

GSAS DESIGN & BUILD ENERGY & WATER PERFORMANCE REPORT

For FIFA World Cup Qatar 2022™ Stadiums



EXECUTIVE
SUMMARY

April 2023

Prepared by:




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GSAS Trust | Gulf Organisation for Research & Development (GORD)





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FOREWORD



Environmental sustainability is a pressing issue that concerns us all. Global statistics and evidence show that the depletion of natural resources such as energy and water has reached an alarming level, which calls for urgent and concerted efforts to reduce consumption and promote efficient use. Releasing its latest 2023 Synthesis Report on Climate Change, the Intergovernmental Panel on Climate Change (IPCC) has reiterated that there are several practical and effective solutions available to mitigate greenhouse gas emissions and adapt to climate change. It is then clear that a lack of dedication to environmental sustainability is the primary factor contributing to the rising levels of climate change.

Fortunately, Qatar's national leadership acknowledges the gravity of the situation and has made

sustainability a top priority, which is reflected in Qatar National Climate Change Action Plan 2030 and the National Environment and Climate Change Strategy (QNE). This commitment was also exemplified in the hosting of FIFA World Cup Qatar 2022™, which has been recognized as one of the most sustainable events in FIFA's history.

A core part of Qatar 2022's sustainability excellence came through the implementation of the Global Sustainability Assessment System (GSAS). All stadiums for the World Cup were certified under GSAS with a minimum 4-Star rating, while most exceeded the mandatory requirement to reach 5-Star rating thus demonstrating ace sustainability credentials. This ambitious undertaking by the Supreme Committee for Delivery & Legacy (SC) resulted in significant savings in the stadiums' overall energy and water consumption along with other areas. The *FIFA World Cup Qatar 2022™ Stadiums – Energy and Water Performance Report* documents the significant amounts of savings in energy and water consumption achieved by the stadiums. At the same time, the report is a testament to the tangible progress that can be achieved by implementing sustainable practices, and it serves as an inspiration for future endeavors.

We would like to extend our heartfelt gratitude to the SC for trusting GORD as its strategic partner in Qatar 2022's sustainability journey. We remain committed to promoting sustainable practices and look forward to continuing our collaboration with all stakeholders towards a more sustainable future.

DR. YOUSEF MOHAMMED ALHORR

Founding Chairman,
Gulf Organisation for Research & Development



1.0 INTRODUCTION

The Supreme Committee for Delivery & Legacy (SC) implemented the Global Sustainability Assessment System Design & Build (GSAS-D&B) certification in all stadiums for the FIFA World Cup Qatar 2022™ with minimum 4-Star certification rating. However, with continuous improvement of the stadiums' features, some stadiums were able to achieve 5-Star certification rating thereby reinforcing SC's commitment towards sustainability.

The objective of this report is to present the energy and water savings achieved by implementing GSAS Design & Build Sports scheme for all FIFA World Cup Qatar 2022™ stadiums.

Stadium	GSAS-D&B Rating	Stadium Capacity
Al Bayt Stadium	5 Stars	60,000
Al Janoub Stadium	4 Stars	40,000
Ahmad Bin Ali Stadium	4 Stars	40,000
Al Thumama Stadium	5 Stars	40,000
Education City Stadium	5 Stars	40,000
Khalifa International Stadium	4 Stars	40,000
Lusail Stadium	5 Stars	80,000
Stadium 974	5 Stars	40,000

Table 1: GSAS Awarded Ratings

To evaluate the percentage savings, it is vital to determine the reference values for energy and water consumption. The determination of the reference values in GSAS for typical building types is based on a parametric study using international standards. These values are called "the baseline". Internationally acceptable standard ASHRAE 90.1-2010 (Energy Standard for Buildings) is considered to establish the energy baseline calculations including the minimum energy efficiency requirements and plan for operation and maintenance. In this parametric study, the baseline is compared to GSAS benchmarks and the SC design standards. The comparison was done based on the calculations and the design modelling for the stadiums. The assessment of the stadiums was done considering similar pattern and schedule.

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The combined energy performance of all the stadiums shows that there was an improvement of 25% and 42% in energy efficiency as compared to the GSAS benchmark and ASHRAE 90.1 – 2010, respectively. This indicates that GSAS benchmarks are more stringent than ASHRAE 90.1 – 2010.

Similarly, the water baseline is established by using two standards: Kahramaa (Code of Practice 2016) and the International Plumbing Code (IPC-2015). The stadiums' design has shown reductions of 28% and 40% in water consumption compared to GSAS benchmark and Kahramaa/IPC, respectively.

Parameters that affect the stadiums' energy and water consumption are demonstrated in this report and the overall energy and water performance as compared to standards and regulations is summarized in Table 1 and 2.

2.0 ENERGY

Table-2 presents the actual energy savings achieved in each stadium due to the implementation of energy saving measures. The savings are compared with GSAS-D&B Sports and ASHRAE 90.1-2010 benchmarks.

Stadium	Total Area (m ²)	Seating Capacity	Energy Savings %		Remarks
			Compared to GSAS Benchmark	Compared to ASHRAE 90.1-2010 Benchmark	
Al Bayt Stadium	237,089	60,000	25%	42%	New Built
Al Janoub Stadium	98,495	60,000	29%	45%	New Built
Ahmad Bin Ali Stadium	114,600	40,000	15%	34%	New Built
Al Thumama Stadium	114,560	40,000	23%	41%	New Built
Education City Stadium	148,112	40,000	21%	39%	New Built
Khalifa International Stadium	81,832	40,000	27%	44%	Renovated
Lusail Stadium	204,060	80,000	31%	47%	New Built
Stadium 974	80,531	40,000	29%	45%	New Built
Overall			25%	42%	

Table 2: Energy Performance Summary

The combined energy performance for all the stadiums is shown in Figure 1.

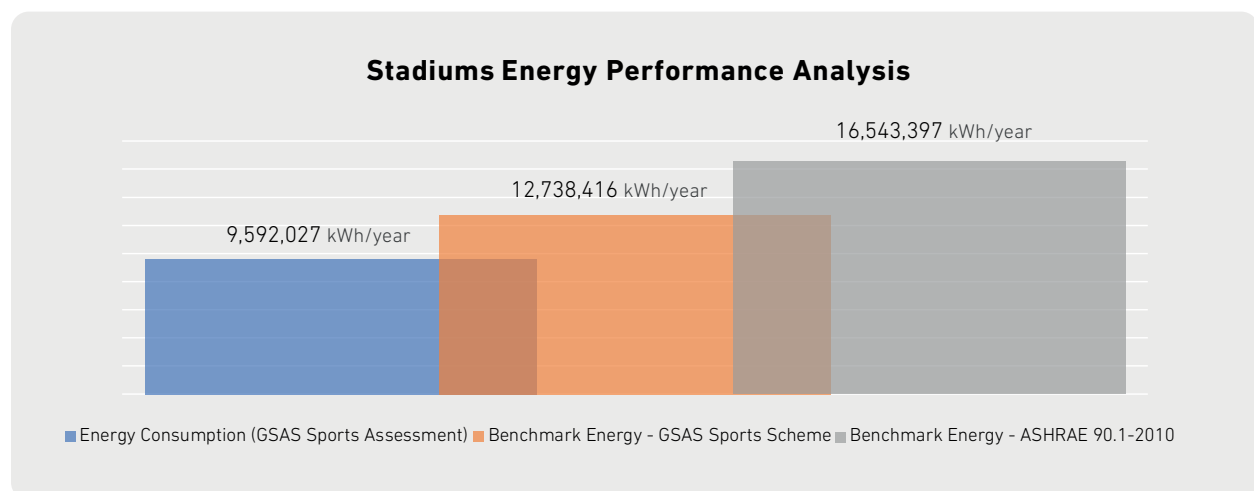


Figure 1: Energy Performance Analysis – All Stadiums (combined)

