologies. Furthermore, climate factors were not factored into the analysis given that all properties analysed were within the same city. A thorough understanding of the methodologies used here and used for other benchmarks is required before any valid comparisons can be made.

For instance, the evaluation of the hotels' operational performance was limited to the guests staying in the hotel rooms; the restaurant covers, conference guests, spa guests and other operational parameters were not considered. It is also important to note that while the fuel conversions used in this study were from the IEA [14], using the actual HHV of fuels and the actual Site to Source Conversion value can reflect a better representation of the performance of hotels.

For schools, it was difficult to obtain the required data as some schools only track energy and water costs and do not record their consumption figures. This was further complicated as some of the schools did not have dedicated personnel with the expertise to provide the specific data that was requested. Additionally, it would be sensible to use the occupied hours or days of operations instead of the annual year for the evaluation of their performance. However, as this information was not provided by all the properties, this was not used for the analysis. While it is possible to approximate the hours of operations, it would not reflect an accurate representation of the school performance given that some schools, especially those with extra facilities such as football fields, tracking grounds and swimming pools, are often used by non-students and staff outside school hours. Additionally, it was not possible to separate the time of use consumption from the overall consumption data.

Calculation of all the performance metrics for the participating malls was not possible given that some mall owners/operators do not record or have access to the consumption of their tenants. Furthermore, malls do not have cooling submeters for tenants, which made it impossible to separate the tenants' contribution from the common space consumption. It should also be pointed out that LPG consumption was not accounted in the total energy consumption of the malls as not all properties provided the data. Even though the operational data requested from the properties was much more in-depth as compared to the other building typologies, the complete profile of the properties was not captured. For a much more detailed analysis of the data, the number, type and area percentages of the different tenants (anchor, mini-anchor, large speciality and speciality[5]) should be factored and normalised for within the analysis. Given that malls also vary significantly in terms of their operations and types of tenants, it was not possible to classify them as best or worst performers.

5 For definitions, refer to [27]

For all properties, the total energy consumption was normalised by gross floor conditioned area. While this serves to provide a sensible approximation, the accuracy of the approximation can be improved by normalizing by the volume of conditioned space. This is because the energy is being used to cool a volume of space rather than an area. This is particularly important for buildings with high ceiling spaces such as malls and hotels.

Lastly, data provided for the study was not verified on site. One of the reasons the monthly breakdown of energy, fuel and water was requested was to spot discrepancies and input errors. When required, the energy and water bills from some properties was requested to ensure validity but, validation of the gross conditioned area, a key parameter, was not possible due to practical reasons.

Next Steps & Recommendations

To support the participating properties in gauging their energy and water efficiency, EmiratesGBC will provide them with tailored performance scorecards. The scorecards will highlight the performance of the properties based on the established benchmarks and are intended to serve as an evaluation tool to support their decision making - on whether urgent action is needed to increase their efficiency measures. The scorecards, on their own, should not be used to drive specific actions, but rather should be used to investigate the causes of concern and thus develop actions to rectify the causes, if needed. This could be in the form of obtaining further technical support, either through audits, retro-commissioning and/or retrofits by in-house facility management/operators or by energy saving companies (ESCOs), or through sustainable initiatives driving behavioural change with the use of awareness campaigns or trainings.

EmiratesGBC will also provide the participating hotel, school chains and developers who make up the Leadership Team with corporate reports to support the corporate management in evaluating which of their properties are under performing and which are best practices. The corporates will be invited to share more details on operations of their properties to help educate the industry and share best practices. In conjunction, discussions about the worst performers will be held to investigate the underlying causes for their low performance, with potential avenues for different types of retrofits being explored.

Given that some schools track their operational energy and water costs through their utility bills, as noted previously in the Schools Summary and Recommendations section, it is recommended that school owners and/or management should start recording and tracking their consumption data to benchmark against their own historical data or even against the benchmarks established here in this report.

Similarly, in the Malls Summary and Recommendations section, it is recommended that mall owners and/or operators record and track the consumption of their tenants, as understanding and evaluating their operational and spatial performance can be very complex and time-consuming, especially if there is unavailable data. It is also recommended to set a consistent industry benchmark using the performance metrics used in this study (Table 3).

For all properties, it is recommended to have sufficient number of sub-meters to track and measure their energy and water use. This is not only specific for benchmarking, but to also aid facility management teams to understand normal operations within the property and thus identify and rectify faults faster. It is therefore recommended that developers embed benchmarking practices in their operations and request for submeters in strategic locations at the design process.

For existing buildings, it is vital that the facility management or operators of buildings are aware of the best practices and technologies available within the market, as well as know what benchmarks are available for their building typologies. This can allow them to evaluate their own performance and help present and justify the business case for efficiency investments to the building owners.

