



# A CARBON NEUTRAL OASIS IN THE DESERT

MASDAR CITY, ABU DHABI'S ZERO-WASTE CITY, ANALYZES EVERY FACET OF DESIGN AND BUILD WITH ARCGIS

Many of us are invested in decreasing our carbon footprint, whether one individual, one family, or one organization at a time. Imagine living in an entire city specifically designed to meet the ambitious goals of zero waste; sustainable living; and, ultimately, carbon neutrality. This is the vision of Masdar City, which is being designed and constructed near Abu Dhabi, the capital of the United Arab Emirates (UAE). The initiative behind the city is called Masdar, which is tasked with advancing the development, commercialization, and deployment of renewable and alternative energy technologies and solutions.

To reach its carbon-neutral ambitions, Masdar City will use only renewable energy sources. A photovoltaic power plant will generate most of the electricity, while the city's cooling will be provided via concentrated solar power. The zero-waste targets of Masdar city will be achieved through a combination of recycling, reuse, and some breakthrough waste-to-energy technologies. Landscaping within the city and crops grown outside will be irrigated with gray water and treated wastewater produced by the city's water treatment plant.

Through this innovative design, residents in Masdar City are expected to consume far less energy than residents of any other city in the world. Masdar City will require only 200 megawatts of power instead of the 800 megawatts normally consumed by a conventional city of the same size. Desalinated water consumption will drop from 20,000 cubic meters per day to only 8,000. Finally, Masdar City will eliminate the need for millions of square meters of landfill.

The first residents of Masdar City will be the students and faculty of the Masdar Institute of Science and Technology (MI). MI is a graduate-level university specializing in alternative energy and environmental technologies. The school is a collaboration between Masdar and the Massachusetts Institute of Technology (MIT).

Masdar's progress since its development has been significant. The company has established partnerships and large-scale renewable energy programs around the world, including the honor of hosting the International Renewable Energy Association (IRENA) headquarters. A shimmering oasis of six square kilometers, Masdar City is located on the Arabian Peninsula, 30 kilometers from Abu Dhabi. Geographic information system (GIS) technology is playing an important role in the city's progress.

### Shifting from Oil to Renewable Energy

Abu Dhabi has a rapidly growing economy due largely to the Emirate's vast oil reserves, which are estimated to hold approximately nine percent of the world's crude oil. Despite its vast hydrocarbon resources, UAE has adopted a progressive approach to its economic growth. The Emirate is committed to diversifying its economy, moving away from oil and ensuring the long-term development and prosperity of the country.

The Emirate believes it is well placed to invest its knowledge and financial resources into the world's future energy markets—renewable energy. The Abu Dhabi government established Masdar in April 2006 with the aim of creating a full life cycle for renewable energy, from research to commercial deployment.

Masdar, which means "the source" in Arabic, hopes to have a positive effect on mitigating climate change through its portfolio of projects that includes carbon monetization, clean technology investments, and renewable utilities projects located both in Abu Dhabi and abroad. Masdar is playing a key role in the development of Abu Dhabi's renewable energy sector as it drives continual innovation and commercialization of clean and sustainable energy technologies.

### Lean, Green City Planning

"GIS is imperative in managing the overall spatial information necessary for designing, building, and operating Masdar City," says Derek Gliddon, GIS manager, Property Development Unit, Masdar.

CH2M HILL, a global leader in full-service engineering and consulting based in Colorado, was chosen as a leading partner for the Masdar City design-build project. CH2M HILL had used ESRI technology on many projects in the past and knew ArcGIS was the solution necessary to manage and analyze information throughout the life cycle of the city.

To meet the city's challenging goals, the



A 10 megawatt photovoltaic power plant

harsh geography of the area was taken into careful consideration. Sun angles, wind patterns, street widths, and building density and height were analyzed to find the most significant energy savings using natural heating and cooling from placement of structures. The orientation of buildings on a diagonal grid to provide maximum natural shading was modeled in ArcGIS.

To understand all the variables and communicate effectively during the project, a geodatabase, which stores both geographic and tabular data in one common database, was used. This also ensured one coordinate system was applied across the project, making sharing of data easier and more accurate. A common basemap was created to support planning, design, and construction for the city, with the foresight that the city would also be maintained and operated using the same data for years to come.

"Building a city like this has never been done before, and GIS is proving to be an absolutely critical tool," says Shannon McElvaney, information solutions consultant, CH2M HILL.

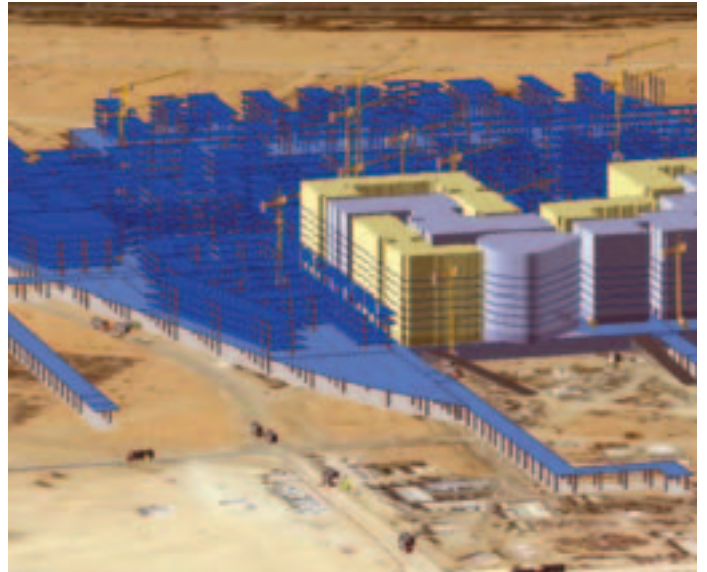
Data layers contained in the geodatabase include information such as transportation, vegetation, drainage, structures, boundaries, elevation, biodiversity, buildings, and utilities as well as terrain elevation, bathymetric data, and remotely sensed imagery. Information from tabular databases is incorporated into the map layers, as well as GPS coordinates and georeferenced photographs. All construction-related information, including cost, schedule, and carbon-tracking data, is tied together by location, making it more accurate and efficient to use.

The resulting information is available company-wide. ArcGIS Server allows access to maps, data, and analytic services to the more than 100 organizations involved in developing Masdar City. Using ArcGIS Server reduces problems of multiple data versions in circulation.

A Web-based virtual city visualization and navigation tool is used to examine the city over time. The tool uses master plan data from ArcGIS Server linked to the program scheduling software. Construction managers use the visualization tool to navigate anywhere in the



Planning biodiversity conservation strategies



Construction emulation visualization software aids planners

city; watch the progress of the project timeline; and identify spatial-temporal clashes, accessibility, and other logistical issues. Modeling the GIS data in this manner has proved to be very important, especially on a project as fast-paced as the high-density development of Masdar City. Information can be searched using spatial criteria and viewed on easily readable thematic maps. Using GIS to visualize the massive amounts of data makes communicating about the project easier.

### Optimized Facility Placement

ArcGIS introduced the spatial analysis and modeling necessary for the most efficient placement of facilities at the city. Water and sewage treatment plants, recycling centers, a solar farm, geothermal wells, and plantations of various tree species were placed using traditional planning principles modeled with ArcGIS. Questions including "Is there enough physical space available?," "How much are the buildings shading each other?" and "How much space is needed between a facility and the residents?" are all modeled, with the best answer being chosen through GIS.

McElvaney cites a problem that was quickly resolved when line work from one building was off by 30 centimeters from the previous line work. Having access to all the data and visualizing it with GIS allowed them to catch the mistake. "A mistake like that could be very time- and cost-intensive to fix during the construction stage. GIS is extremely helpful in preventing that kind of thing from happening," says McElvaney.

### From Models to Real Life

GIS has ensured that the carbon-neutral status of the city translates from concept to design. Even placement of construction materials during the building phase was chosen using ArcGIS. Alternative scenarios for where to place the materials were modeled and, in the end, the most efficient location to reduce transportation-related carbon emissions was chosen.

GIS was also able to model water and power usage over a period of 10 years, plotting monthly resource demands across the city like a geographic histogram. The variables appear as different heights, allowing planners to see any issues rapidly. "This exercise immediately revealed a couple of problems with the logic that had not been easy to spot in a massive spreadsheet format," says McElvaney.

Changes happening during construction were tracked and recorded to monitor the effect on carbon neutrality. Masdar City has a team that keeps track of all fuel and materials used and reused on the build.



Plotting Masdar City preserve potential

This team is also responsible for logging any environmental infractions. They used a GPS-enabled camera to send photos to the GIS. This documented the location of the infraction and allowed them to see what happened and where. Any underlying trends could be seen. All this contributed to managing the sustainability of the build.

### Innovative Transportation

Masdar City will utilize transportation technologies that redefine urban travel. A Personal Rapid Transit (PRT) running on solar-charged batteries will transport residents around the city. There will be 3,000 PRT vehicles, generating 130,000 trips each day across 85 stations. A Freight Rapid Transit (FRT) system will make up to 5,000 trips per day transporting the city's goods.

ArcGIS was an instrumental tool in visualizing all routes for the PRT network and testing predicted walk times between PRT stations. Transportation planners also used ArcGIS to find optimal locations for perimeter parking garages along with effective road and rail transport routes into the city. Real estate planners also used routing to value plots; locations closer to PRT stations have higher leases because of their proximity.

### Beyond Construction

Conventional cities of similar size create approximately 1.1 million tons of CO<sub>2</sub> per year: 80 percent from buildings and energy creation, 13 percent from waste, and 7 percent from transportation. Masdar City expects to eliminate these statistics by producing zero carbon emissions. ArcGIS will continue to be used and integrated with a computerized maintenance management system (CMMS) that will include the location of all infrastructure assets including gas pipes; smart grid infrastructure; clean gray and black water networks; and the transportation network. Moving forward, GIS will make facilities maintenance easier and will enable the tracking of resource use and reuse and support the overall carbon balance of the operational city. GIS will be used in city governance, where it will form part of the city's sustainability performance feedback service, which will inform residents about their personal contribution toward overall city performance. Using GIS, the sustainable future looks bright.

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