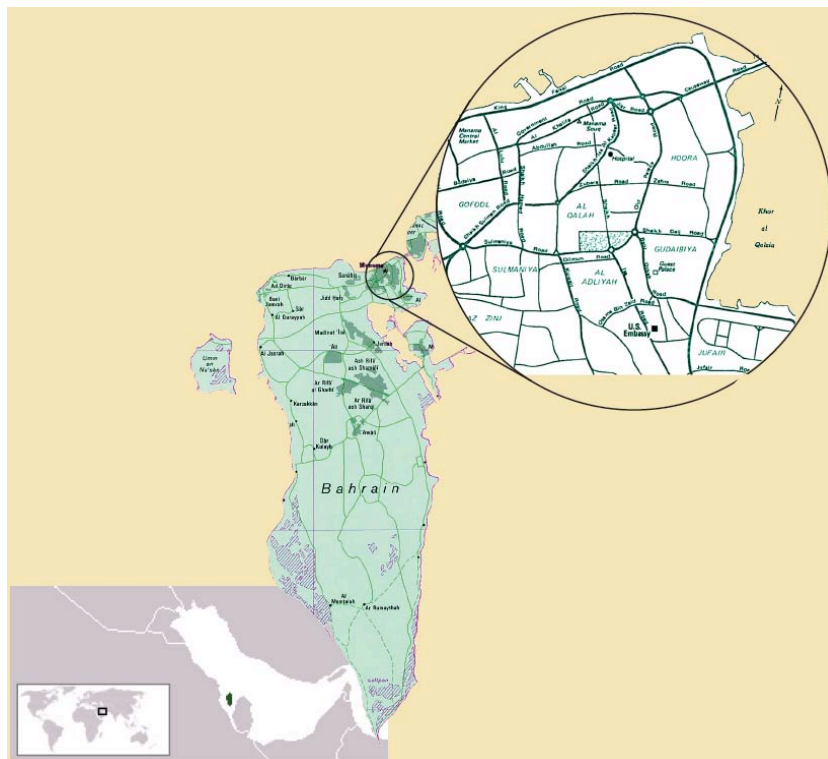


# Bahrain World Trade Center



Receiving multiple awards in the area of sustainability (2006 LEAF Award, The Arab Construction World for Sustainable Design Award, a 2008 'Best Tall Building Award', an honorable mention in the 2009 NOVA)<sup>1</sup>, the Bahrain World Trade Center (BWTC) serves as a revolutionary model for innovation in green design as the first skyscraper in the world to embed industrial wind turbines within its building's structure. The BWTC is situated on the Manama waterfront (Bahrain's capital city) bordering northern Qatar in eastern Saudi Arabia in the heart of the region's financial hub (about an hour's car journey from Dubai). The Kingdom of Bahrain is made up of an archipelago of 33 island- the largest being Bahrain island- with an entire country only spanning an area of 700 square kilometers and a population just under 700,000. Bahrain- one of 33 islands- has long been regarded as the financial and banking hub of the Middle East.



<sup>1</sup> The LEAF award (formerly The Emirates Glass LEAF Award) serves as an international architectural prize that recognizes architectural design in both private and public sectors of any building in the world. Operated by a Forum known as the Leading European Architects founded in 2001, this private association like the Arab Construction World for Sustainable Design Award is operated by private entities without governmental regulation and oversight. The NOVA Award is an annual award governed by the Construction Innovation Forum (CIF) since 1989, to acknowledge innovations proven to provide significant advances that have had significant effects on construction to improve quality and reduce cost.

<sup>2</sup> Bahrain World Trade Centre, Manama, Bahrain. *Designbuild-network.com*. <http://www.designbuild-network.com/projects/bahrain/> Accessed 2009.

Thus, the investment in such an innovative and revolutionary skyscraper should be understood as a product of an emerging private demand in sustainable design and construction. The building however, should not be construed as being situated in an extremely ‘busy’ or ‘metropolitan’ environment with a range of neighboring structures and buildings. This will become important in understanding both the genius of its innovation and potential limitations of this type of design.

