Exploring Masdar City

Masdar CITY

Section 1

Masdar City Tour

Welcome to Masdar City, a clean-technology cluster located in what aims to be one of the most sustainable cities in the world. As you will see and hear during your tour, bringing such a project to life necessarily began at the design stage, long before the first shovel of sand was lifted. It will continue throughout the construction phase and will be maintained during the life of the city.

Proposed Masterplan of Masdar City.

Masdar City Tour Map

Masdar City Introduction

In order to achieve the city's goal of being one of the most sustainable cities in the world – as well as a great place to live and work – every aspect of the city's urban planning and architecture has been approached with sustainability in mind.

More specifically, design should seek to facilitate energy generation where applicable (such as the angling and shape of roofs) and reduced consumption of electricity and water. As a result, seven overriding characteristics define Masdar City:

Optimally Oriented
The city and street grid are oriented on a southeast-northwest axis, thereby providing some shading at the street level throughout the day, minimising thermal gain on building walls and facilitating the flow of cooling breezes through the city.

Integrated
There are no separate zones for industry or culture. The university and traditional business elements are embedded in the heart of the community, as are entertainment and leisure facilities. Residents and commuters living and working here will find everything they need close at hand.

Low Rise, High Density
These two elements are central to a low-energy urban community for a variety of reasons, including lower energy use on transportation (both between and within buildings) and reduced heating/cooling loads.

Vibrant urban Realm
Public spaces are as important as the buildings in Masdar City, with a variety of tactics used to activate these space. As a result, the city is a place where streets and squares facilitate interaction and engagement with fellow residents, commuters and visitors.

Pedestrian Friendly
A pedestrian city on the pedestrian level of the street allows buildings to be closer together, thereby providing greater overshading and a cooler street environment.

High Quality of Life
Masdar City is designed to provide the highest quality of life with the lowest environmental impact, in part to demonstrate that environmentally responsible living does not imply hardship.

Masdar City Facts

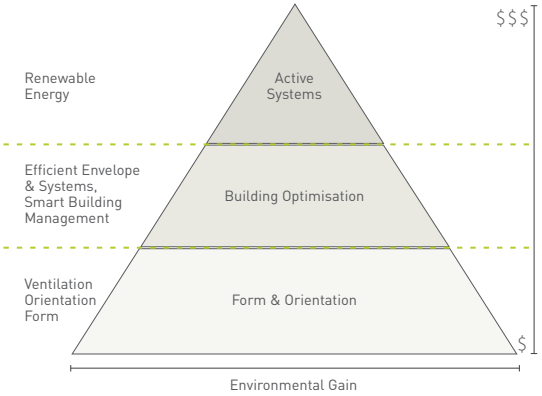
Area of development:
Approximately 7 square km

City Footprint:
50% of total site area

Population density:
130-160 people/hectare

Building heights:
Average height: 4-6 storeys
Maximum height: 40 metres

Street width:
Central Spine: 25 metres
Main streets maximum: 14 metres
Secondary streets: 8.5 metres



Convenient Public Transportation

Whether through the network of electric buses, other clean-energy transport solutions and the PRT system being test piloted, or the Abu Dhabi light rail and metro systems, Masdar City is designed to be comfortably and easily reached and traversed by public transportation.

Traditional Arabian City Design

The city's master planners, took inspiration from traditional Arabian city planning. Not only does this indigenous design incorporate numerous strategies to address the desert climate, but it also is characterised by relatively low overall energy consumption. That's because traditional Arabian cities are compact and densely populated. They are also socially diverse places where people live and work in the same environs, and feature lively and enjoyable public spaces.

Environmental Pyramid

As this simple pyramid shows, the biggest environmental gains come from the least financial investment: the city's orientation and form. This is equally true of the buildings. In the middle of the pyramid is building performance optimisation, with tools such as responsive shading and maximising the use of natural lighting and ventilation. At the top, where you have active controls such as heat recovery and photovoltaics, you spend the most money with the lowest (relative) returns. Given this, designers concentrated on the lower two tiers of the pyramid first, thereby reducing a large amount of energy demand with little cost, and only then focused on the active controls because they are the most expensive.

01 International PV Competition

There are more than 35 different panels being tested as part of the competition, including both thin-film and crystalline. The results of the first round of testing helped in the selection of the roof-mounted PV panels used for one of the Masdar Institute buildings.

