CIBSE JOURNAL

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**GREEN HOMES**
Does the zero carbon definition stack up?

**COOL IDEA**
A fresh concept in heat recovery

**CIBSE'S NEW MAN**
The thoughts of President Ford

# DESERT BLOOM

## QATAR SCORES WITH WORLD CUP INNOVATIONS

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All images courtesy of Arup Associates

# SOCCER SPECIAL

Qatar is not only demonstrating its ability to build football stadiums that will remain cool in desert conditions. The nation that is hosting the 2022 World Cup also has 'carbon neutral' design at the top of its agenda. **Andy Pearson** reports

Qatar's demonstration mini-stadium will be monitored to assess how the technologies used will perform in desert conditions. Applications include armour-like PVC scales covering the steel frame (far left) and extensive use of photovoltiac sheets (left)

It was a surprise for some when Qatar's bid to host the 2022 football World Cup was successful. In the desert state's hot and humid summers, temperatures typically average 44C, but the thermometer can nudge 50C.

The football world governing body, FIFA, has even warned of a risk of heat stress for players in conditions above 24C wet bulb globe temperature (WBGT), which measures humidity, solar and wind factors as well as temperature. But Qatar is used to dealing with the heat, and one of the reasons for its successful bid can be found in the desert, on the outskirts of the capital, Doha, in the form of a miniature stadium.

Constructed in just four months, the 500-seat Qatar Showcase stadium was built to demonstrate that a harsh desert climate need not be a barrier to hosting the World Cup. When a delegation from FIFA visited the little circular stadium, the temperature was a scorching 44C outside; yet inside, on the stadium's five-a-side pitch, it was a very pleasant 23C WBGT.

The significance of the Showcase stadium in the desert state's bid success is not simply that it was air conditioned: the country's Al Sadd stadium already has a successful air conditioned pitch and stands. FIFA's remit to Qatar was 'to achieve the first carbon-neutral World Cup'. And so, according to its designers, the Showcase stadium stands as an example of a zero carbon development.

'This zero carbon, environmentally friendly, mini-stadium demonstrates that it is possible to provide comfort for football matches in the heat of the desert,' explains Mike Beaven, head of building services and environmental engineering at Arup Associates, the stadium's designer.

In addition to 'showcasing' these technologies, the stadium's other main purpose is to provide a facility to monitor the performance of the technologies under desert conditions. It is an important undertaking because Qatar has plans to incorporate low carbon technologies into the giant football stadiums planned for the World Cup. The three major components that will be investigated in the design of the stadium are: passive energy-saving architecture, solar-thermal cooling, and grid-connected, photovoltaic-generated electricity.

The stadium's architecture plays a critical role in ensuring comfortable conditions

> The Showcase stadium is important because Qatar has plans to incorporate low carbon technologies into the giant football stadiums planned for the World Cup

The mini-stadium aims to show how conditions can be kept to mild temperatures for players on the pitch with the use of sustainable technologies

> This zero carbon, environmentally friendly, mini-stadium demonstrates that it is possible to provide comfort for football matches in the heat of the desert

on the pitch. During the day the pitch and stands are protected from the sun beneath a giant domed roof canopy. This is formed from hundreds of triangular, amour-like scales of PVC material stretched over a steel frame. The PVC has a low-emissivity coating to reduce re-radiation of the heat. The scales are arranged to form a series of shaded, north-facing openings to let heat escape from beneath the roof while allowing reflected daylight to bounce into the space. Beneath the canopy a blanket of pillows made of ETFE – a transparent polymer sheeting – provide thermal insulation to limit the amount of heat radiated by the roof. This helps to ensure that conditions remain within ASHRAE comfort standards for the spectators.

In the run-up to a match the roof will remain closed throughout the day to shelter the stadium from the burning sun and enable the stadium's cooling system to cool the interior effectively. FIFA rules state that World Cup games should not be played under cover. The Showcase stadium's roof is divided into two semi-circular halves: a fixed, western section and a movable eastern section, mounted on tracks. To open the roof, the eastern half is rotated until it nestles beneath the fixed section. Matches will be played in the evening, so the fixed section is designed to shield the pitch from late-afternoon sunlight and to offer some protection against strong desert winds.