Stadiums Energy Savings Summary

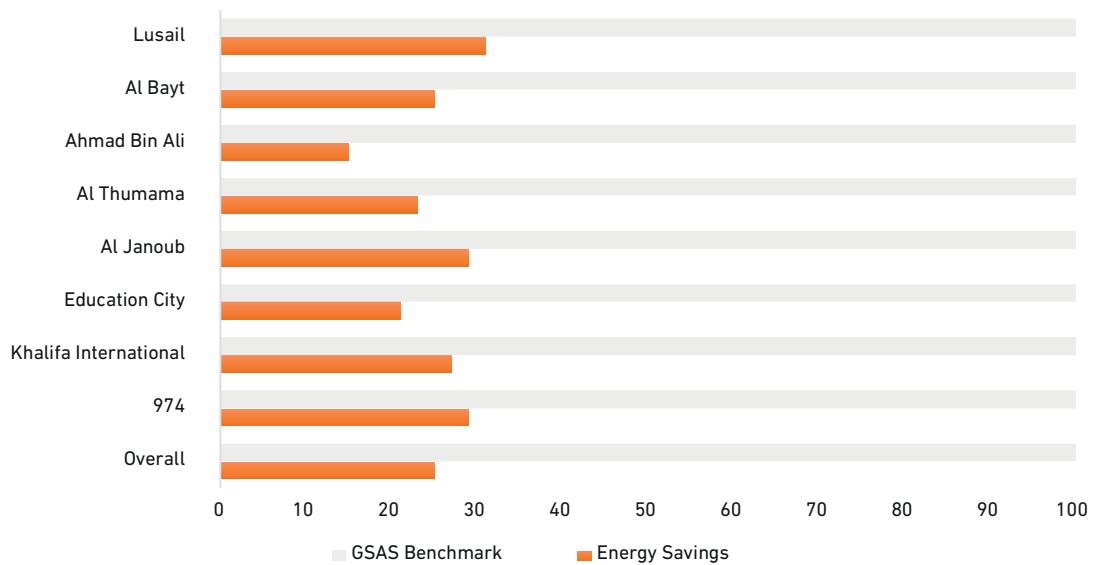


Figure 2: Energy Performance Summary Chart

Since the stadiums are mostly meant to host high occupancy events for a short duration of time such as Qatar 2022 matches, it is important to establish the yearly energy consumption per seating capacity. Therefore, the combined yearly energy consumption for all the stadiums is shown in Figure 2 as compared to ASHRAE 90.1 – 2010 and GSAS benchmarks.

Stadiums Yearly Energy Performance Per Seating Capacity

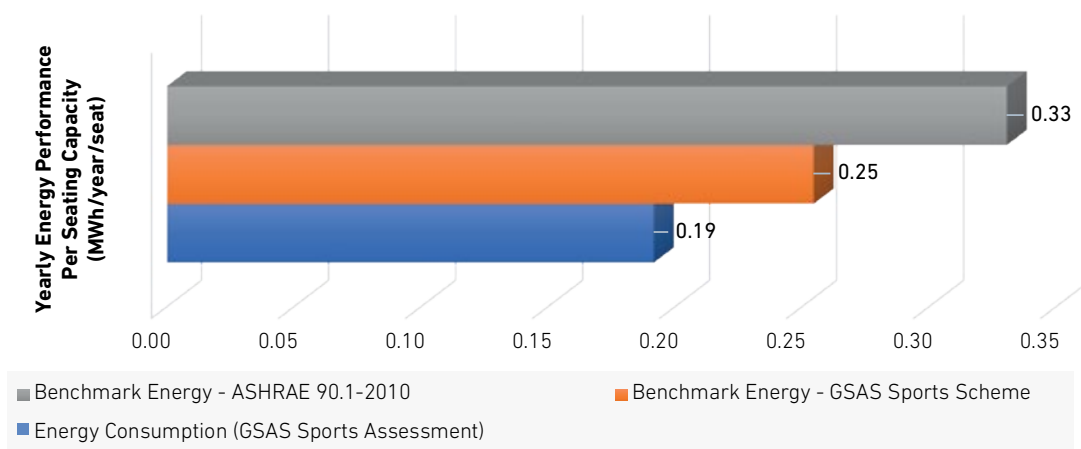


Figure 3: Yearly Energy Performance Per Seating Capacity – All Stadiums (combined)

3.0 WATER

Table-3 presents the actual water savings achieved in each of the stadiums due to the implementation of water saving measures. The savings are compared with GSAS-D&B Sports and Kahramaa/IPC benchmarks.

Stadium	Total Area (m ²)	Seating Capacity	Water Savings %		Remarks
			Compared to GSAS Benchmark	Compared to Kahramaa/IPC Benchmark	
Al Bayt Stadium	237,089	60,000	24%	36%	New Built
Al Janoub Stadium	98,495	60,000	39%	51%	New Built
Ahmad Bin Ali Stadium	114,600	40,000	1%	13%	New Built
Al Thumama Stadium	114,560	40,000	37%	49%	New Built
Education City Stadium	148,112	40,000	26%	38%	New Built
Khalifa International Stadium	81,832	40,000	30%	42%	Renovated
Lusail Stadium	204,060	80,000	31%	44 %	New Built
Stadium 974	80,531	40,000	36%	48%	New Built
Overall			28%	40%	

Table 3: Water Performance Summary

Water Savings Summary

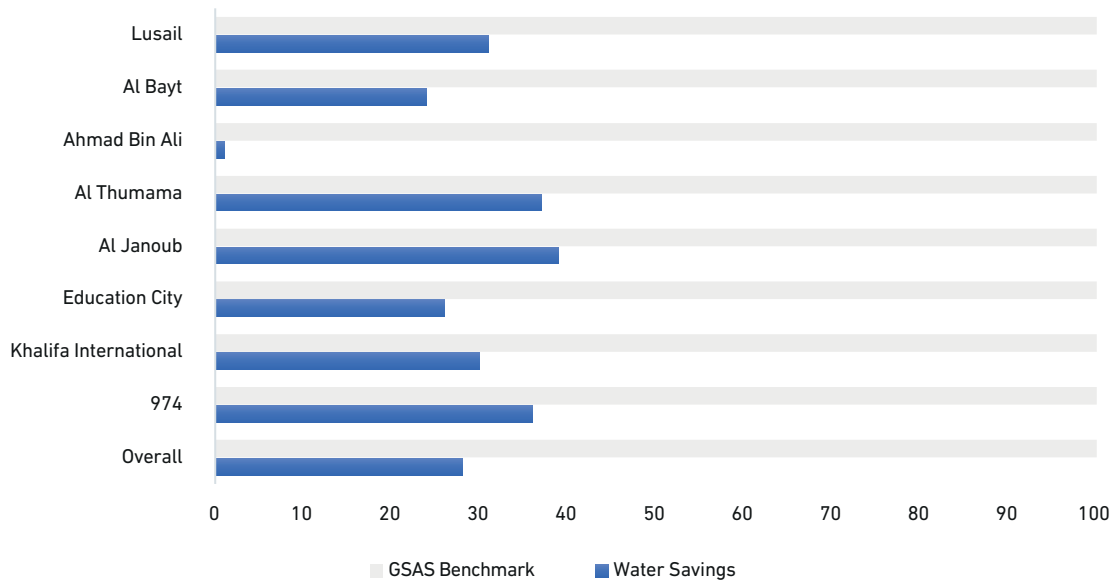


Figure 4: Water Performance Summary Chart

Similarly, the combined water performance for all the stadiums is shown in Figure 4 and the indoor water performance per seating capacity is shown in Figure 3 as compared to Kahramaa and International Plumbing Code (IPC) and GSAS benchmarks.

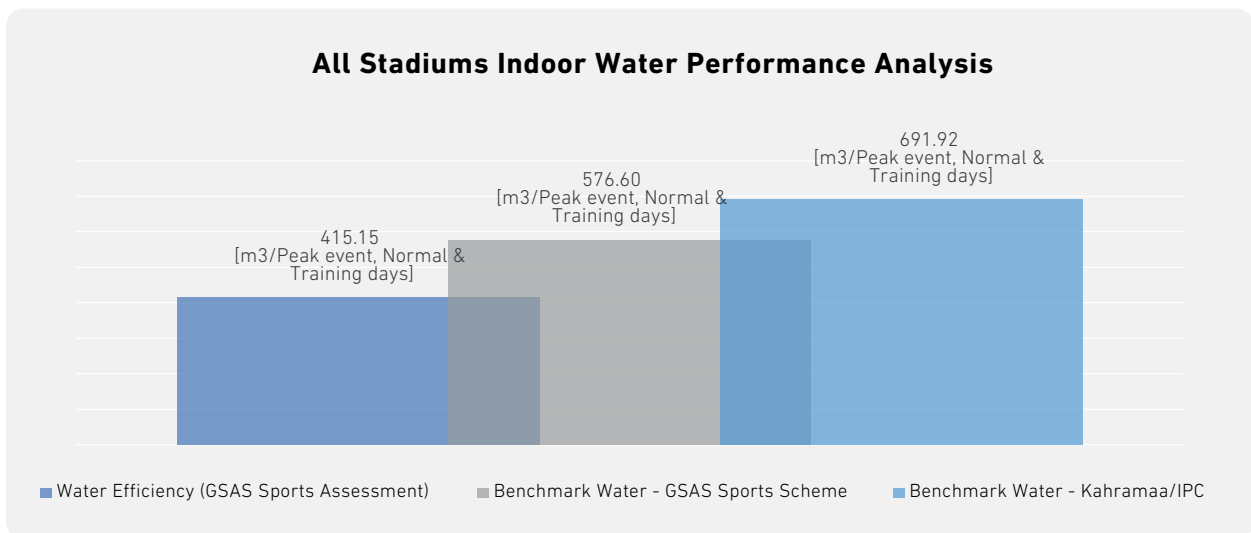


Figure 5: Indoor Water Performance Per Seating Capacity – All Stadiums (combined)

4.0 ENERGY & WATER PERFORMANCE ANALYSIS

The energy and water performance analysis for all the stadiums are indicated in this section. The energy performance of the stadiums is compared to ASHRAE 90.1-2010. The analysis shows that the energy performance of all the stadiums is 42% better than the ASHRAE 90.1-2010 benchmark. Similarly, the water performance of all the stadiums is better than the local regulation Kahramma and IPC by 40%.