## Origins

A member of the World Trade Center Association, the BWTC was fully backed and well financed with institutional investors but required a construction feat unaccomplished by any engineer or architect. The original impetus for the integration of wind turbines between the twin towers was strictly architectural, but soon developed as a sustainable solution. The wind climate in the Arabia Gulf prompted designers to utilize the concept of wind turbines in large-scale buildings. Previous research and attempts at integration turbines into failed to materialize due to high costs associated with such an adaptation of building design. Such endeavors would increase project costs up to 30%. However, designers from Atkins Architects and Norwin turbine specialists<sup>3</sup> were able to design an integrated turbine system that required only a 3% premium on project costs. This combination of a favorable natural wind system alongside creative design and lowered construction costs make the BWTC an important step toward innovated cost-effective designs.<sup>4</sup>



ATKINS

## Technology

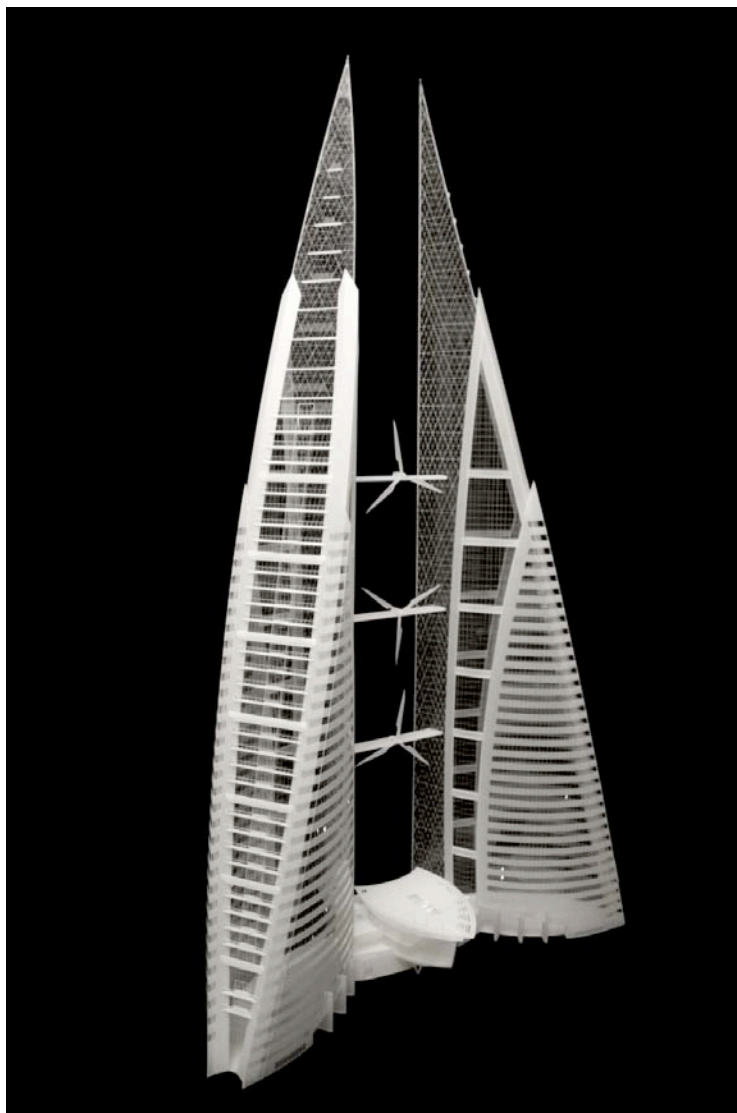
The BWTC introduces an array of technologies to become the kingdom’s first intelligent building. “SMART” technology is integrated throughout both office towers. The SMART technology utilizes Intelligent Building Management Systems (IBMS) to monitor operational, facility

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<sup>3</sup>Included among the “20 Best Big Companies to Work For 2008”, Atkins Architects plans, designs and facilitates the delivery of complex capital programs for clients in both public and private sectors all across the world. They represent the largest engineering consultancy in the United Kingdom and the world’s 5<sup>th</sup> largest design firm. Norwin Wind Turbine Technologies is a Denmark based engineering company focused on turbine development with operations all over the world and most currently in China and India.