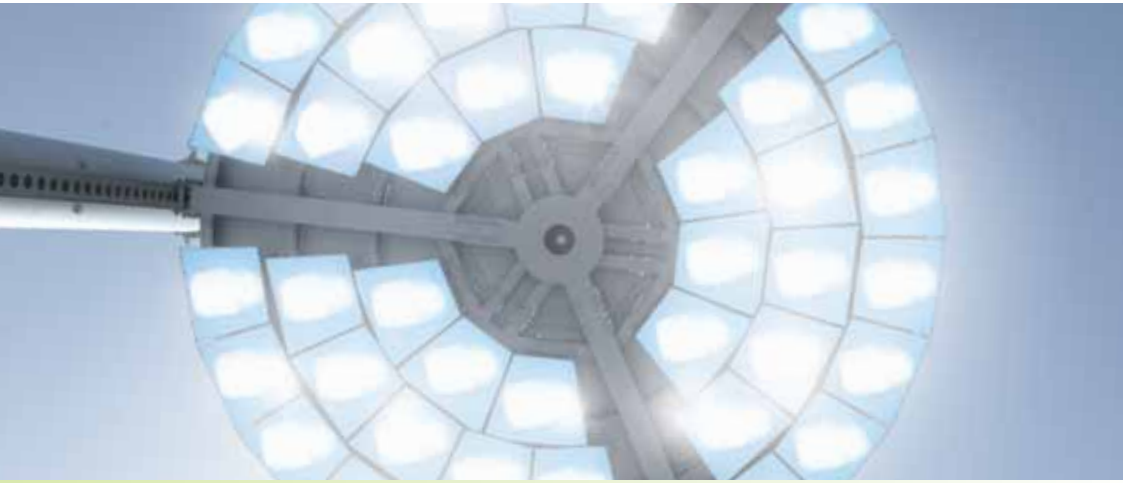
Photovoltaic panels will provide much of the electricity generated within Masdar City, so selecting the right technologies for Abu Dhabi's climate is crucial. For example, some types of panels are less efficient in the UAE's strong desert sun, while others may not perform well in the humid, sandy conditions prevalent during significant periods of the year.

As a result, one of the first test programmes to be inaugurated at Masdar City was the International PV Competition, which began in September 2008. Currently there are panels from more than 35 suppliers being tested for their energy yield, efficiency, ambient temperature effects, sand effects, etc.

The results from the test field help guide Masdar City in selecting the best PV modules for both roof and ground placement. The information is also shared with Abu Dhabi authorities to aid in their decisions regarding use of PV panels in the emirate.

At the completion of the first one-year cycle of testing, several companies' panels were removed because of low performance. They were replaced by panels from some of the many other companies on a waiting list to be part of future rounds of testing.

02 Beam Down Project



DID YOU KNOW

Depending on the receiver technology used, the temperature of the heat-transfer fluid in the tower could reach 700 degrees Celsius, 2-3 times hotter than the temperature achieved in trough concentrating collectors and the same temperature as volcanic magma.

The Beam Down Project - a joint pilot project of the Masdar Institute of Science and Technology, Japan's Cosmo Oil Company and the Tokyo Institute of Technology - takes the conventional concentrated solar power (CSP) design and literally turns it on its head.

Most CSP plants use mirrors (heliostats) to direct the sun's rays onto a receiver at the top of a central tower, heating a heat-transfer fluid (molten salt, oil or water), which then is used to generate steam for a steam turbine.

Managed by Masdar Institute, the Beam Down Plant has the potential to convert sunlight into electricity in a more efficient, lower-cost way than other technologies. By placing the receiver at the base of the tower (ground level), the thesis is that it will eliminate the energy loss resulting from pumping the fluid to an elevated receiver.

Sustainability Fact
Although still in the R&D stage, initial results show that the 100kW tower could generate 75-85MWh of clean electricity a year, enough to power 10-15 homes.

03 Geothermal Testing

DID YOU KNOW

The drilling rig is approximately 58m high – as tall as a 20-storey building – and weighs 500 tons. There is more than 18 kilometres of piping on site for use in the drilling.

One of the most exciting projects at Masdar City was the exploratory drilling deep underground to test the availability of sufficient, and sufficiently hot, geothermal water to be used in thermal cooling and domestic hot water. Power production and desalination also constitute possible applications of geothermal energy, although in our case, purely thermal applications (cooling, domestic hot water, desalination) are the most advantageous. The amount of cooling, desalination and heating the geothermal resource can provide is being evaluated. This will be a direct geothermal plant relying on heat exchange with deep underground aquifers.

Initial results are promising and confirm Masdar City's ability to address a significant portion of the base cooling load of the city's first phase using absorption chillers continuously supplied with geothermal heat. The main focus initially is expected to be thermal cooling and, possibly, central provision of hot water for showers and sinks.

The drilling of a pair of wells is now complete – one for drawing hot water, one for re- injection of this water after heat extraction. Both wells have been drilled to about 2,500m, where sufficient temperature and flow have been achieved to drive an efficient configuration of absorption chillers. For power generation and/or desalination, deeper wells would be needed to reach higher temperature aquifers. The stationary geothermal water temperatures in the aquifers below Masdar City can be estimated at between 85°C and 105°C.

The rig used for drilling was a relatively large oil- and-gas drilling rig that had undergone minor modifications for geothermal operations. Now that the rig has completed drilling, the wells will provide energy to Masdar City with a minimal visible footprint on the ground.

04 10MW Solar Photovoltaic Farm

DID YOU KNOW

The farm aims to produce 17,500MWh of clean electricity annually, thereby offsetting 15,000 tons of carbon emissions per year - equivalent to taking 3,300 cars off Abu Dhabi's roads.