AL BAYT STADIUM

Energy Performance Analysis

EPC_{det} - Energy Performance Coefficient for Delivered Energy	0.75	
Energy Consumption (GSAS Sports Assessment)	19,601,890	kWh/Yr
Benchmark Energy - GSAS Sports Scheme	26,066,343	kWh/Yr
EPC_{ASHRAE} (23% lower than GSAS) - Energy Performance Coefficient Adjusted to ASHRAE 90.1-2010 Benchmark	0.58	
Benchmark Energy - ASHRAE 90.1-2010	33,852,393	kWh/Yr
% Better than GSAS Sports Benchmark	24.8%	
% Better than ASHRAE 90.1-2010	42.1%	

Yearly Energy Performance Per Seating Capacity

Seating Capacity	60,000	Seats
Energy Efficiency (GSAS Sports Assessment)	0.33	MWh/Yr/Seat
Benchmark Energy - GSAS Sports Scheme	0.43	MWh/Yr/Seat
Benchmark Energy - ASHRAE 90.1-2010	0.56	MWh/Yr/Seat

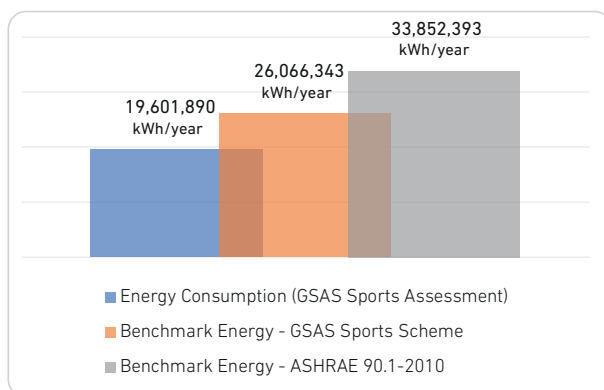


Figure 6: Energy Performance Analysis - Al Bayt Stadium

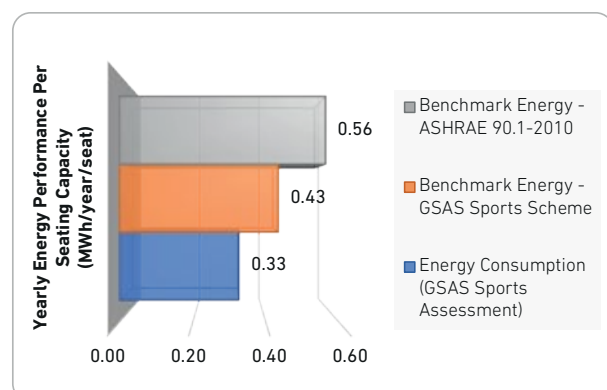


Figure 7: Yearly Energy Performance Per Seating Capacity - Al Bayt Stadium

▶ AL BAYT STADIUM

Indoor Water Performance Analysis

WPC _{eff} - Water Performance Coefficient for Water Efficiency	0.76	
Water Consumption (GSAS Sports Assessment)	502.71	[m3/Peak Event, Normal & Training Days]
Benchmark Water - GSAS Sports Scheme	661.47	[m3/Peak Event, Normal & Training Days]
WPC _{KM/IPC} – Water Performance Coefficient adjusted to Kahramaa/IPC Benchmark	0.64	
Benchmark Water - Kahramaa/IPC	785.49	[m3/Peak Event, Normal & Training Days]
% Better than GSAS Sports Benchmark	24.0%	
% Better than Kahramaa/IPC	36.0%	

Indoor Water Performance Per Seating Capacity

Seating Capacity	60,000	Seats
Water Efficiency (GSAS Sports Assessment)	8.38	[Liters/(Peak Event, Normal & Training Days)/Seat]
Benchmark Water - GSAS Sports Scheme	11.02	[Liters/(Peak Event, Normal & Training Days)/Seat]
Benchmark Water – Kahramaa/IPC	13.09	[Liters/(Peak Event, Normal & Training Days)/Seat]

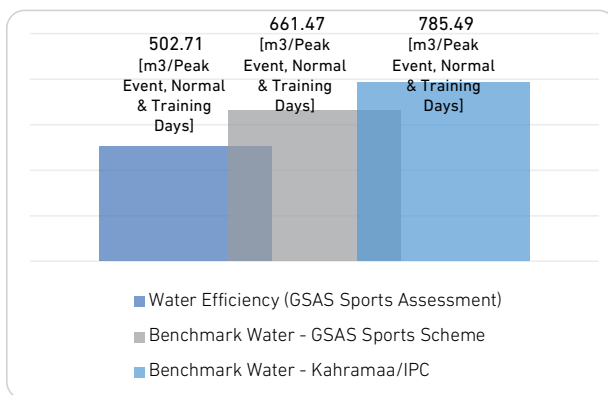


Figure 8: Indoor water Performance Analysis - Al Bayt Stadium

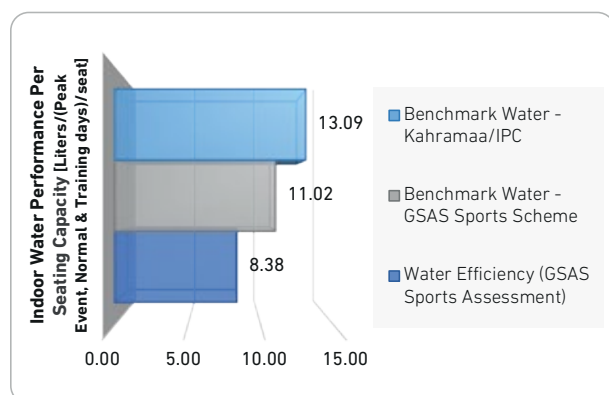


Figure 9: Indoor Water Performance Per Seating Capacity - Al Bayt Stadium

▶ AL JANOUB STADIUM

Energy Performance Analysis

EPC_{del} - Energy Performance Coefficient for Delivered Energy	0.72	
Energy Consumption (GSAS Sports Assessment)	7,827,923	kWh/Yr
Benchmark Energy - GSAS Sports Scheme	10,887,236	kWh/Yr
EPC_{ASHRAE} (23% lower than GSAS) - Energy Performance Coefficient Adjusted to ASHRAE 90.1-2010 Benchmark	0.55	
Benchmark Energy - ASHRAE 90.1-2010	14,139,268	kWh/Yr
% Better than GSAS Sports Benchmark	28.1%	
% Better than ASHRAE 90.1-2010	44.6%	

Yearly Energy Performance Per Seating Capacity

Seating Capacity	60,000	Seats
Energy Efficiency (GSAS Sports Assessment)	0.13	MWh/Yr/Seat
Benchmark Energy - GSAS Sports Scheme	0.18	MWh/Yr/Seat
Benchmark Energy - ASHRAE 90.1-2010	0.24	MWh/Yr/Seat