Arup Associates has turned the country's climate to its advantage when it comes to keeping the stadium, players and spectators cool. Adjacent to the stadium is a giant solar farm, covering an area roughly twice that of the stadium itself. The farm contains a giant linear Fresnel collector formed from 44 strips of flat-plate mirrors. These 32m-long mirrors are motorised so that they can rotate around a single axis to track the sun. The mirrors are arranged into four groups of 11. Each group of mirrors is angled to focus the sun onto a single vacuum absorber tube supported above the array. The tube contains water at a pressure of 16 bar. The high pressure enables the water to be heated by the sun to a temperature of to 200C without turning to steam.

The super-heated water is stored in a buffer tank before being pumped to a double-effect lithium bromide absorption chiller. Here it is used to drive water from the diluted lithium bromide solution as part of the absorption cooling process. The chiller produces water cooled to 6C.

To enable the solar-powered chiller's output to be stored until it is needed in the evening, the chilled water is piped to a 3.5m diameter, 12m long cylindrical storage tank buried below ground adjacent to the stadium. The water-filled tank is packed with eutectic blocks, measuring roughly 300 x 200 x 25mm. The blocks are filled with a material which freezes at 6C. The cooling is stored as latent energy in the material as it changes phase from liquid to a solid. When a match is under way, cooling energy is released back to the system as it returns to its liquid form.

> Arup has turned the country's climate to its advantage when it comes to keeping the stadium, players and spectators cool

Once the store is fully charged it can provide up to five hours of cooling. 'The really good thing about this solution is that once the tank is charged, the chillers can stop but you've still got cooling,' says Beaven. Should the solar system fail completely, the designers have taken no chances and installed a conventional, standby chiller.

From the storage tank, the chilled water circuit connects to two air handling units (AHUs). One AHU serves the back of house areas with chilled, dehumidified air; the other serves the pitch area through grilles beneath the spectators' seats. The pitch is surrounded with a concrete structure to add to the stadium's thermal mass, to mitigate heat gain from spectators and floodlighting. As the cold air descends to the pitch it forms a reservoir of cooled air in the bowl of the stadium to keep the players cool.

The biggest threat to the design is the wind. On cool days the cold air is held within the stadium bowl. However, on windy days there are concerns that the desert winds

Arup Associates

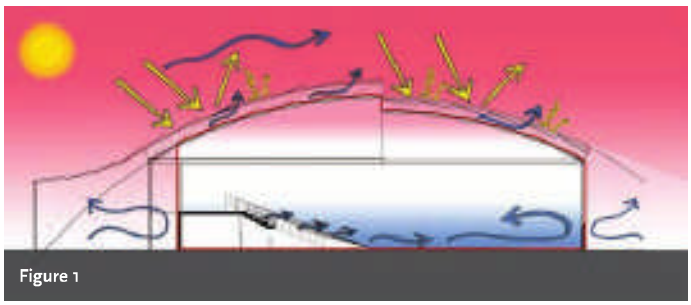


Figure 1

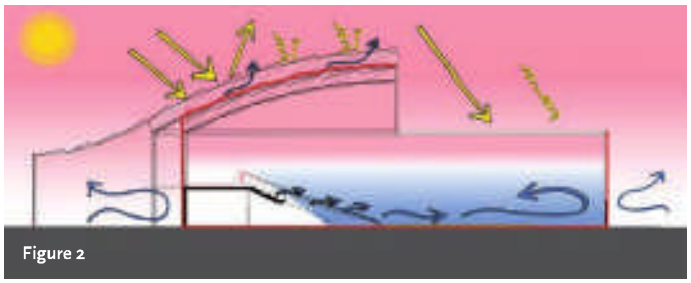


Figure 2

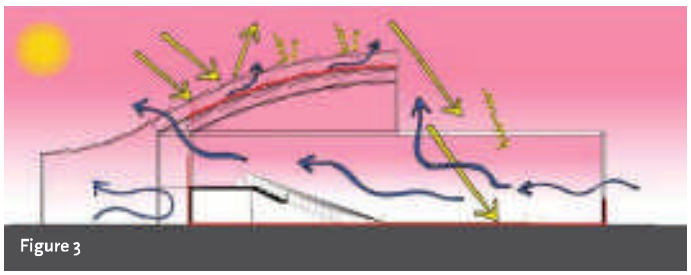


Figure 3

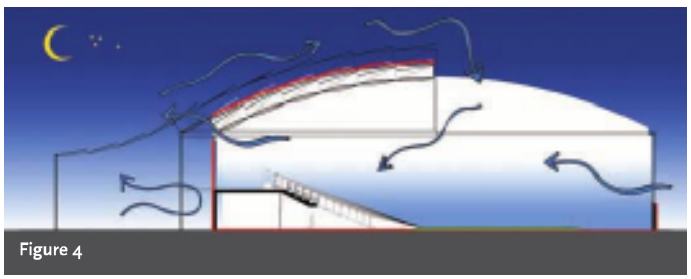


Figure 4

**Four depictions of the expected flow of hot and cool air during day- and night-time conditions:**

**Figure 1**
***Preparing for match – hot day:***
**Protection from direct sunlight and wind**
**Diffuse light entry through north roof lights**
**Underseat air supply**