<sup>4</sup> Bahrain World Trade Center Press Release. *Bahrain WTC*. Accessed 2009

and infrastructure management. These systems optimize energy use in heating, cooling, lighting, and security functions. The towers are also equipped with a structured cabling system (SCS) that integrates all forms of surveillance, data, and energy use with all operating systems. Security at the BWTC includes the latest CCTV surveillance and monitoring systems equipped to provide tenants with crisis management and disaster recovery emergency protocols. The building also includes “the automation of visitor management from parking to building admission including that for VIPs, a reservation management system for shared building facilities, an online helpdesk for maintenance requests and servicing and web-based billing enquiry systems.”<sup>5</sup>



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<sup>5</sup><http://www.menareport.com/en/business./198880>

<sup>6</sup> Bahrain World Trade Center Press Release. *Bahrain WTC*. Accessed 2009

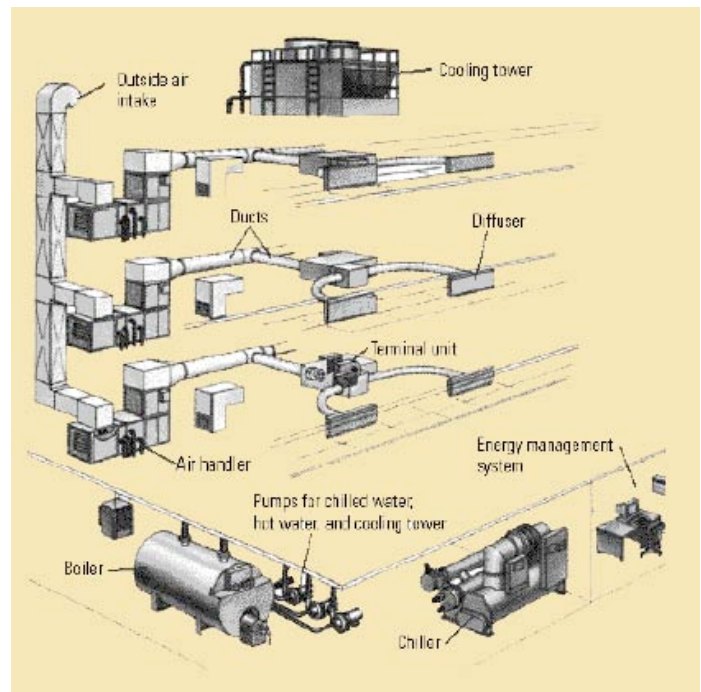
## Structural Details

The BWTC will primarily service business tenants in its office spaces in the two wind sail shaped towers. The three ground floor levels will accommodate a MODA shopping mall, food courts, retail dining, a business complex, and access to parking.

## Resource Efficiency

The structure boasts a host of environmentally sensitive designs and energy saving features contributing to reducing carbon emissions. Each individual office in the towers has its own energy meter allowing each individual tenant and occupant to control their energy use and monitor usage and costs.

Certain areas provide deep gravel roofs that provide kinetic insulation, while balconies to the sloping elevations with overhangs that provide shading. Dense concrete core and floor slabs will level loads and reduce peak demand with associated reductions in air and chilled water transport systems.<sup>7</sup>



To minimize energy lost to cooling and ventilation, buffer zones were incorporated between outside environments and air-conditioned spaces. The buildings and adjoining complex is cooled by a highly innovative air conditioning and cooling system using chilled water (see figure above). This setup allows for optimal efficiency and cost savings and provides an environmentally sound alternative to conventional cooling systems through the recycling of water (discussed later)/ Examples also include adjacent car parks to reduce solar air temperature and solar gain.<sup>8</sup>

<sup>7</sup> Bahrain World Trade Center Press Release. *Bahrain WTC*. Accessed 2009

<sup>8</sup> Solar gain commonly referred to as solar heat gain or passive solar gain refers to the increases in temperature in either a space, structure, that results from solar radiation.

The building uses double-paned low-leakage windows with the ability to be opened.<sup>9</sup> This provides a mixed mode operation with the option to open or close windows according to seasonal and climate changes.

### *Sewage Treatment*

According to Karolides, “in most cities, up to 10% of everything that is flushed down the toilet escapes the treatment plant and ends up in waterways,” and that often, “the first goal for more sustainable sewage systems is to reduce the amount of effluent that needs to be treated in the first place with water-efficient plumbing fixtures.”<sup>10</sup> In congruence with Karolides’ recommendations, the Bahrain WTC provide water and air transport systems (water pumping, piping, fan systems) that employ systems which require less initial start-up and maintenance energy. The water system’s piping structure also uses a dual drainage system that distinguishes between clean and wastewater for water treatment purposes. This also allows for water recycling within the Bahrain WTC towers themselves and diverting sewage, wastewater, and solids through an isolated sewage treatment system. The flushing systems are also completely electronic with flow restrictors that optimize water usage and provide more sanitation. Decorative pools in actuality serve as reflection pools at the building entrances to provide local evaporative cooling<sup>11</sup>. Surrounding all this are solar powered road lighting.