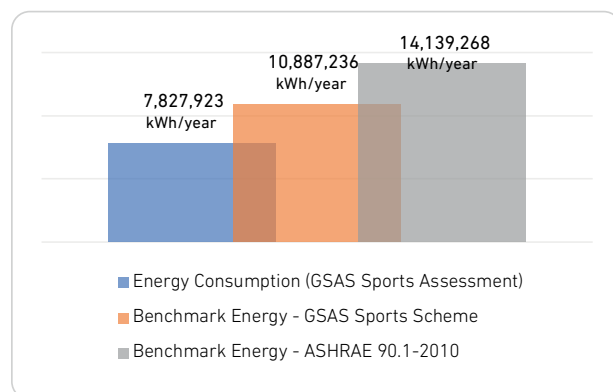


Figure 10: Energy Performance Analysis - Al Janoub Stadium

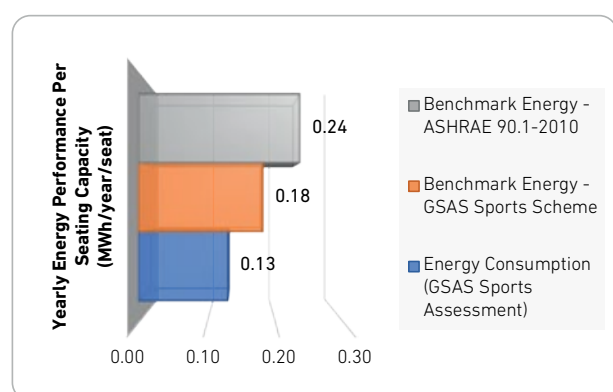


Figure 11: Yearly Energy Performance Per Seating Capacity - Al Janoub Stadium

▶ AL JANOUB STADIUM

Indoor Water Performance Analysis

WPC _{eff} - Water Performance Coefficient for Water Efficiency	0.61	
Water Efficiency (GSAS Sports Assessment)	468.90	[m3/Peak Event, Normal & Training Days]
Benchmark Water - GSAS Sports Scheme	768.69	[m3/Peak Event, Normal & Training Days]
WPC _{KM/IPC} - Water Performance Coefficient Adjusted to Kahramaa/IPC Benchmark	0.49	
Benchmark Water - Kahramaa/IPC	956.94	[m3/Peak Event, Normal & Training Days]
% Better than GSAS Sports Benchmark	39.0%	
% Better than Kahramaa/IPC	51.0%	

Indoor Water Performance Per Seating Capacity

Seating Capacity	60,000	Seats
Water Efficiency (GSAS Sports Assessment)	7.82	[Liters/(Peak Event, Normal & Training Days)/Seat]
Benchmark Water - GSAS Sports Scheme	12.81	[Liters/(Peak Event, Normal & Training Days)/Seat]
Benchmark Water - Kahramaa/IPC	15.95	[Liters/(Peak Event, Normal & Training Days)/Seat]

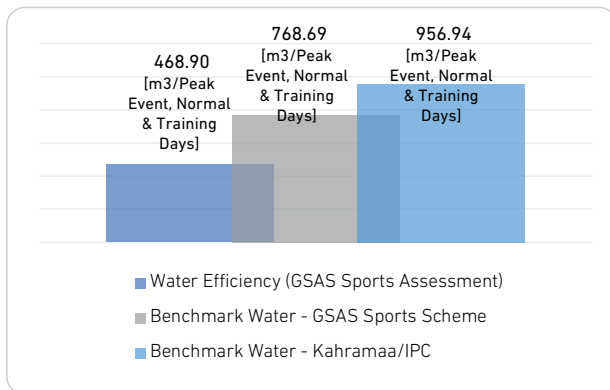


Figure 12: Indoor water Performance Analysis - Al Janoub Stadium

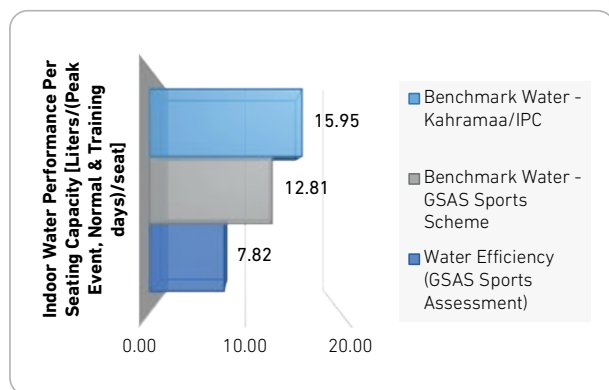


Figure 13: Indoor Water Performance Per Seating Capacity - Al Janoub Stadium

AHMAD BIN ALI STADIUM

Energy Performance Analysis

EPC_{del} - Energy Performance Coefficient for Delivered Energy	0.86	
Energy Consumption (GSAS Sports Assessment)	10,043,082	kWh/Yr
Benchmark Energy - GSAS Sports Scheme	11,705,224	kWh/Yr
EPC_{ASHRAE} (23% lower than GSAS) - Energy Performance Coefficient Adjusted to ASHRAE 90.1-2010 Benchmark	0.66	
Benchmark Energy - ASHRAE 90.1-2010	15,201,590	kWh/Yr
% Better than GSAS Sports Benchmark	14.2%	
% Better than ASHRAE 90.1-2010	33.9%	

Yearly Energy Performance Per Seating Capacity

Seating Capacity	40,000	Seats
Energy Efficiency (GSAS Sports Assessment)	0.25	MWh/Yr/Seat
Benchmark Energy - GSAS Sports Scheme	0.29	MWh/Yr/Seat
Benchmark Energy - ASHRAE 90.1-2010	0.38	MWh/Yr/Seat

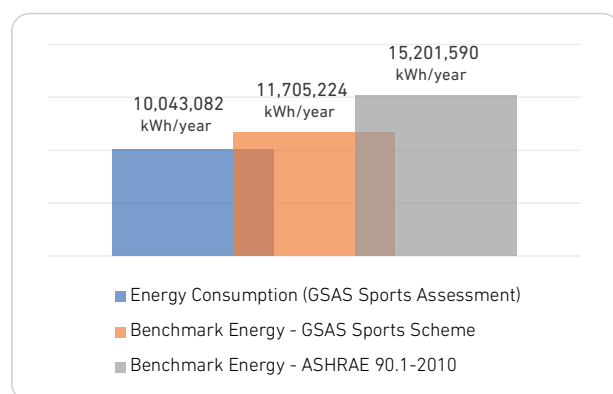


Figure 14: Energy Performance Analysis - Ahmad Bin Ali Stadium

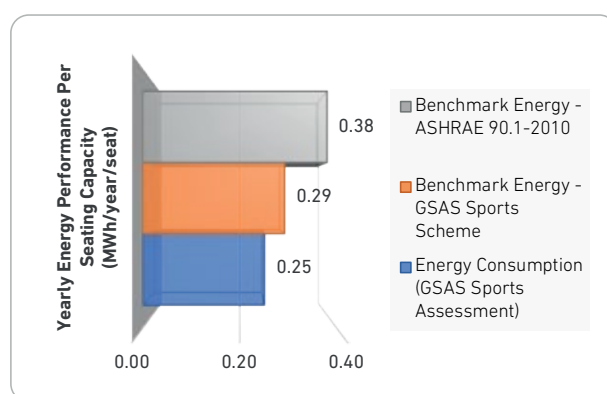


Figure 15: Yearly Energy Performance Per Seating Capacity - Ahmad Bin Ali Stadium

AHMAD BIN ALI STADIUM

Indoor Water Performance Analysis

WPC _{eff} - Water Performance Coefficient for Water Efficiency	0.99	
Water Efficiency (GSAS Sports Assessment)	283.54	[m3/Peak Event, Normal & Training Days]
Benchmark Water - GSAS Sports Scheme	286.40	[m3/Peak Event, Normal & Training Days]
WPC _{KM/IPC} - Water Performance Coefficient Adjusted to Kahramaa/IPC Benchmark	0.87	
Benchmark Water - Kahramaa/IPC	325.91	[m3/Peak Event, Normal & Training Days]
% Better than GSAS Sports Benchmark	1.0%	
% Better than Kahramaa/IPC	13.0%	

Indoor Water Performance Per Seating Capacity

Seating Capacity	40,000	Seats
Water Efficiency (GSAS Sports Assessment)	7.09	[Liters/(Peak Event, Normal & Training Days)/Seat]
Benchmark Water - GSAS Sports Scheme	7.16	[Liters/(Peak Event, Normal & Training Days)/Seat]
Benchmark Water - Kahramaa/IPC	8.15	[Liters/(Peak Event, Normal & Training Days)/Seat]