This plant, whose 87,777 polycrystalline and thin-film modules occupy a 22-hectare site at the outer boundary of Masdar City, is the largest grid-connected solar plant in the Middle East. Inaugurated in May 2009, the farm provides clean energy to the Masdar Institute of Science and Technology campus and Masdar's temporary on-site offices, as well as some of the ongoing Masdar City construction activities.

The energy is fed into the Abu Dhabi power grid. Abu Dhabi-based Enviromena Power Systems, a leading developer of solar projects in the region, constructed the plant.

Accumulated dust impacts performance, while dust storms can reduce performance by 20-30% or more. Therefore, the cleaning of panels represents a significant cost, leading to the ongoing evaluation and testing of various cleaning options to minimise water use.

Sustainability Fact

No unsustainable materials such as bitumen or polystyrene were used for the concrete foundation. The array uses recycled materials and a form of low-carbon concrete that uses a large amount of ground granulated blast-furnace slag (GGBS), a waste product of iron making.

05 Material Recycling Centre

DID YOU KNOW

Masdar City and its contractors are diverting up to 96% of construction waste from landfill and using it in the build of the city.

Masdar City is working to minimise waste during the construction process by seeking to reuse and recycle all waste steel, concrete and timber generated during building. In order to achieve this, nearly all Masdar City construction waste is brought by contractors to the onsite Material Recycling Centre (MRC) for separation and processing. The 12-hectare site is divided into areas for concrete, wood, metal and other materials, which then are made available for use by other contractors working on site.

Wood is segregated and stockpiled for reuse in building the city or processing in a wood chipper. Steel, other metals and plastics are collected and sent offsite for recycling. Concrete waste is ground down using a crusher for reuse in construction. This material is particularly handy as infill, given the loose soil conditions at Masdar City.

In addition, excavated sand is being stockpiled (rather than trucked away as is common on UAE construction sites) for reuse as general backfill. Other materials such as gypsum board and damaged glass-reinforced concrete panels are being tested to see whether they can be recycled. Waste that cannot be recycled may be used as fuel in a future waste-to-energy plant.

Sustainability Fact
Some waste wood has been reused, while other wood has been turned into mulch for use in landscaping around the Masdar offices and in other developments in the UAE.

06 Parking Garage/PRT Station

DID YOU KNOW

Hanging from the ceiling of the PRT station are numerous glass-reinforced concrete panels. Copper pipes carrying chilled water run through the panels, cooling the concrete, which in turn provides highly efficient radiated cooling to the station.

This marks the entrance to Masdar City. The parking garage and PRT station will be the beginning of the Masdar City experience for visitors, as well as the Masdar Institute's students and faculty. The floors of the lot are constructed of prefabricated concrete slabs that are fitted together on site. This means less construction waste in terms of both materials and wooden formworks.

Backlit recycled glass walls accent the PRT station entrance. Inside, the attractive and eye-catching numeration of the four PRT berths, with the multiple smaller Arabic numbers embedded into the single large Western numeral, was designed by Saatchi & Saatchi. Benches are made of polished low-carbon concrete. There are four berths for four PRT vehicles at any one time, while recharging panels in the berths mean vehicles can recharge while standing in the station.

Sustainability Fact

Each element of Project 1 looked to use various sustainable strategies, such as pre-fabrication, natural ventilation, self-shading and photovoltaics.

07 Personal & Freight Rapid Transit

DID YOU KNOW

Legendary Italian automotive and design house Zagato, which has designed cars for Ferrari, Bentley, Rolls Royce, Jaguar and Aston Martin, designed the Masdar City PRT vehicles.

The Personal Rapid Transit (PRT) vehicles are air conditioned with wide comfortable cushioned seating that exceeds conventional public transport standards. The vehicle's user control panel consists of an information screen and interfaces for the vehicle activation, intercom, doors, medical assistance and emergency stop.

Two benches – each with two sunken-in seats – face each other and are located over the wheels. Wide sliding doors make it easy to enter the vehicle, while sensors ensure that nothing can get caught in the doors as they close. Vehicles, which can travel at speeds up to 40kph on straightaways and 25kph on curves, are powered by a battery that recharges while vehicles are standing in the stations between trips.

The driverless vehicles are controlled by an advanced navigation system; they use magnets embedded in the corridor to know their position and onboard sensors to detect any obstacles in their path; a wireless connection keeps them linked to the central computer, which guides them on their journey and ensures smooth operation among all vehicles.

Three flatbed Freight Rapid Transit (FRT) vehicles will play the role of trucks and vans to transport deliveries to and from the Masdar Institute campus and its resident students and retailers, as well as the university itself. The FRTs also will transport waste from the campus for sorting and reuse or recycling.

Sustainability Fact
Every aspect of the vehicles will be studied by Masdar City, Masdar Institute and others to determine the feasibility of a large-scale deployment of low or low carbon public transportation system.