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<sup>9</sup> Double-paned glass or windows consist of two facing glass panels in a frame separated by a small space (.5 -1 inch wide) often filled with nontoxic gases like argon to improve insulation. Depending on the window specifications, double-pane windows usually have R-values above 2 and can account for a 10-25% reduction in heating and cooling bills.

<sup>10</sup> Karolides, 15

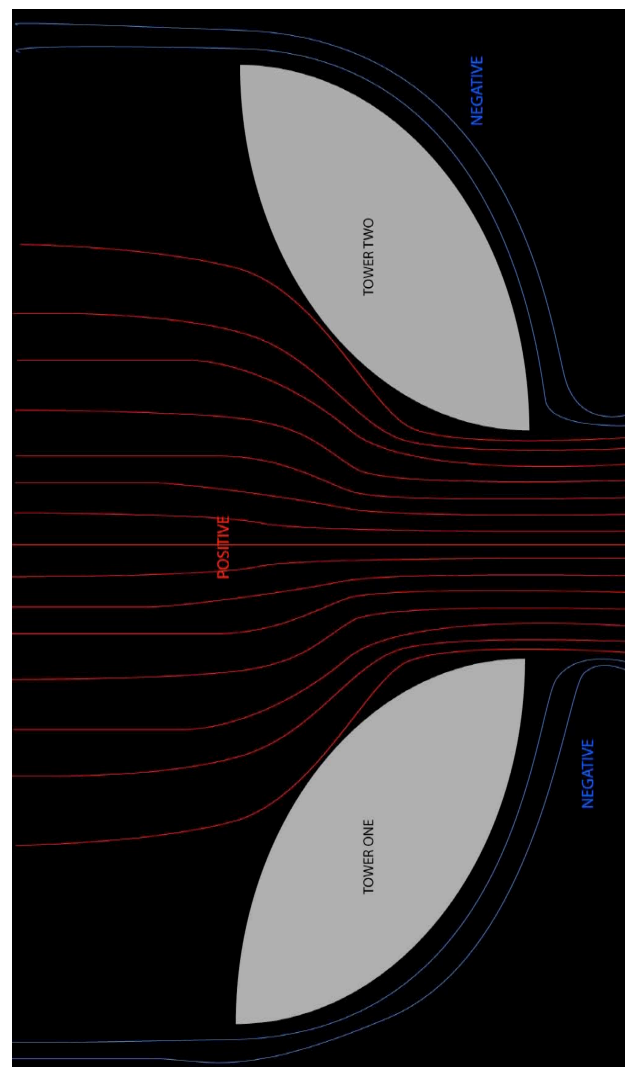
<sup>11</sup> Evaporative cooling refers to a physical phenomenon where the evaporation of a liquid cools the surrounding area’s air and objects nearby.

## Wind Turbines

The most impressive innovation however, is the ground-breaking incorporation of wind turbines between the two towers as a source of renewable energy. The BWTC stands 787 feet high (50 stories) as a twin tower complex with three bridges each holding their own 39-meter diameter wind turbine. Each turbine has the capacity to generate 225kW of energy totally 674kW. These wind turbines operate roughly 50% of the time and provide 11% - 15% of the entire structures total power consumption (1.1-1.3 MWh/year).<sup>12</sup> The turbines are placed between the buildings, with the sail-like forms of the towers creating a concentrated flow of wind to power the turbines. As Bahrain experiences periodic droughts and dust storms, in the case of severe weather and wind conditions, the turbines are designed to automatically slow down and have the blades pivot to avoid any volatile and potentially dangerous wind forces beyond the engineering threshold of the turbines.



The shape and curvature of the two towers acts as an airfoil and funnels sea breeze from the Arabian Gulf between them. Servicing as airfoils, the two buildings can divert wind to create greater wind speeds. These turbines convert kinetic win energy into mechanical energy in the form of electricity. Referring to the diagram, the towers' elliptical forms and sail-like profiles act as airfoils, creating a negative pressure zone behind, thus accelerating the wind velocity between the towers into the path