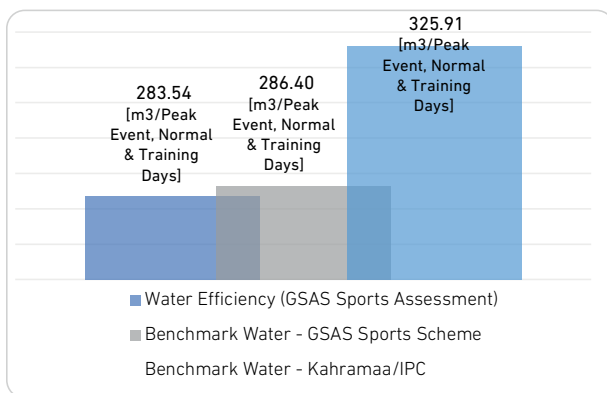


Figure 16: Indoor water Performance Analysis - Ahmad Bin Ali Stadium

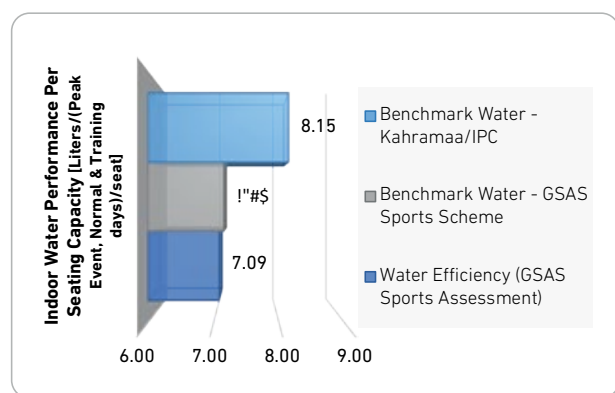


Figure 17: Indoor Water Performance Per Seating Capacity - Ahmad Bin Ali Stadium

▶ AL THUMAMA STADIUM

Energy Performance Analysis

EPC _{del} - Energy Performance Coefficient for Delivered Energy	0.77	
Energy Consumption (GSAS Sports Assessment)	9,530,886	kWh/Yr
Benchmark Energy - GSAS Sports Scheme	12,345,707	kWh/Yr
EPC _{ASHRAE} (23% lower than GSAS) - Energy Performance Coefficient Adjusted to ASHRAE 90.1-2010 Benchmark	0.59	
Benchmark Energy - ASHRAE 90.1-2010	16,033,386	kWh/Yr
% Better than GSAS Sports Benchmark	22.8%	
% Better than ASHRAE 90.1-2010	40.6%	

Yearly Energy Performance Per Seating Capacity

Seating Capacity	40,000	Seats
Energy Efficiency (GSAS Sports Assessment)	0.24	MWh/Yr/Seat
Benchmark Energy - GSAS Sports Scheme	0.31	MWh/Yr/Seat
Benchmark Energy - ASHRAE 90.1-2010	0.40	MWh/Yr/Seat

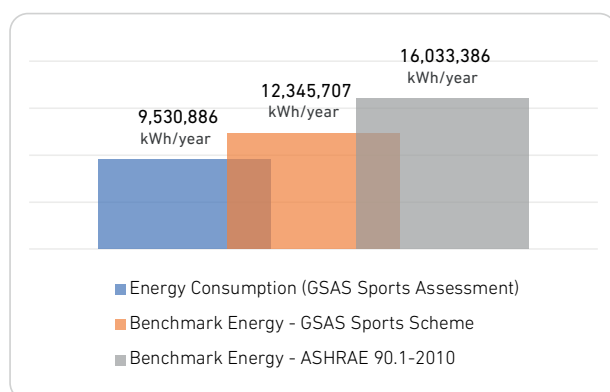


Figure 18: Energy Performance Analysis - Al Thumama Stadium

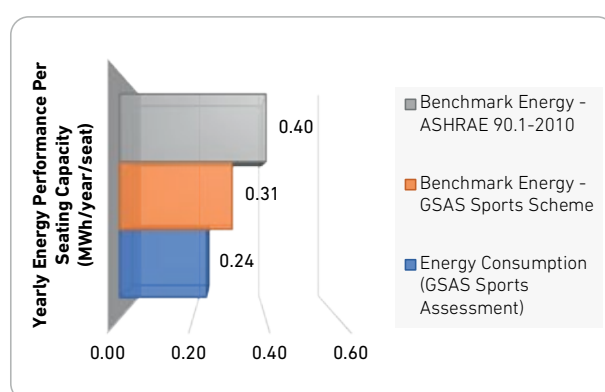


Figure 19: Yearly Energy Performance Per Seating Capacity - Al Thumama Stadium

AL THUMAMA STADIUM

Indoor Water Performance Analysis

WPC _{eff} - Water Performance Coefficient for Water Efficiency	0.63	
Water Efficiency (GSAS Sports Assessment)	312.84	[m3/Peak Event, Normal & Training Days]
Benchmark Water - GSAS Sports Scheme	496.57	[m3/Peak Event, Normal & Training Days]
WPC _{KM/IPC} - Water Performance Coefficient Adjusted to Kahramaa/IPC Benchmark	0.51	
Benchmark Water - Kahramaa/IPC	613.41	[m3/Peak Event, Normal & Training Days]
% Better than GSAS Sports Benchmark	37.0%	
% Better than Kahramaa/IPC	49.0%	

Indoor Water Performance Per Seating Capacity

Seating Capacity	40,000	Seats
Water Efficiency (GSAS Sports Assessment)	7.82	[Liters/(Peak Event, Normal & Training Days)/Seat]
Benchmark Water - GSAS Sports Scheme	12.41	[Liters/(Peak Event, Normal & Training Days)/Seat]
Benchmark Water - Kahramaa/IPC	15.34	[Liters/(Peak Event, Normal & Training Days)/Seat]

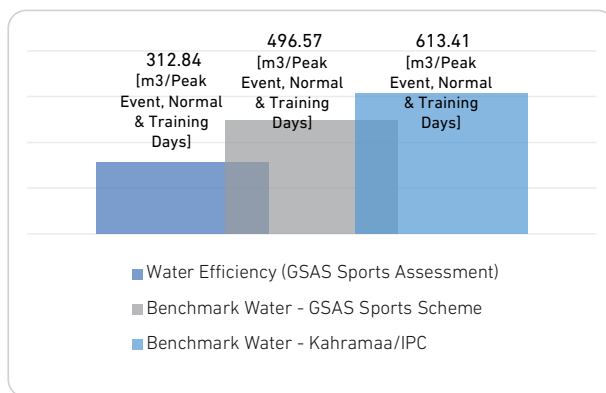


Figure 20: Indoor water Performance Analysis - Al Thumama Stadium

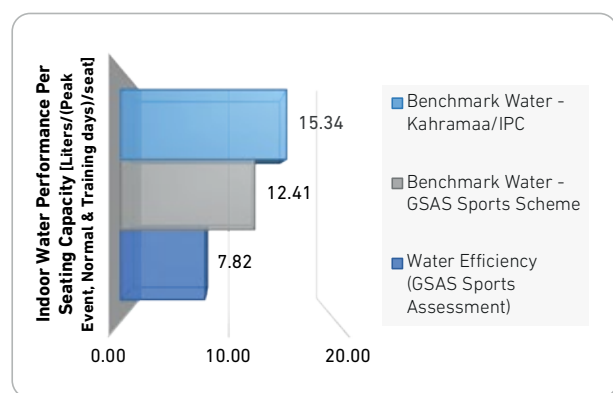


Figure 21: Indoor Water Performance Per Seating Capacity - Al Thumama Stadium

▶ EDUCATION CITY STADIUM

Energy Performance Analysis

EPC_{del} - Energy Performance Coefficient for Delivered Energy	0.80	
Energy Consumption (GSAS Sports Assessment)	12,279,905	kWh/Yr
Benchmark Energy - GSAS Sports Scheme	15,485,378	kWh/Yr
EPC_{ASHRAE} (23% lower than GSAS) - Energy Performance Coefficient Adjusted to ASHRAE 90.1-2010 Benchmark	0.61	
Benchmark Energy - ASHRAE 90.1-2010	20,110,880	kWh/Yr
% Better than GSAS Sports Benchmark	20.7%	
% Better than ASHRAE 90.1-2010	38.9%	

Yearly Energy Performance Per Seating Capacity

Seating Capacity	40,000	Seats
Energy Efficiency (GSAS Sports Assessment)	0.31	MWh/Yr/Seat
Benchmark Energy - GSAS Sports Scheme	0.39	MWh/Yr/Seat
Benchmark Energy - ASHRAE 90.1-2010	0.50	MWh/Yr/Seat