**Figure 2**
***During evening match – hot, still day:***
**Roof open (On a windy day the the roof will remain closed)**

**Figure 3**
***Mild day (most of the year):***
**Roof and wall open**
**Direct sunlight**
**Entry openings for cross-ventilation**

**Figure 4**
***Mild evening (most of the year):***
**Roof and wall open**

will scour the chilled air from the stadium, exposing the players to untreated air. 'We predicted that wind will be an issue,' says Beaven. The extent of the problem, and finding appropriate solutions, is one of the areas that will be investigated further through monitoring actual performance of the Showcase stadium.

The final component of Arup Associates' design is a giant photovoltaic (PV) installation, located adjacent to the Fresnel reflectors on the stadium's solar farm. The PVs are connected to the stadium, from where they feed Qatar's national grid. They will generate electricity year round from solar radiation. Games take place in the evening so the PV's are of little use to power the stadium.

Instead, power for the stadium is imported from liquid biofuel-powered generators or it is drawn directly from the grid. However, the amount of electricity generated from PVs over a year has been calculated to exceed the total amount of electricity imported on match days. This allows the stadium to be described as a 'zero carbon' facility, according to Arup Associates.

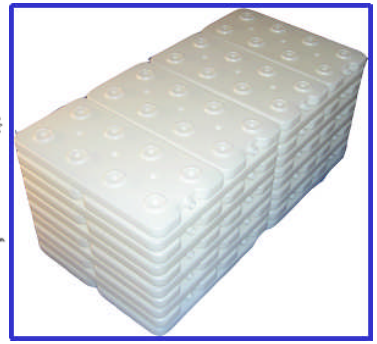
> Work is being undertaken to monitor the Showcase stadium's performance, as well as that of the various low carbon technologies

A curious part of electrical design is the inclusion of the biofuel-powered generators. According to Beaven, it is normal to power a stadium from generators to ensure certainty of electrical supply for critical matches. The electrical grid then acts as back-up should the generators fail. There is no shortage of gas to power generators in gas-rich Qatar. However, as FIFA is expecting Qatar to use 'clean, renewable energy resources'. So the generators are biofuel-powered. Unfortunately, Qatar has no biofuel resources and will have to rely on importing 'green' fuel.

Work is being undertaken to monitor the Showcase stadium's performance, as well as that of the various low carbon technologies, to see if they are appropriate to be integrated into the giant stadiums for the 2022 World Cup. Beaven is optimistic that Arup Associates is close to developing a suitable zero carbon solution: 'This is a prototype; it can be improved and upscaled,' he says. **CJ**