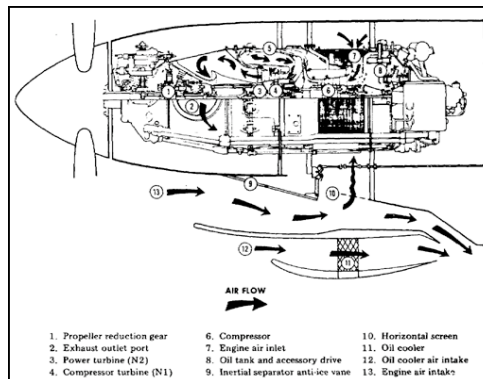


<sup>12</sup> equivalent to providing lighting for approximately 300 home annually

of the turbines. Because wind speeds vary with height, the engineers had to develop a plan to normalize turbine speeds to avoid collapse and structural strain on the two towers. The designers came up with a tapered shape that can adequately adjust for these varying wind speeds. Even with higher wind speeds at higher altitudes, the turbines still have nearly constant vertical velocity profiles. The exact curvature and airfoil created also allows for any wind coming within a 45 degree angle to either side of the central axis (area between the two towers) will create a wind stream perpendicular to the propellers, significantly increasing the turbines ability to harness wind streams.

For the BWTC, horizontal axis wind turbines are used where rotors must be placed facing into the wind, making the positioning of the turbines between the two towers of utmost importance. A horizontal axis wind turbine does have its advantages and disadvantages. Mentioned earlier, the angle of the blades can be adjusted to accommodate and optimize for the most efficient use of wind conditions. These blades can also be “pitched” in the event of strong winds to minimize stress. On the other hand, wind turbines require constant smooth wind flows. With the BWTC’s three elevations of turbines, performance of the lower turbines may be inconsistent as wind speed and direction tends to be more variable closer to the ground. From a cost standpoint, turbine production has not yet kept up with demand and prices have skyrocketed over 60% in the past three years with industrial orders fully booked up almost a year in advance with no signs of slowing in demand.

The positioning of the BWTC has also been a topic of argument regarding environmental sensitivity. Though coastal locations are usually windy<sup>13</sup> and good sites for turbine installations, wind farms in these locations often jeopardize environmental aesthetics and certain natural ecologies (birds).<sup>14</sup>



<sup>13</sup> A primary source of wind convection comes from the differential heating and cooling of land and sea over the course of 24 hours. Winds at sea level carry more energy than winds of the same speed in mountainous regions because of denser air at sea level.

<sup>14</sup> Bahrain World Trade Centre, Manama, Bahrain. *Designbuild-network.com*. <http://www.designbuild-network.com/projects/bahrain/> Accessed 2009.

## Conclusions

There is no doubt that the Bahrain World Trade Center tackles many key criteria of resource efficiency and green design. But despite the many successes, the BWTC still has many shortcomings in terms of sustainability. One must remember that the original drive for the BWTC's sustainable design came from a somewhat aesthetic and architectural incentive, using its design as simply a symbol of sustainable development and design solutions. In no way should one downplay the brilliance of the building's design, engineering, or sustainable approach, but simply keep in mind the heavy architectural emphasis of its origins.

Sustainable development and "true" green building as Karolides describes, "is a holistic approach to programming, planning, designing, and constructing (or renovating) buildings and sites. It involves analyzing such interconnected issues as site and climate considerations, building orientation and form, lighting and thermal comfort, systems and materials, and optimizing all these aspects in an integrated design."<sup>15</sup> To categorize the entirety of the BWTC as a "true green" initiative and project simply isn't true. The concept design of the BWTC was inspired by the traditional Arabian "Wind Towers". The intent and purpose behind installing wind turbines- albeit green- was not "holistic" with sustainability at the core of the buildings concerns. Issues of transportation and accessibility often conflict with notions of sustainable urban design and infrastructure development relying solely on private automobiles. Construction also used the most cost-effective (cheap) materials and processes regardless of environmental impact with no cradle-to-grave assessments. Most shockingly, according to a recent paper by Shaun Killa and Richard F. Smith (Design Director and Principal Architect for Atkins) on the technical proficiencies of the BWTC, they even cautioned that, "This building is not intended to be a low carbon emission solution by **European and other world-wide standard,**" and only, "reduce carbon emissions when compared to other buildings in the Middle East."<sup>16</sup> Even with the array of sustainable features, the lack of independent certification (LEED or otherwise) and standardization (in which one could grade its performance) severely jeopardizes the BWTC's label as a sustainable project applicable to other scenarios.

Ultimately, while the building's limitations does raise certain questions and environmental concerns, one should appreciate and understand this revolutionary design as a pioneering step toward sustainability and green design through the potentials of modern engineering and architecture.

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<sup>15</sup> Karolides, 4

<sup>16</sup> CTBUH 8th World Congress 2008

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