08 Utility Trench / Undercroft

DID YOU KNOW

The undercroft between the station at the entrance to the city and the Masdar Institute station provides a 1,700m loop circuit for the PRT and FRT vehicles.

In order to allow for pedestrian-friendly narrow streets, while also accommodating the PRT/FRT network, the Masdar Institute is built on a 7m podium. Given that the PRT technology is not ready for wider-scale rollout, the undercroft and podium infrastructure will be a distinguishing feature of Masdar Institute, where the PRT will operate. Essentially, the undercroft – and below it the utility trench – provides a citywide service level that allows for quick, efficient and easy access to the city's complex utility infrastructure, which includes not only power and sewerage lines, but multiple pipes for potable, grey and black water; wiring for the city's elaborate information and communication system; waste and recycling networks; and other plant and equipment.

Beneath Masdar Institute, the undercroft houses the university's most sophisticated and technical labs, including Class 1000 and Class 100 clean rooms (particle-free environments), high-bay labs, imaging labs, a metallographic lab and a composite fabrication lab.

In the undercroft's PRT corridors, magnets have been embedded in the concrete floor every four metres to help the PRTs navigate, while overhead, an antenna runs the length of the undercroft to provide a wireless link between the PRTs and the system computer. Set in the ceiling of the main PRT corridors every 1.7 metres are 500mm-diametre 'light tubes'. Lined with highly reflective steel, the holes enable natural light from the street above to easily bounce down into the undercroft.

09 Masdar Institute PRT/FRT Station

DID YOU KNOW

A full-width light tube behind the spiral staircase floods the end wall with daylight, while programmed LED lighting creates the effect of 'falling water' against the back wall. Both elements create a focus for disembarking passengers and draw them through the station toward the staircase and up to the university.

This station is how all university students, professors, staff and visitors will enter Masdar Institute, at least until Project 1 is completed, by which time people will be able to walk from the parking lot to the Masdar Institute on the street level.

The first thing people will see on arrival into the PRT station is the media wall. "Light tubes" will help illuminate the station with natural light during the day, while the ceiling itself is composed of waffled-concrete soffit panels.

A spiral staircase leading up to the university is prominently located at one end of the station and serves as the primary means of reaching the street level. Elevators, intended only for those unable to use the stairs, are located out of view beyond the staircase.

Sustainability Fact
With walking encouraged to reduce energy use in Masdar City, stairs are always prominently featured, while elevators are hidden – the reverse of conventional buildings, where stairs are often hard to find.

10 Student Reception, Pedestrian Environment

DID YOU KNOW

The combination of shading, planting and water features may lower the perceived temperatures on Masdar City streets by 20 degrees Celsius compared to the open desert and by 25 degrees compared to modern Gulf city centres during the hottest days of the year.

The student reception area reflects the citywide objective to design buildings to be comfortably and naturally ventilated for as much of the year as possible. In cooler months, this area will be an open-air link between the two laboratory buildings, while in summer months, large doors will be closed to provide an air-conditioned passage. Its location also provides easy access to all areas of the campus.

Making the pedestrian environment at the street, or podium, level as comfortable for much of the year as possible was one of the core objectives of the Masdar City master plan. With the buildings' facades stepping out as they move up and the PV panels further overhanging the buildings, a vertical cross-section of the street has an inverted 'V' shape, thereby providing maximum shade to the street. A colonnade at street level further ensures that walls at the pedestrian level never get heated by direct sunlight, but are cooled in evening by the night air.

The thermal cooling from the walls, alongside shade trees, other planting and water features, makes streets in Masdar City feel more pleasant by reducing the perceived temperature. In addition, wind gates help control wind flow through the city.

In fact, the master plan envisions that at least as much attention be paid to the space between buildings as to the buildings themselves. This is emphasised in part through the distinctive street pavement. Developed for Masdar City by Jean Marc Castera, an expert in geometric Arabic pattern making, the pavement features a unique fractal pattern that is formed using reconstituted stone.

Sustainability Fact
Reconstituted stone is largely comprised of the off-cuts discarded in large-scale stone cutting.

11 Windtower

DID YOU KNOW

The LED lighting of the tower will change colours to let residents, students, professors and visitors know whether they are using too much energy in the Masdar Institute buildings or whether they are consuming energy at an appropriate level.

Rising 45m above the podium, this modern interpretation of one of the region's most iconic traditional architectural features will be a landmark for the Masdar Institute neighbourhood. The tower's height means it can capture upper-level winds and direct them to the open-air public square at its base. Sensors at the top of the steel structure will operate high-level louvers to open in the direction of prevailing winds and to close in other directions to divert wind down the tower.

A PTFE membrane will carry the wind downward, while mist generators at the top will add additional cooling to the air. PTFE is the scientific name for the well-known non-stick brand Teflon. Combinations of evaporative cooling and air movement techniques help to moderate perceived air temperatures, thereby improving personal comfort.

Masdar Institute will use the tower as a platform for their scientific instruments. This includes weather measuring equipment and air quality testing tools.