Many of the properties evaluated in this study were under a corporate group, which represents a very good opportunity for improving the energy and water performance of multiple properties. To enable this, it is recommended that groups develop targets based on the established benchmarks and implement measurement and verification schemes. This can also be encouraged by creating and implementing internal incentives such as award systems to encourage their properties to improve performance.

While the Emirate of Dubai has taken great strides in positioning itself as a global leader in sustainability, further actions can drive the state of building efficiency to higher levels. A recommended action is to build upon its existing strategies and policies to encourage benchmarking across the entire emirate for all building typologies. This can help seed the way for future mandates for building audits and retrofits for poor performing buildings, paving the way for decarbonization and net zero buildings.

Finally, this report's main aim was to support the energy performance labelling of existing buildings as part of Dubai's commitment to the BEA. As such, the benchmarks will be used to help establish the baseline for the different building typologies so that the performance of the building can be established within the energy scale or classification of the labels.

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Appendix A
Information Requested from Participating Properties for the BEA Benchmarking

Hotels	
General Characteristics	Hotel Type Location Star Rating Part & name of chain Site Area Gross Conditioned Floor Area Year Built Number of Guest rooms Number of Staff Green Building and/or Eco-certification (Yes/No)
Operational Characteristics	Laundry Services (Yes/No) Renewable Energy Systems (Yes/No) Chillers (Yes/No) Connected to District Cooling (Yes/No)
Monthly Energy Data for 2013 - 2017	Electricity (kWh) Chilled Water (RTh) Liquid Petroleum Gas (kg) Diesel (kg) Synthetic Natural Gas (kg)
Monthly Water Data for 2013 -2017	Water (IG)

Schools	
General Characteristics	School Type Type of Curriculum Academic Calendar School Timings Year Built KHDA Rating Number of Classrooms Site Area Gross Conditioned Floor Area Number of Staff Number of Students Green Building and/or Eco-certification (Yes/No)
Operational Characteristics	Chillers (Yes/No) Connected to District Cooling (Yes/No) Fresh air intake (Yes/No)
Monthly Energy Data for 2013 - 2017	Electricity (kWh) Chilled Water (RTh) Liquid Petroleum Gas (kg) Diesel (kg) Synthetic Natural Gas (kg)
Monthly Water Data for 2013 -2017	Water (IG)

Malls	
General Characteristics	Mall Type Year Built Area of Common Areas Gross Conditioned Floor Area Total Leasable Area Yearly footfall for 2015 - 2017
Operational Characteristics	Connected to District Cooling (Yes/No) Type of Chillers Renewable Energy Systems (Yes/No) Treated Sewage Effluent (Yes/No)
Yearly Energy Data for 2015 - 2017	Total Electricity (kWh) Total Tenants Electricity (kWh) Chiller Electricity (kWh) Renewable Solar Electricity (kWh) Chilled Water (RTh) Liquid Petroleum Gas (kg)
Yearly Water Data for 2015 -2017	Total Water (m^3) Total Tenants Water (m^3) Common Water Area (m^3) Makeup Water (m^3) Treated Sewage Effluent (m^3)

Appendix B
Site to Source Calculation

Source energy incorporates the heat and electricity requirements of the building back to the raw fuel input, thereby accounting for any losses such as transmission and distribution losses [16]. The site-source ratio reflects the losses incurred when these fuels are converted into electricity, and any losses that occur on the electric grid as the electricity. The site-source ratio is calculated as Primary Energy (i.e., the total primary energy involved in electricity generation) divided by Net Generation minus the Transmission and Distribution (T&D) Losses.

$$\textbf{Site-Source Conversion (SSC):} = \frac{\boldsymbol{Primary\ Energy\ Consumed}}{(\boldsymbol{Net\ Generation - Losses})}$$

Figures are taken from IEA for the United Arab Emirates from the year 2015 [17].

- Total Primary Energy Input: 30.66 Mtoe
    - Natural Gas Input to Power Station: 29.98 MtoE
    - Solar/Tide/Wind Input to Power Station: 0.07 Mtoe
    - Oil Input to Power Station: 0.61 Mtoe
- Electricity from Power Plants: 10.95 Mtoe
- Energy Industry use (includes use by plant and electricity used for pump storage): 0.62 Mtoe
- Other Losses: 0.79 Mtoe

$$\textbf{Site-Source Conversion (SSC):} = \frac{\mathbf{30.66}\ \boldsymbol{Mtoe}}{\mathbf{10.95}\ \boldsymbol{Mtoe} - (\mathbf{0.62}\ \boldsymbol{Mtoe} - \mathbf{0.79}\ \boldsymbol{Mtoe})} = \mathbf{3.21}$$

The 3.21 site-source conversion ratio for UAE is comparable to 3.14 average source-site conversion ratio (2007-2011) for the US [16].