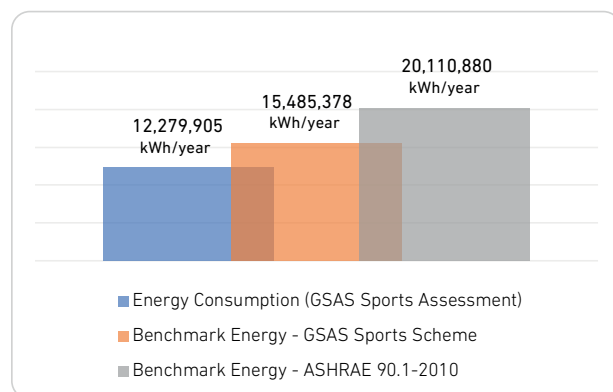


Figure 22: Energy Performance Analysis - Education City Stadium

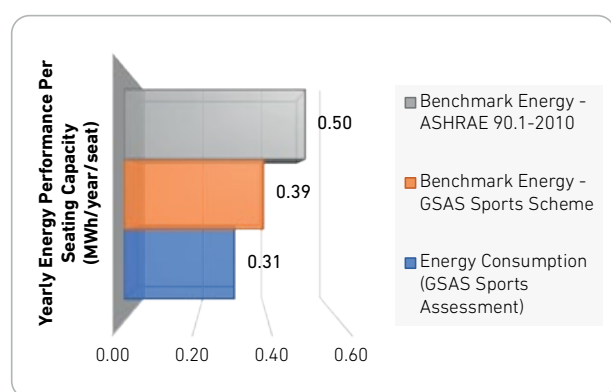


Figure 23: Yearly Energy Performance Per Seating Capacity - Education City Stadium

▶ EDUCATION CITY STADIUM

Indoor Water Performance Analysis

WPC _{eff} - Water Performance Coefficient for Water Efficiency	0.74	
Water Efficiency (GSAS Sports Assessment)	213.92	[m3/Peak Event, Normal & Training Days]
Benchmark Water - GSAS Sports Scheme	289.08	[m3/Peak Event, Normal & Training Days]
WPC _{KM/IPC} - Water Performance Coefficient Adjusted to Kahramaa/IPC Benchmark	0.62	
Benchmark Water - Kahramaa/IPC	345.03	[m3/Peak Event, Normal & Training Days]
% Better than GSAS Sports Benchmark	26.0%	
% Better than Kahramaa/IPC	38.0%	

Indoor Water Performance Per Seating Capacity

Seating Capacity	40,000	Seats
Water Efficiency (GSAS Sports Assessment)	5.35	[Liters/(Peak Event, Normal & Training Days)/Seat]
Benchmark Water - GSAS Sports Scheme	7.23	[Liters/(Peak Event, Normal & Training Days)/Seat]
Benchmark Water - Kahramaa/IPC	15.95	[Liters/(Peak Event, Normal & Training Days)/Seat]

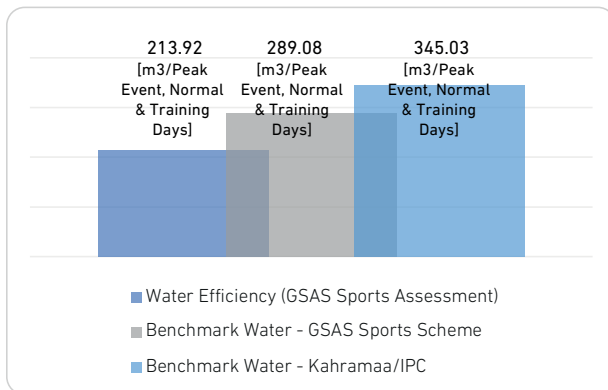


Figure 24: Indoor water Performance Analysis - Education City Stadium

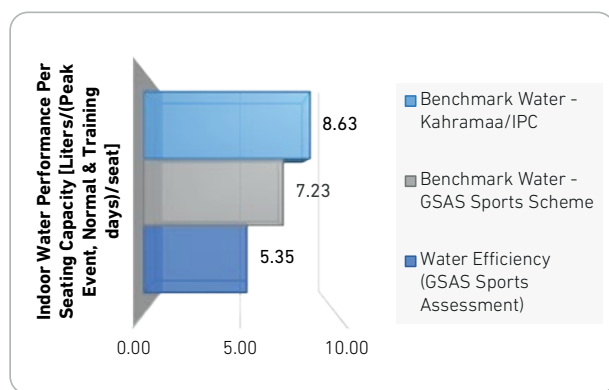


Figure 25: Indoor Water Performance Per Seating Capacity - Education City Stadium

► KHALIFA INTERNATIONAL STADIUM

Energy Performance Analysis

EPC _{del} - Energy Performance Coefficient for Delivered Energy	0.73	
Energy Consumption (GSAS Sports Assessment)	4,475,349	kWh/Yr
Benchmark Energy - GSAS Sports Scheme	6,130,615	kWh/Yr
EPC _{ASHRAE} (23% lower than GSAS) - Energy Performance Coefficient Adjusted to ASHRAE 90.1-2010 Benchmark	0.56	
Benchmark Energy - ASHRAE 90.1-2010	7,961,838	kWh/Yr
% Better than GSAS Sports Benchmark	27.0%	
% Better than ASHRAE 90.1-2010	43.8%	

Yearly Energy Performance Per Seating Capacity

Seating Capacity	40,000	Seats
Energy Efficiency (GSAS Sports Assessment)	0.11	MWh/Yr/Seat
Benchmark Energy - GSAS Sports Scheme	0.15	MWh/Yr/Seat
Benchmark Energy - ASHRAE 90.1-2010	0.20	MWh/Yr/Seat

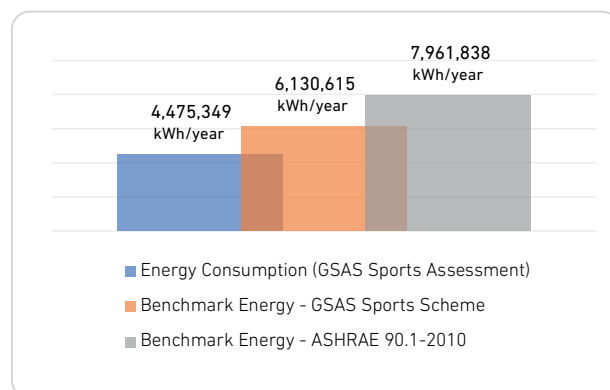


Figure 26: Energy Performance Analysis - Khalifa International Stadium

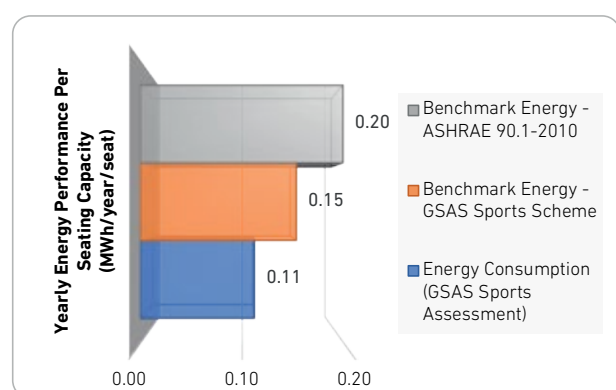


Figure 27: Yearly Energy Performance Per Seating Capacity - Khalifa International Stadium

KHALIFA INTERNATIONAL STADIUM

Indoor Water Performance Analysis

WPC _{eff} - Water Performance Coefficient for Water Efficiency	0.70	
Water Efficiency (GSAS Sports Assessment)	418.08	[m3/Peak Event, Normal & Training Days]
Benchmark Water - GSAS Sports Scheme	597.26	[m3/Peak Event, Normal & Training Days]
WPC _{KM/IPC} - Water Performance Coefficient Adjusted to Kahramaa/IPC Benchmark	0.58	
Benchmark Water - Kahramaa/IPC	720.83	[m3/Peak Event, Normal & Training Days]
% Better than GSAS Sports Benchmark	30.0%	
% Better than Kahramaa/IPC	42.0%	

Indoor Water Performance Per Seating Capacity

Seating Capacity	40,000	Seats
Water Efficiency (GSAS Sports Assessment)	10.45	[Liters/(Peak Event, Normal & Training days)/seat]
Benchmark Water - GSAS Sports Scheme	14.93	[Liters/(Peak Event, Normal & Training days)/seat]
Benchmark Water - Kahramaa/IPC	15.95	[Liters/(Peak Event, Normal & Training Days)/Seat]

