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A tall order – Cooling Dubai's Burj Khalifa

In January the world's tallest building, the Burj Khalifa, was officially opened in Dubai. At 828m tall, its mechanical services are on a scale like nothing seen previously in the Middle East, writes Carly Fordred.

In a lavish opening ceremony on January 4, the Burj Khalifa was officially opened for use in Dubai in the United Arab Emirates.

The building, which is of mixed-use (see page 11), is part of Dubai's flagship development, Downtown Burj Dubai, which is also home to a mall, parks, hotels and a $226 million fountain. The entire Downtown Burj Dubai precinct is reported to have cost in the region of $22.6 billion, with the tower alone costing $1.7 billion.

The Burj Kahilfa was formerly known as Burj Dubai. The change to Khalifa refers to the ruler of the neighbouring emirate of Abu Dhabi, whose multi-billion dollar bailout in the middle of the economic slump helped Dubai's biggest developer to avoid a potentially disastrous debt default. Burj simply refers to the "tower".

The tower not only breaks records for its height. Some of the more unusual records include the world's highest mosque (located on the 158th floor) and the world's highest swimming pool. Four air-cooled chillers that provide standby cooling capability for data centres installed on the 155th and 159th floors are believed to be the highest installation of air-cooled chillers in the world.

The design and build of the tower defines a truly global partnership, with architecture and engineering services performed by a US-based firm and primary contractors sourced from South Korea, Belgium and locally in the United Arab Emirates.

The plant

Reportedly, HCFC-123 refrigerants are used to cool the Burj Khalifa, which has a significantly lower global warming potential than similar projects using HFC-134a in surrounding areas, one source reports.

The tower is cooled via a specially designed district cooling plant, which houses three individual plants and supplies chilled water to Burj Khalifa, and part of the Downtown Burj Dubai precinct, including the Dubai Mall and two five-star hotels.

The size and location of the tower in the desert heat necessitated the installation of an ice-chilled water system.

The core of the system is the central district water plant from which the tower is normally serviced. In the case of a problem, the system can be switched to use water from one of the other cooling plants to service the tower.

The central water plant uses a massive ice reservoir as a thermal storage system. Ice slurry is created

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in off-peak hours and then used to reduce power consumption during the day.

The ice system allows for a one-third reduction in the size of the chiller network. It permits delivery of water to the tower that is colder than usually delivered by conventional chillers alone. This ice-based thermal storage chilling system is the first of its kind to be used in the Middle East.

Large 75cm pipes bring water with a temperature of 3.3˚C from the central water plant to the basement control centre in the tower, where heat exchangers act to separate the incoming water from the higher pressure water in the tall tower. These pipes also deliver chilled water from the central water plant to several other associated buildings before arriving at the tower itself. From the tower basement the water is distributed up into the tower in 60cm pipes that gradually diminish in diameter as the water moves upward through the various sections of the building. Once the chilled water has passed through the fan coil units that cool the air for the air conditioning systems, the water flows back down the tower before being pumped back to the central water cooling station.

The Burj Khalifa is home to 160 habitable floors, plus 46 maintenance levels in the spire and two parking levels in the basement. Designed as a building of mixed-use, its floor space is divided into the following:

Floors	Use
160 and above	Mechanical
156–159	Communication and broadcast
155	Mechanical
139–154	Corporate suites
136–138	Mechanical
125–135	Corporate suites
124	Observatory
123	Sky lobby
122	Restaurant
111–121	Corporate suites
109–110	Mechanical
77–108	Residential
76	Sky lobby
73–75	Mechanical
44–72	Residential
43	Sky lobby
40–42	Mechanical
38–39	Armani Hotel suites
19–37	Armani Residences
17–18	Mechanical
9–16	Armani Residences
1–8	Armani Hotel
Ground	Armani Hotel
Concourse	Armani Hotel
B1–B2	Parking, mechanical

Fireworks blast from the Burj Khalifa during the opening ceremony.

The Burj Khalifa's water system supplys an average of about 946,000 litres of water per day. At peak cooling times, the tower will require approximately 10,000 tonnes of cooling per hour, which is equivalent to the capacity provided by 10.2 million kg of melting ice in one day.

Condensate collection system

Due to the high humidity of the Persian Gulf, which can sometimes reach as high as 98 per cent for many months of the year, water condensation can be problematic when building skyscrapers such as the Burj Khalifa.

Large quantities of condensation water can cause discolouration on windows and cladding, and damage to electrical systems and steel components. The risk of developing precipitate condensation if sufficient warm exterior air is introduced to the interior of the building is also high.

The air conditioning system is the tower's largest producer of condensation water. The plants generate about 191,000 litres of condensed water per day.

A separate system collects all of the condensation water, including from the air conditioning system and external surface collectors, and carries it through a set of pipes back down to a holding tank located in the basement car park. The water is then pumped into the site irrigation system for use on the surrounding Burj Khalifa park.

The electrical systems are protected by thousands of small low-voltage anti-condensation heaters, particularly in the enclosed electrical switch panels where moisture has the potential to build.

To avoid warm air clouds in the building, the air conditioning system units were slowly brought up to speed while increasing the cooling function over a week-long process. To avoid over-complicating the problem, exterior air is not introduced into the tower. Rather, areas such as the atrium are vented to an interior airspace. ▲

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Sustainable design features

To achieve high performance in the Burj Khalifa, designers looked to sustainable technology.

High performance glazing with a low emissivity glass provides the tower with enhanced thermal protection against the high temperatures experienced in Dubai. (Between 35°C – 45°C from April to October)

The conduction of electric power using higher voltage reduces energy losses and increases energy efficiency compared to low voltage energy distribution.

Electronic metering enables ongoing energy optimisation over the tower's lifetime.

Smart lighting and mechanical control using a Building Management System (BMS) lowers the costs of operation, and allows a more efficient use of building resources and services.

Thermal differences between the building's interior and exterior generate a stack effect. Stack effect controls were designed to passively control these forces, reducing the need for mechanical means of pressurisation.