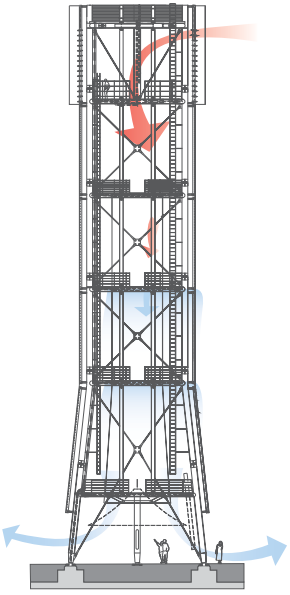
Sustainability Fact
The structure is anchored in low-carbon concrete reinforced with recycled steel rebar.

12 Urban Square

DID YOU KNOW

The layout of the square has been designed so that the more actively used areas will receive a larger share of the windtower's moderating effects.

The large urban square at the base of the windtower will have cafes and other retail outlets with seating that spills out on to the square in temperate weather, while mature landscaping will provide shade, and numerous services, such as a gym, prayer room, organic grocery store and bank will be located on or near the square. As a result, the square will provide a place of recreation and social interaction that will serve as a counterpoint to the serious work going on inside the labs. A raised platform beneath the windtower could serve as a performance stage.



13 Building Facades

DID YOU KNOW

Wall insulation levels are more than three times higher than the benchmark set by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), while strict air-tightness standards aim to control the infiltration of hot, humid air.

Managing solar gain is one of the biggest challenges to sustainable building in the extreme heat of the UAE desert environment. As such, facades at Masdar City incorporate a variety of technologies and materials to address this issue.

Laboratory buildings are characterised by air-filled ETFE cushions that ensure almost no solar gain on the structures and limit the heat re-radiated to the street. A reflective foil-clad inner layer behind the cushions sends light to the pedestrian street below. Behind the foil is a highly insulating and highly sealed panel. Windows that are not already shaded by adjacent buildings have louvers (vertical to block morning and afternoon sun and horizontal to block midday sun) set to prevent direct sunlight from shining into the building.

Residential buildings are defined by the red sand-coloured, undulating glass-reinforced concrete (GRC) screens that serve much the same role as traditional Arab mashrabiya screens. They provide shade from the sun, thus preventing solar gain on the building walls; they allow residents to look out at the street below while maintaining their privacy, and they also permit air to pass through to cool the balconies. Aside from the windows, the rest of the façade is again highly sealed and insulated, and wrapped in 90% recycled aluminium sheeting in the same rose-red colour as the GRC screens.

Sustainability Fact

The aluminium sheeting used on the residential buildings has 6.7kg of embedded carbon per square metre of 2mm-thick sheeting compared to conventional aluminium sheeting, which has 56kg of embedded carbon per square metre.

14 Masdar Institute Laboratory Building

DID YOU KNOW

In addition to the building's active and passive energy management technologies, the Institute will seek to coordinate research in the labs to avoid high peaks and troughs in energy consumption.

One of the distinctive features of the Masdar Institute is the integrated and cross-disciplinary nature of its study and research programmes. The laboratory interior has been designed with an open-plan, column-free floor plan to facilitate realisation of this philosophy. All services, such as power, data, gasses and ventilation, are located in the overhead service carriers, thereby enabling plug-and-play access anywhere on the floor. All lab furniture, and even the largely glass-walled offices, can easily be moved. As a result, students and researchers can configure and reconfigure their workspaces to conduct their research efficiently.

Sustainability Fact

To save on materials and to help contain the overall building footprint, no finishing to the lab walls was done beyond use of fair-faced concrete and polished metal sheeting. Floors too were only minimally finished. All Masdar Institute buildings use concrete made with GGBS and recycled steel rebar.

15 Masdar Institute Residential Building

DID YOU KNOW

In the Masdar Institute's first phase, there is a men's dorm and a women's dorm with studio apartments, and a family dorm with two- and three-bedroom units.

The interior hallways of the residential buildings are distinguished by their central atrium, which is naturally ventilated for as much of the year as possible. During the evening, cool air flows from openings on the podium level, cooling the interior walls and flowing out through open louvers at the top of the buildings. In warm weather, these openings are closed during the day to keep cool air in, while the thermal cooling of the walls keeps the interior hallways pleasant. These atriums also serve as a transitional space for people moving from hot outdoor temperatures to air-conditioned apartment temperatures.

The apartment units themselves have screen-shielded windows and windows located near the ceilings to maximise natural light, both from the outside and from the interior atrium, while maintaining privacy.

Highly insulating and sealing FSC-certified wood frame windows can be opened in temperate weather and closed when air conditioning is being used.

Waste separation compartments in the apartments reflect the separate waste chutes for glass, aluminium, plastic, paper and other waste found in each floor's waste room.

Sustainability Fact
Modular prefabrication of the entire bathroom minimises the amount of waste created during the manufacturing process and ensures consistent high quality. Water-saving specifications aims to have a 70% reduction in potable water consumption compared to the UAE average, with separate grey- and black-water drainage.

