World Cup matches cannot be played under cover, so a rotating roof protects the showcase from the sun and wind, but opens the pitch to the sky when needed

last year it commissioned Arup Associates design and deliver a 500-seat test stadium at would demonstrate how it could be done stainably.

The aim was to create a micro-climate well elow the danger level, which would also be mfortable for spectators. Arup took a ree-pronged approach with the design, hich has been built to accommodate a ve-a-side pitch.

According to Beaven, the easiest and robably cheapest way to achieve a ero-carbon stadium would have been to enerate as much electricity as possible sing renewables and use it for cooling. nfortunately, this would have created nwanted peaks on the electricity grid. nstead, the electrical energy needed for owering items such as the floodlights, fans nd pumps has been separated from that eeded for cooling.

A photovoltaic array will export electricity the national grid all year round and this hould exceed the amount of electricity nported for events during the year, making he facility zero-carbon for electricity.

Alongside the PV is an array of solar hermal collectors. These strips of mirrored etal track the sun and focus its light onto ollecting tubes filled with water. These heat he water to about 200°C after which it is iped to a storage tank, then to an bsorption chiller that charges up the ice tore (see box, opposite) that provides cooling or the match. "It's all existing, scaleable chnology," says Beaven. "They wanted radical nnovation using conventional components."

The third prong of the design is the uilding itself. A lightweight roof is designed

The PVC roof panels create north facing "cowls" that block out direct sunlight but allow a degree of natural light onto the grass pitch.

to protect the stadium from the hot summer sun and offer wind protection during matches. It comprises an oversailing west-facing fixed section made up of PVC "petals" on the outside arranged to create north-facing cowls that bring light into the space. Beneath this are ETFE pillows that help control solar gain.

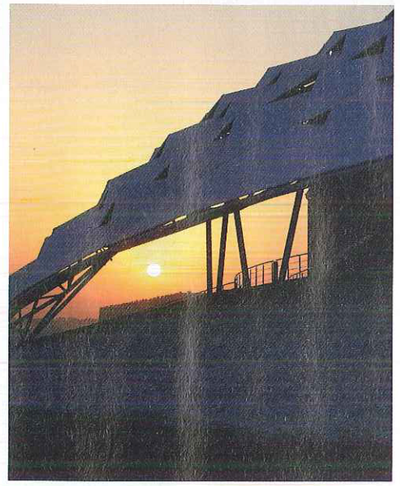
World Cup matches cannot be played under cover, so the other half of the roof is designed to rotate on motorised tracks, slipping beneath the fixed section and exposing the pitch to the sky. The idea is that the roof will be closed and the cooling started on the day leading up to a match. Air-handling units will pump out chilled air beneath the raked seats and this will create a reservoir of cold air in the stadium bowl.

To absorb and store the cold, the test stadium has been designed with a heavyweight, precast concrete structure at the lower levels. Come match day, the shading roof will remain closed over the space until the sun has passed overhead. Unless outside conditions are extremely hot and windy, the roof will then open and the match will begin, with the ice store providing cool air for spectators and players.

The biggest threat to this design is wind. The danger is that when it hits the rim of the stadium's top tier of seating, it will create currents that scour out the reservoir of cool air in the bowl. "On a still day this isn't an issue but on a windy day the cool layer of air is reduced and one of the things that will need to be looked at in future designs is how we prevent this happening," says Beaven.

The baby stadium was designed in just six weeks and construction was completed in six months, in time for the FIFA delegates to visit after the South African World Cup.

UNLESS IT IS EXTREMELY HOT AND WINDY, THE ROOF WILL OPEN AND THE MATCH WILL BEGIN, THE ICE STORE PROVIDING A CONSTANT SUPPLY OF AIR TO COOL SPECTATORS AND PLAYERS



OLD TECH IN A NEW WAY

The Qatar 2022 test stadium packages together a host of well understood technologies. The photovoltaics are off-the-shelf panels, and the solar thermal array is made up of mirrored strips on motorised pivots that track the sun and are lighter and easier to control than the parabolic mirrors that are more commonly used.

One of the concerns with the mirrors was how to keep the reflective surfaces clean in the dusty environment without wasting water on washing them. The solution turned out to be simple: run a squeegee along the surfaces in the morning when they are covered in dew.

The idea of the hot water storage tank is to create a two-hour buffer of hot water to supply the absorption chillers. These work best when there is a continuous supply of water at a constant temperature, and the store is sized to provide two hours' worth at 200°C.

The absorption chillers take this hot water and, through a complex process, use it to generate water cooled to 7°C, which is used to charge the ice store. In fact, this is packed with hundreds of balls made from a wax-like phase change material that freezes at 7°C. These store the cold like an ice pack in a freezer bag ready for the match later in the day. The store is oversized to provide six to seven hours of cooling, although for a larger stadium this could be resized to provide about two hours.

Key components of the 2022 showcase

1) *Solar thermal collectors*
2) *Hot water storage tank*
3) *Absorption chillers*
4) *Ice store*
5) *Air-handling units that blow cold air out beneath the seating*
6) *Lightweight rotating roof*