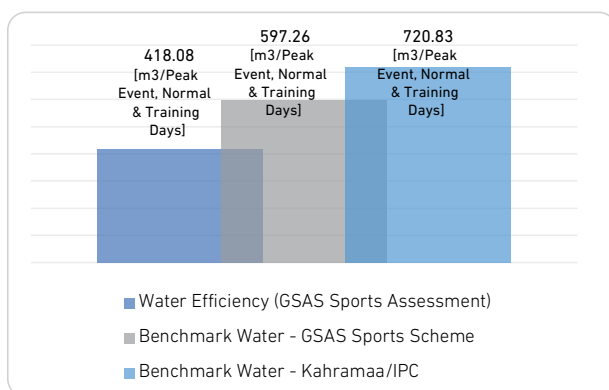


Figure 28: Indoor water Performance Analysis - Khalifa International Stadium

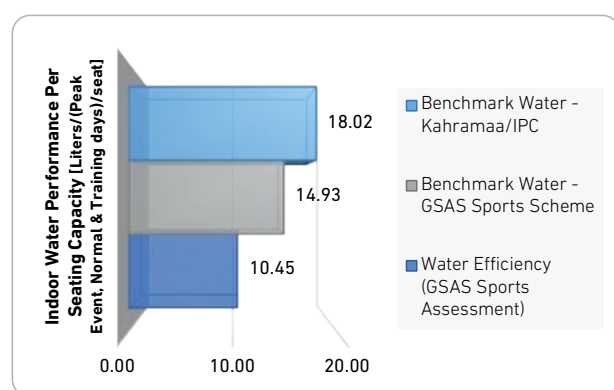


Figure 29: Indoor Water Performance Per Seating Capacity - Khalifa International Stadium

LUSAIL STADIUM

Energy Performance Analysis

EPC _{del} - Energy Performance Coefficient for Delivered Energy	0.69	
Energy Consumption (GSAS Sports Assessment)	8,592,343	kWh/Yr
Benchmark Energy - GSAS Sports Scheme	12,452,671	kWh/Yr
EPC _{ASHRAE} (23% lower than GSAS) - Energy Performance Coefficient Adjusted to ASHRAE 90.1-2010 Benchmark	0.53	
Benchmark Energy - ASHRAE 90.1-2010	16,172,299	kWh/Yr
% Better than GSAS Sports Benchmark	31.0%	
% Better than ASHRAE 90.1-2010	46.9%	

Yearly Energy Performance Per Seating Capacity

Seating Capacity	80,000	Seats
Energy Efficiency (GSAS Sports Assessment)	0.11	MWh/Yr/Seat
Benchmark Energy - GSAS Sports Scheme	0.16	MWh/Yr/Seat
Benchmark Energy - ASHRAE 90.1-2010	0.20	MWh/Yr/Seat

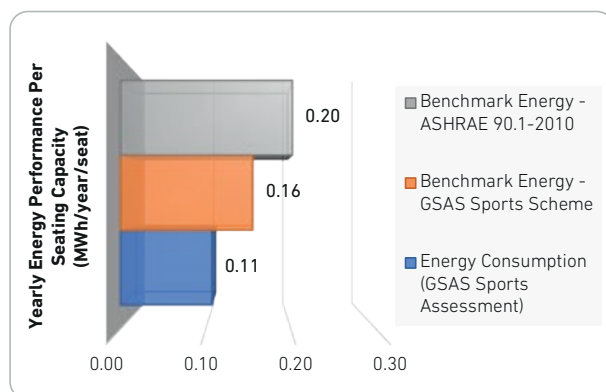


Figure 30: Energy Performance Analysis - Lusail Stadium

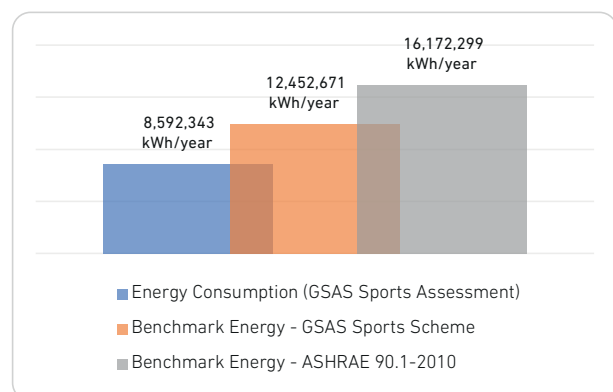


Figure 31: Yearly Energy Performance Per Seating Capacity - Lusail Stadium

LUSAIL STADIUM

Indoor Water Performance Analysis

WPC _{eff} - Water Performance Coefficient for Water Efficiency	0.69	
Water Efficiency (GSAS Sports Assessment)	834.62	[m3/Peak Event, Normal & Training Days]
Benchmark Water - GSAS Sports Scheme	1,209.60	[m3/Peak Event, Normal & Training Days]
WPC _{KM/IPC} - Water Performance Coefficient Adjusted to Kahramaa/IPC Benchmark	0.56	
Benchmark Water - Kahramaa/IPC	1,490.39	[m3/Peak Event, Normal & Training Days]
% Better than GSAS Sports Benchmark	31.0%	
% Better than Kahramaa/IPC	44.0%	

Indoor Water Performance Per Seating Capacity

Seating Capacity	80,000	Seats
Water Efficiency (GSAS Sports Assessment)	10.43	[Liters/(Peak Event, Normal & Training Days)/Seat]
Benchmark Water - GSAS Sports Scheme	15.12	[Liters/(Peak Event, Normal & Training Days)/Seat]
Benchmark Water - Kahramaa/IPC	18.63	[Liters/(Peak Event, Normal & Training Days)/Seat]

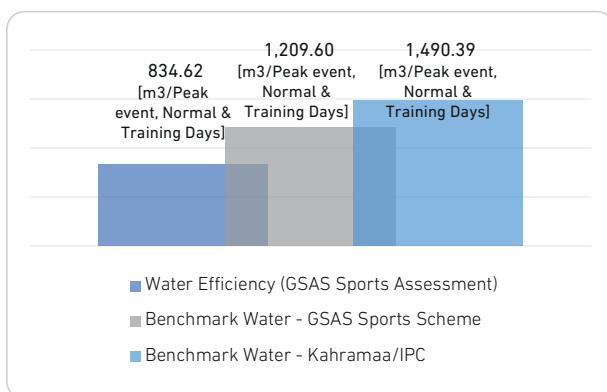


Figure 32: Indoor water Performance Analysis - Lusail Stadium

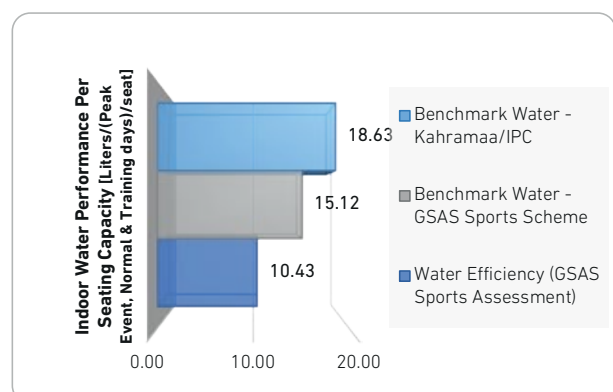


Figure 33: Indoor Water Performance Per Seating Capacity - Lusail Stadium

▶ STADIUM 974

Energy Performance Analysis

EPC_{del} - Energy Performance Coefficient for Delivered Energy	0.72	
Energy Consumption (GSAS Sports Assessment)	4,384,835	kWh/Yr
Benchmark Energy - GSAS Sports Scheme	6,132,636	kWh/Yr
EPC_{ASHRAE} (23% lower than GSAS) - Energy Performance Coefficient Adjusted to ASHRAE 90.1-2010 Benchmark	0.55	
Benchmark Energy - ASHRAE 90.1-2010	7,964,463	kWh/Yr
% Better than GSAS Sports Benchmark	28.5%	
% Better than ASHRAE 90.1-2010	44.9%	

Yearly Energy Performance Per Seating Capacity

Seating Capacity	40,000	Seats
Energy Efficiency (GSAS Sports Assessment)	0.11	MWh/Yr/Seat
Benchmark Energy - GSAS Sports Scheme	0.15	MWh/Yr/Seat
Benchmark Energy - ASHRAE 90.1-2010	0.20	MWh/Yr/Seat

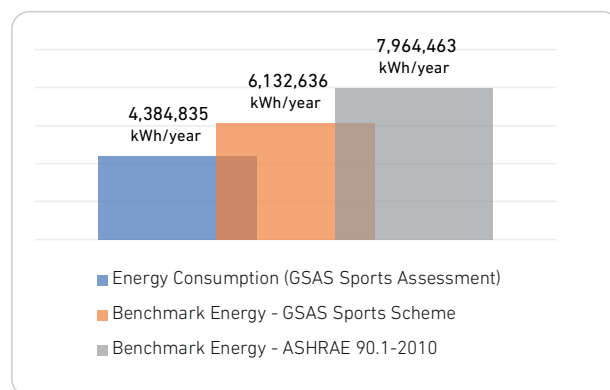


Figure 34: Energy Performance Analysis - Stadium 974

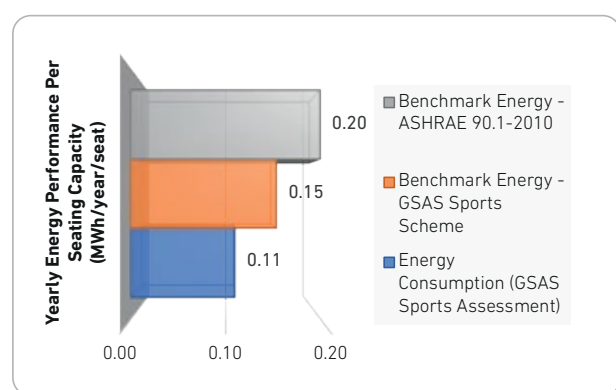


Figure 35: Yearly Energy Performance Per Seating Capacity - Stadium 974

▶ STADIUM 974

Indoor Water Performance Analysis

WPC _{eff} - Water Performance Coefficient for Water Efficiency	0.64	
Water Efficiency (GSAS Sports Assessment)	286.62	[m3/Peak Event, Normal & Training days]
Benchmark Water - GSAS Sports Scheme	447.84	[m3/Peak Event, Normal & Training days]
WPC _{KM/IPC} - Water Performance Coefficient Adjusted to Kahramaa/IPC Benchmark	0.52	
Benchmark Water - Kahramaa/IPC	551.19	[m3/Peak Event, Normal & Training days]
% Better than GSAS Sports Benchmark	36.0%	
% Better than ASHRAE 90.1-2010	48.0%	

Indoor Water Performance Per Seating Capacity

Seating Capacity	40,000	Seats
Water Efficiency (GSAS Sports Assessment)	7.17	[Liters/(Peak Event, Normal & Training days)/seat]
Benchmark Water - GSAS Sports Scheme	11.20	[Liters/(Peak Event, Normal & Training days)/seat]
Benchmark Water - Kahramaa/IPC	13.78	[Liters/(Peak Event, Normal & Training days)/seat]

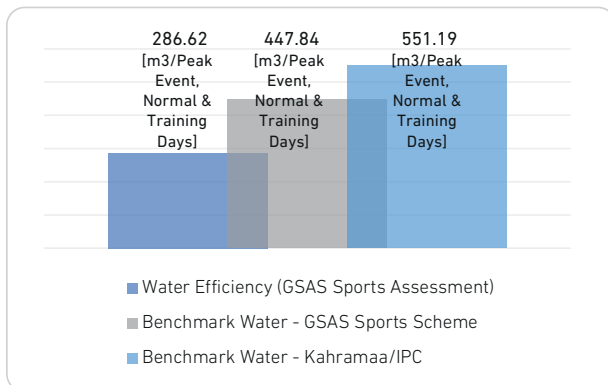


Figure 36: Indoor water Performance Analysis - Stadium 974

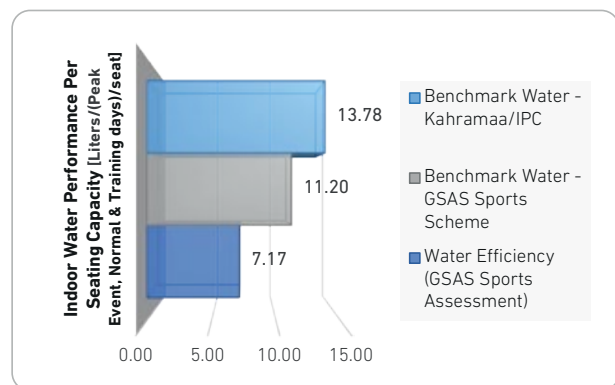


Figure 37: Indoor Water Performance Per Seating Capacity - Stadium 974

5.0 SALIENT FEATURES

Combining traditional Qatari design elements with cutting-edge technology, the FIFA World Cup Qatar 2022™ stadiums have been created with a focus on sustainability and efficiency. Drawing inspiration from the cultural heritage of the State of Qatar, the stadiums' designs feature a range of innovative features that prioritize energy and water efficiency.

► Envelope Design

High-performance envelope elements were used compared to conventional designs to reduce both solar and transmission heat gains thereby reducing thermal energy demand.

Below are the overall heat transfer coefficients (U-values) for main envelope elements:

- Average wall U-values – 0.28 W/m²K
- Average roof U-values – 0.29 W/m²K
- Average glazing U-values – 1.53 W/m²K



► HVAC System Design

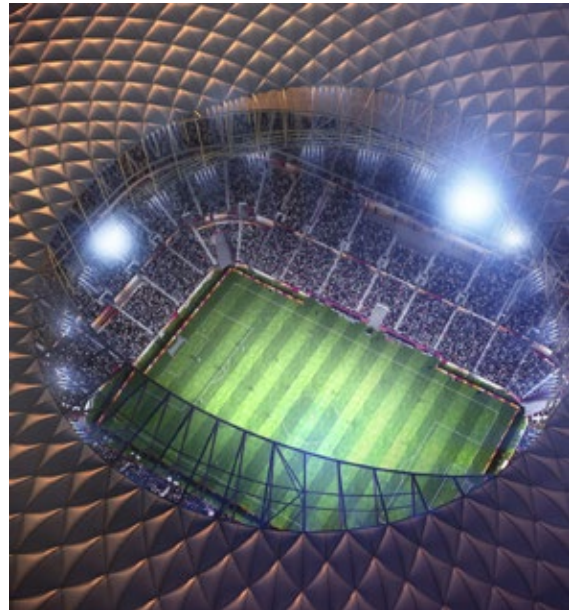
Energy recovery system was utilized in fresh air ventilation system to reduce the overall energy consumption.

Premium efficiency electronically commutated (EC) motors and plug fans were used in air handling units to reduce specific fan power (SFP). Additionally, Variable Air Volume (VAV) and Variable Frequency Drives (VFD) systems were used.



Below are the main elements of the efficient HVAC design:

- Average heat recovery efficiency – 69%
- Average ventilation SFP– 2.23 W/l/sec
- Average supply air SFP (AHUs) – 1.11 W/l/sec
- Average supply air SFP (FCUs) – W/l/sec



► Lighting System Design

Energy-efficient LED lighting fixtures were used. Automatic lighting sensors were also utilized.

Below are the main elements of efficient lighting design for non-sports lighting:

- Average lighting power density – 4.47 W/m²



► District Cooling System

Energy-efficient district cooling plants were designed and commissioned to produce chilled water for cooling stadiums. Each plant was assessed for 'Seasonal Energy Efficiency Ratio (SEER)' using GSAS Aracadia™ tool.

Below are the main elements of efficient district cooling plant design:

- Average SEER value – 3.95



EXECUTIVE SUMMARY

► Plumbing Fixtures Selection

Water-efficient plumbing fixtures were used to reduce the overall potable water demand; this includes dual flush WCs and waterless urinals.

Below are the main elements of the efficient plumbing fixtures:

- Average WC flush rate – 3.91 lpf
- Average flow rate of public lavatory faucet – 1.85 l/min.
- Average showerhead flow rate – 6.79 l/min.
- Waterless urinals installation in Al Janoub Stadium



► Landscape Design and Irrigation Systems

Local or native plants were considered for the landscape to reduce the consumption of water. Furthermore, Treated Sewage Effluent (TSE) was used for irrigation purposes further reducing the demand for fresh water.



6.0 CONCLUSION

A comprehensive review of all the stadiums evidences that the Qatar 2022 venues were designed with the objective of minimizing their impact on the environment, preserving natural resources and reducing carbon emissions. Due to this, 4 out of 8 stadiums were able to achieve GSAS 5-Star rating instead of 4-Star rating that was originally mandated by FIFA.

The measurable impact of these energy and water efficient features will ensure that the stadiums are operated in a sustainable manner and the same was verified by GSAS Operations certification where all the stadiums achieved GOLD rating while Al Bayt Stadium achieved PLATINUM rating.

On a wider level, the sustainability excellence of the FIFA World Cup Qatar 2022™ stadiums has ultimately built a long-lasting green legacy by serving as a driving force for future construction projects to adopt similar environmentally friendly practices.





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