16 Family Square

DID YOU KNOW

Part of the square will be shaded by the Knowledge Centre roof, emphasising the intimate nature of this public space.

This square is designed as a meeting place and point of interaction, although smaller, quieter, more intimate and more family focused than the square at the base of the windtower. This is deliberate given the family residential building and study centre that abut this square.

A small number of cafes and services, such as a student affairs office and a canteen, will be located off this square.

Water features, such as a water sphere, where a thin layer of water flows over the shape, will provide cooling effects in a water- efficient manner.

Sustainability Fact
Most water features are shaded to reduce the water lost through evaporation.

17 Knowledge Centre

DID YOU KNOW

A place for research and study, the Knowledge Centre has more than 900 square metres of space for students and researchers, and primarily offers a wide range of electronic information resources, as well as a limited number of paper books, magazines and journals.

The slightly flattened spherical shape of the university's Knowledge Centre reflects the designers' efforts to optimise the building's photovoltaic (PV) energy harvesting – based on its orientation, the inclination of the PV panels and maximisation of the roof's surface area. As well, a large self-shading overhang allows for a full wall of glass. Generally, in order to reduce building cooling loads, all windows in Masdar City must be shaded to prevent direct sunlight from reaching inside. This window not only provides a large amount of natural light to enter the study areas of the centre, but it also offers views on to one of the city's "green finger" linear parks that passes close by the centre.

Although the glulam (glued laminated) timber roof is graceful and beautiful, the reason it was chosen over steel was because by using FSC- and PEFC-certified timber, it has a lower embodied energy coefficient. On the northeast section of the building's exterior roof, the eye-catching flat and folded zinc cladding provides ventilated shading to parts of the building and the Family Square.

Sustainability Fact

The 150 tons of Douglas fir timber used in the ceiling was sourced in equal amounts from Forest Stewardship Council (FSC) certified forests and from Programme for the Endorsement of Forest Certification (PEFC) certified forests, which means the wood came from sustainably managed forests and was provided by timber merchants with "chain of custody" certification from one of these two organisations.

Zinc was chosen as the material for the roof cladding because it had the lowest overall environmental footprint.

18 Green Fingers, Linear Parks

DID YOU KNOW

In order to enhance air movement in linear parks and the streets, the city is oriented in the direction of the prevailing wind, 38 degrees counter-clockwise of the north axis.

A defining aspect of Masdar City's master plan is the three 'green fingers' or linear parks that traverse the city. Located so as to channel prevailing winds into the city, the green fingers bring cooling breezes into the heart of the built environment.

They also provide close-at-hand, green and shaded oases for residents, workers and visitors, incorporating walking, jogging and bicycle trails, benches and other recreational facilities. The linear parks also connect recreation areas located throughout the city.

Sustainability Fact

In order to reduce water demand for irrigation, plants and trees used in Masdar City are selected from indigenous species, as well as non-native plants that are suited to a hot and dry climate.

19 Masdar Institute, Phase 1b

DID YOU KNOW

Phase 1b incorporates 'energy piles' within the sub-structure that use the high water table as a heat sink during the day to assist in the air conditioning of residential apartments.

The second phase of Masdar Institute will double the size of the university's campus by adding 221 residential apartments in three blocks and three laboratory buildings. Just as the Knowledge Centre is the signature structure for Masdar Institute Phase 1a, a multi-use hall will be the signature structure in Phase 1b. This sport building and performance hall will have an open-air swimming pool adjacent to, and on the same level as, one of the green finger linear parks.

Above this will be a building with sport facilities, a gym, and a large multi-use hall suitable for conferences, sporting events, and music and other cultural performances.

20 Masdar Headquarters

DID YOU KNOW

The building's design, which has won several international awards, is inspired by traditional architectural features of the region – including wind towers, water features and vegetation.

The Masdar Headquarters building has been designed by Adrian Smith + Gordon Gill Architecture to be the world's first large-scale positive-energy building, using sustainable design strategies and systems to produce more energy than it consumes. It will house Masdar's corporate offices, as well as the secretariat of the International Renewable Energy Agency, and retail and commercial office space.

The building's rooftop PV array will generate 5.5 GWh of renewable energy annually. The PV panels also serve as shading for the roof, while various building-integrated PV panels further contribute to the renewable energy supply of the building.

The building's 11 wind cones provide natural ventilation and cooling (drawing warm air up to roof level, where wind moves it away) and form oasis-like interior courtyards at ground level. The cones maximise diffused natural daylight throughout the building, leading to an anticipated energy savings of approximately 3.5%.

The structure's high-performance "sawtooth" facade allows access to daylight and views while mitigating glare and solar heat gain. This results in a lower cooling load and increased energy generation, while also being more structurally sound and sustainable by reducing the structural steel required for mullions.

Sustainability Fact

When installed the 15,590 photovoltaic panels on the roof of the Masdar headquarters will form one of the largest roof-mounted integrated PV panel arrays in the world and displace approximately 4,400 metric tones of CO2 equivalent a year.

21 Ready-Mix Concrete, Batching Plant

DID YOU KNOW

Concrete is the second most commonly used material on earth; however, just one cubic metre of concrete generates approximately 240kg of CO_2. Since production began in January 2009, the plant has supplied more than 250,000 cubic metres of concrete, representing a savings of approximately 29,250 metric tons of CO_2 equivalent.

The ready-mix concrete used to build Masdar City contributes significantly to the city's carbon footprint; however, a variety of steps have been taken to improve the sustainability of this concrete with regard to the sourcing of materials and innovative design mixes and systems. The green ready-mix concrete used in Masdar City's construction is produced on site by Al Falah Ready Mix, using two automated batching plants that have a total capacity of 240 cubic metres per hour. Tested for strength and durability, even in Abu Dhabi's extreme climate, this concrete is more economical and has a higher strength than conventional alternatives, as well as a lifespan exceeding 75 years.

Sustainability Fact

The batching plant replaces a portion of the concrete's Portland cement with two supplementary cementing materials (SCMs) – fly ash from coal combustion and blast furnace slag from iron production – to produce the concrete. This reduces greenhouse gasses and air pollution, and because SCMs are by-products of other industrial processes and are typically directed to landfills, using these materials as raw materials for another process further reduces waste. The SCMs also improve the concrete's strength and durability, while reducing its embodied CO_2 by as much as 70%.

By producing the concrete on site, transportation costs are lower, as is the associated environmental impact. As well, the batching plant can produce just the right amount of concrete for each job, which means less building waste.

22 Membrane Bioreactor

DID YOU KNOW

The MBR process involves a suspended, growth-activated sludge system that uses microporous membranes for solid/liquid separation in lieu of secondary clarifiers.

Wastewater treatment at Masdar City is being provided by a membrane bioreactor (MBR) with a capacity of 1,500 cubic metres per day. The plant is already in use, serving the needs of Masdar's temporary corporate offices, as well as Masdar Institute buildings as they become operational.

MBR is an increasingly popular wastewater treatment technology for reasons that also make it attractive to Masdar City. It has a compact footprint; it performs well in warm climates; it can be scaled up easily, and it produces an effluent suitable for reuse applications such as toilet flushing, district cooling and landscape watering.

Sustainability Fact

The modularity of the MBR technology not only makes it easily scalable but also means there is no need to build excessive infrastructure and that up-to-date technologies can be incorporated as the wastewater treatment plant grows with the city.

Section 2

Pilot Projects

In addition to the testing and pilot programmes underway at the Masdar Institute buildings and in the surrounding environs, Masdar's temporary offices – and the Masdar employees and consultants who work there – also are providing fertile ground for pilot projects. Testing in the areas of solar thermal cooling and daylighting systems are highlighted in the following pages.

Solar Cooling

Solar thermal cooling, which is likely to constitute a significant source of cooling in Masdar City, involves harnessing energy from solar thermal collectors to produce chilled water or dehumidified air (geothermal resources are an alternative energy source). This technology drastically reduces electricity consumption by using a thermo-chemical process that involves a mixture of water and special salts, such as lithium chloride or lithium bromide, to condition air – rather than electric-powered vapour compressors.

Solar thermal air-conditioning systems can generally be divided in two categories:

1. Low-temperature devices (i.e., single-effect absorption chillers, desiccant dehumidifiers), which are powered by low-grade hot water produced from non-concentrating flat-plate or evacuated tube solar collectors or geothermal sources.

2. High-temperature devices (i.e., multiple-effect absorption chillers), which require the use of concentrating solar collectors using reflective mirrors to focus and concentrate sunlight.

Liquid desiccant

Liquid desiccant pilot system

Installed
April 2009

Serving
One office, SAF 1

System
Outside air enters the absorber where it is dehumidified through contact with a concentrated aqueous salt solution (lithium chloride) that absorbs most of the humidity. It is cooled in a heat exchanger as well as through contact with exhaust air coming from the room that is cooler than the outside air. The 'used' salt solution is recharged in a regenerator that heats it to approximately 80°C to drive the collected moisture out of the solution.

Statistics
The test unit has a rated airflow of 600 m^3/h and a maximum capacity of 1000 m^3/h of treated airflow at low humidity levels of down to 15% relative humidity. The dehumidification capacity of the system is 10kg of water per hour under normal operation and 20kg of water when operated at maximum capacity.

Results
Liquid desiccant technology works in the Abu Dhabi climate; however, intensive maintenance may be required and other issues must be monitored.

Yazaki single-effect absorption chiller

Yazaki single-effect absorption chiller

Installed
Late 2008

Serving
Three offices, SAF 1

System
The system's absorption chiller, storage system, cooling tower, solar collectors and fan-coil units were provided by Yazaki of Japan. The system runs on "low temperature" hot water of about 80-90°C, which is provided by a small 80m^2 field of flat-plate solar thermal collectors.

Statistics
The single-effect absorption chiller has a capacity of 5 refrigeration tons operating at a coefficient of performance of up to 0.7.

Results
It has been in continuous maintenance-free operation, including during the demanding summer months, since its launch, confirming that re-cooling of single-effect absorption chillers with hybrid cooling towers is possible in the Abu Dhabi climate. The system has never shut down because of high cooling water temperature.

YAZAKI

Sopogy-Mirroxx-Broad double-effect absorption chiller

Sopogy-Mirroxx-Broad double-effect solar cooling pilot plant

Installed
September 2010

Serving
1700m^2 of offices, meeting rooms and open-plan office space, SAF 2

System
Several advanced technologies are combined with the goal of creating a highly efficient solar thermal air-conditioning system. The hot water produced by two different solar collector technologies is pumped to a 16m^3 pressure vessel that acts as a thermal buffer storage. A separate hot-water cycle with circulation pump delivers the water to a hot water-driven double-effect absorption chiller from to produce the chilled water.

Statistics
One Sopogy Parabolic Trough Collector with uniaxial tracking (total mirror aperture area of 334m^2) and hot oil loop circulating to an oil/water plate heat exchanger as a heat sink, and one Mirroxx Linear Fresnel Collector with uniaxial tracking (total mirror aperture areas of 132m^2) and hot water loop circulating to the thermal storage tank. The 50-refrigeration-ton Broad double-effect absorption chiller runs on hot water supplied at 180°C and returns the water at approximately 160°C. This temperature difference is used to drive a chemical absorption process using lithium bromide as absorbent and water as refrigerant to produce chilled water of 7°C. The coefficient of performance (COP) of the chiller is estimated to reach 1.4.

SOPOGY MIRROXX solar heat for industry BROAD Schneider Electric

Chilled water-cooling system and air handling unit

Block 6, chilled water-cooling system and air handling unit

Installed
February 2010

Serving
1700m^2 of offices, meeting rooms and open-plan office space, SAF 2

System
Chilled water is used in approximately 60 fan-coil units (FCUs) in the offices and meeting rooms, as well as to indirectly power 24 active chilled beams to bring conditioned fresh air to open-plan areas. The conditioned fresh air is produced by an advanced and highly efficient Air Handling Unit (AHU). The AHU is equipped with a rotary enthalpy recovery wheel that allows for 78% of the cool exhaust air from the office to be used to pre-cool the incoming fresh air. As a result, a smaller chiller capacity can be used, reducing energy consumption. The AHU and the 24 active chilled beams were supplied by Swedish company Swegon to Masdar free of charge.

Statistics
The chiller capacity is 70 refrigeration tons, providing chilled water at 7°C. The AHU airflow is 4500 m^3/hr of treated fresh air that is delivered to the offices at a temperature of 14°C.

Results
The AHU with the active chilled beams are providing the building with treated fresh air, creating a comfortable air-conditioned environment – all from an energy-efficient system.

Swegon PETRA
Petra Engineering Industries Co.

Daylighting Systems

Daylighting systems collect sunlight using either passive (i.e., static, non-moving and non-tracking) systems such LightLouvers, skylights or light tubes, or active (i.e., moving and tracking) systems that use mechanical devices with mirrors to follow the sun to increase light collection. The effectiveness of passive daylighting systems depends largely on a building's position and architecture. The advantage of active systems is that they can achieve a higher and more constant lighting output than passive systems.

Solatube passive daylighting system

Solatube daylighting system

Installed
March 2010

Serving
One office, SAF 2

System
Daylight-capturing dome lenses and in-dome reflectors redirect low-angle sunlight and reject overpowering summer midday sunlight to provide consistent lighting throughout the day. The system measures the light intensity in the room and either closes a damper to avoid excessive light on a clear day or uses the integrated electric light kit to provide additional illumination in low daylight and night conditions.

Statistics
Sunlight can be transferred up to 15m, while at the same time UV rays are blocked. The system includes four 250mm Solatubes with Vusion Diffusers and electric light add-on kits with daylight dimmer.

Results
Office occupants enjoy natural daylight for improved quality of life, while also registering reduced electricity consumption.

SOLATUBE
Innovation in Daylighting

3M-Targetti active daylighting system

3M-Targetti daylighting system

Installed
February 2010

Serving
SAF 1

System
This active daylighting system from 3M and Targetti uses a collector with a sun-tracking mirror array to provide maximum and constant illumination. The system measures the light intensity in the room and either defocuses part of the mirror array to avoid excessive light on a clear day or illuminates integrated backup fluorescent lights installed in the light duct to provide illumination in low daylight or night conditions.

Statistics
The system emits the collected daylight through a 12m-long lighting duct. It replaces six conventional fluorescent light fixtures with a total capacity of 432W and is set to deliver a constant illumination of 500 LUX to office workspaces.

Results
Early results show significant savings through reduced electricity consumption in the visitors' centre.

3M TARGETTI

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