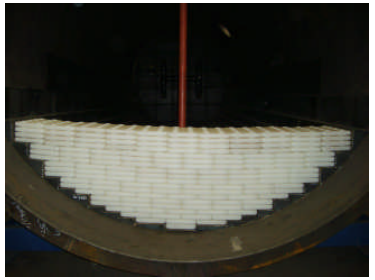
# QATAR SOLAR A/C APPLICATION







**100 m3 Tank filled with 16,750 FlatICE using S15 (+15C) PCM solutions providing 5 MWh thermal energy storage**





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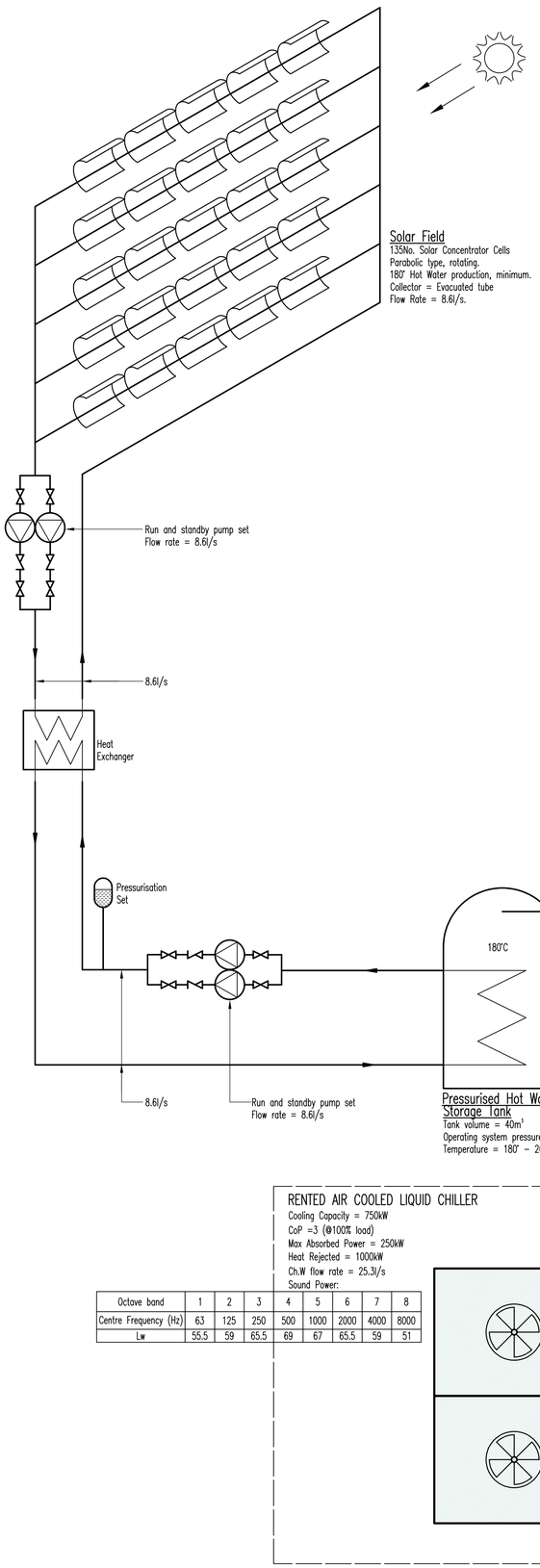


| Octave band | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Centre Frequency (Hz) | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
| Lw | 55.5 | 59 | 65.5 | 69 | 67 | 65.5 | 59 | 51 |

| Octave band | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Centre Frequency (Hz) | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
| Lw | 102 | 101 | 101 | 96 | 92 | 85 | 80 | 77 |

FIGURED DIMENSIONS ONLY TO BE USED

## Safety, Health and Environmental Information

In addition to the hazards/risks normally associated with the types of work detailed on this drawing and noted in the designer risk assessments and health and safety plan, note the following:

- It is assumed that all works on this drawing will be carried out by a competent contractor working, where appropriate, to an approved method statement.
- Where applicable, significant residual risks are highlighted in the body of the drawing.

Notes

Hot Water:
Temperature – 180 – 165°C
Flow Rate – 8.6l/s
Capacity – 540kW

Chilled Water:
Temperature – 7 – 14°C
Flow Rate – 61.7l/s
Capacity – 750kW

Cooling Water:
Temperature – 39 – 34°C
Flow Rate – 25.3l/s
Capacity – 1300kW

Outside Conditions:
Dry Bulb – 45°C
Wet Bulb – 23.8°C
Wet Bulb (extreme), for Cooling tower – 31°C

Commissioning & Control Valves to suit

All Equipment to be provided with onboard controls with the capability of connecting to Showcase BMS head end panel

All pump efficiencies to be greater than 70%.

| | | |
|---|---|---|
| C | 29/01/10 | ISSUED FOR TENDER |
| B | 25/01/10 | ISSUED FOR INFORMATION |
| A | JAN/10 | ISSUED FOR INFORMATION |

Revision A


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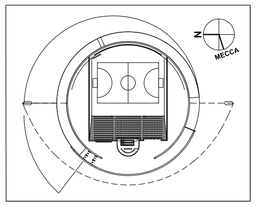
qatar 2022 | Qatar Football Association | BIDDING NATION QATAR

THE SHOWCASE




Drawing Title

MECHANICAL SERVICES
PRIMARY COOLING
SCHEMATIC

Scale bar

Scale N.T.S.

Status Tender

First Issued JAN 2010

| Job No. | Dwg. No. | Rev. |
|---|---|---|
| AA 211893-00/ | W-55-800 | C |

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PLOT ID: