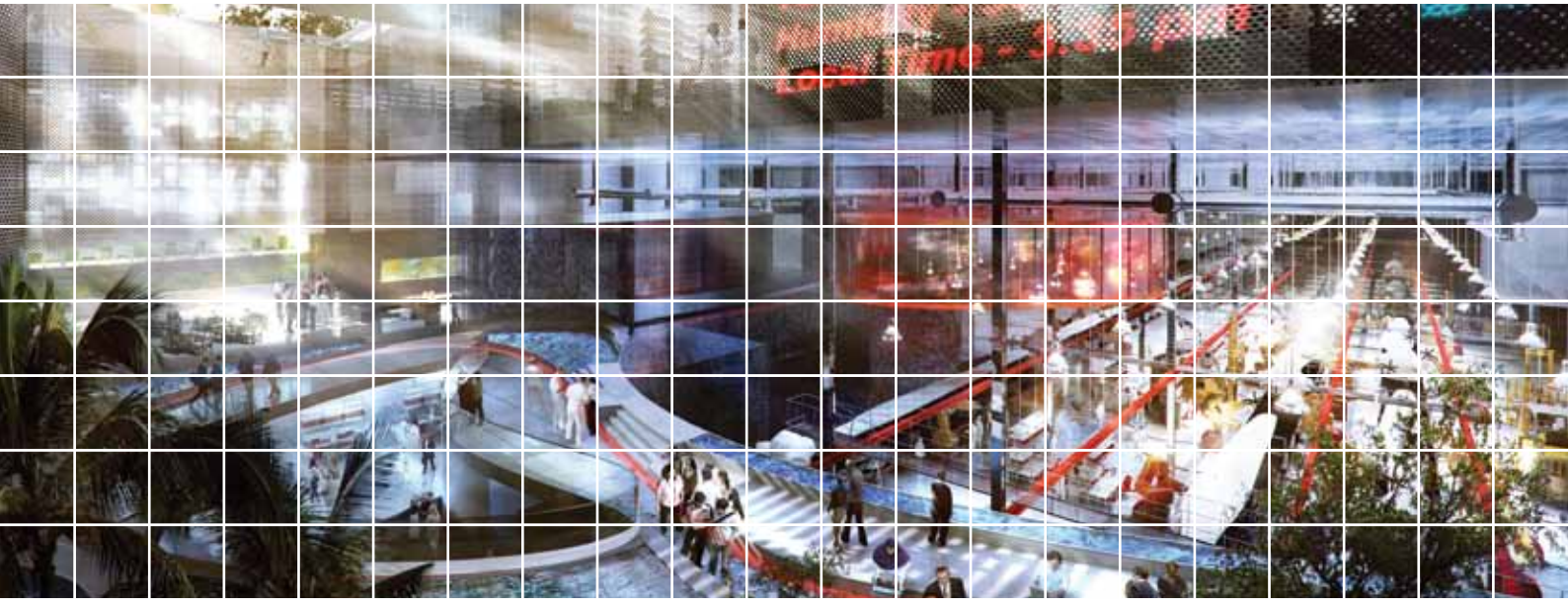
ESRI UK
VISIONARY THINKING

Masdar City

The world's first carbon-neutral city



Business Case Study

“Here, in the heart of the desert, thousands of dedicated people, billions of dollars and years of effort are coming together to achieve a groundbreaking goal: the world’s first entirely carbon-neutral, zero-waste city...”

Shannon McElvaney, Site Control and GIS Manager for CH2M HILL

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The challenge of the 21st century

Carbon neutrality is at the forefront of public consciousness. Individuals, businesses, states and even countries are pledging to dramatically reduce carbon emissions, recycle waste and offset the remainder. The result? Ideally, zero net carbon emissions – and a chance to help arrest the progress of climate change.

For anyone contemplating this work, it demands stamina and meticulous attention to detail. The scope of the project must be thoroughly analysed, the right technologies must be put in place to support the work, and constant evaluation is needed to prove it's successful.

For most, this can prove to be highly complex. But in Abu Dhabi, capital city of the United Arab Emirates, it's proving to be like nothing ever attempted before.

Here, in the heart of the desert, thousands of dedicated people, billions of dollars and years of effort are coming together to achieve a ground-breaking goal: the world's first entirely carbon-neutral, zero-waste city...

... constructed from scratch.

Innovation cubed

Masdar City will be a clean technology research hub, designed to rival Silicon Valley. Commissioned by the Abu Dhabi Future Energy Company, the city's five and a half square kilometres will be home to 50,000 people, 1,500 businesses and some 40,000 daily commuters, and will strive to be entirely self-sufficient for all energy needs.

Some 80 percent of water will be recycled. In addition to solar and biomass conversion, other renewable sources of power under consideration include geothermal, hydrogen and wind. Biological waste will be used to create fertiliser, whilst industrial waste will be recycled or re-used.

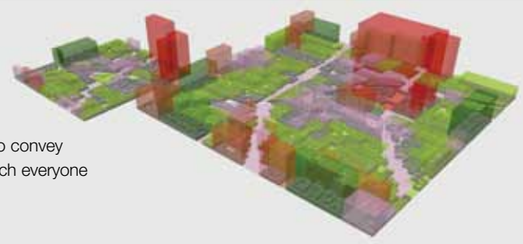
This is an experiment of colossal proportions, with no historical frame of reference. Yet it's also a serious business venture with a tight schedule and savvy project managers. The question is, how do you manage a build of this scale? How can you contain costs and manage cash flow of such vast sums of money? And how do you prove to the watchful eyes of the world that the entire build is, and always will be, completely carbon-neutral?

The answer is to use a host of sophisticated technologies – including a Geographic Information System (GIS) built using ESRI GIS software.

The art of the possible

Read on, and you'll see how Masdar and programme manager CH2M HILL use ESRI ArcGIS as part of its suite of tools to manage the complexity of one of the world's most ambitious construction projects. You'll learn how GIS helps technologists and planners increase energy savings and minimise carbon emissions during the build. You'll see how cutting-edge "6D" GIS modelling is being used to track costs, schedules and carbon emissions, and empowering collaborative thinking for creative problem-solving. And you'll discover how GIS will be used to underpin an automated, paperless asset management system when the new city is up and running, thus extending the city's life.

You'll understand how construction of the world's first carbon-neutral, zero-waste city is made substantially easier when planning and programme management is spatially enabled using GIS.



3D GIS is an easy way to convey complex information which everyone can digest quickly.

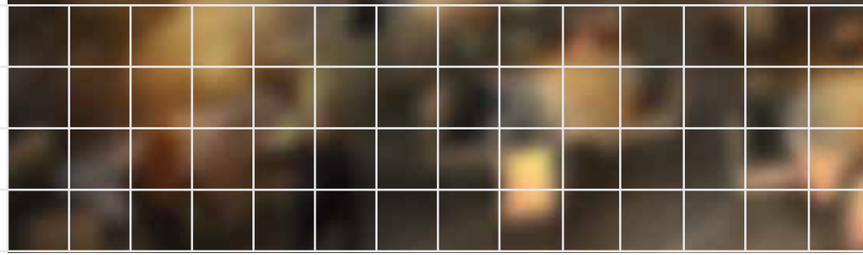
"The GIS will be integrated with a Computerised Maintenance Management System (CMMS) which will automatically generate work orders that are sent directly to technical engineers who will then carry out the work, and instantly update the system. The whole process will be paperless as befits a sustainable city!"

Shannon McElvaney, Site Control and GIS Manager for CH2M HILL

"To plan and design a city like Masdar, it helps to look to the past to get inspiration for the future," explains Shannon McElvaney, CH2M HILL's Site Control and GIS Manager on the Masdar City project. "So at the very start of this project, extensive analysis was carried out on traditional Arab city infrastructures."

"Masdar City was planned with careful consideration of both human and physical geography," states McElvaney. From Marrakech to Fez, sun angles, wind patterns, street widths, building density and height, and even city orientation were studied in detail, to create a master plan for Masdar City. In a harsh desert environment, understanding this geography is vital. "Since CH2M HILL joined the project, the core role of the GIS team has been to co-ordinate contractors' activities, put processes in place to help them work to the master plan, and continually monitor that plan for accuracy, especially spatial accuracy."

"Building a city like this has never been done before. And ESRI ArcGIS is proving to be an absolutely critical tool."



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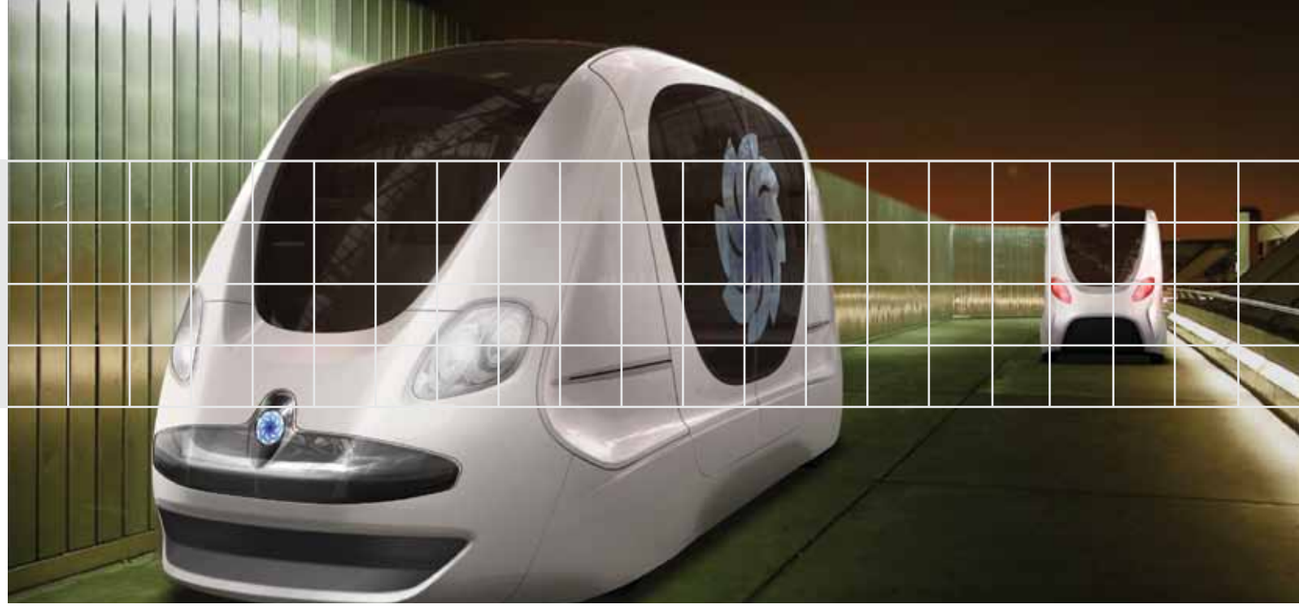

From cutting-edge planning, design and construction...

When contemplating a carbon-neutral build of this scale, it's not just the end result that must be sustainable. To be truly a carbon-neutral city, the construction phase must also be closely monitored to ensure minimal waste and optimal use of resources.

This is a real challenge – not least because Masdar City is near the heart of the desert. This meant planning for a workers' village to house 5,000 labourers, a dozen site offices and lay-down areas, an organised waste consolidation area, and a plan to transport people and materials from local towns and cities. "GIS has proven to be very valuable for the logistics of the build," confirms McElvaney. "It helps the Masdar team to do everything we can to minimise use of materials, mileage and carbon emissions."

"When planning the placement of construction materials, we used GIS to place the building materials as close to the work as possible. We did the same thing with proposed electrical utility substation locations and utility routes. In this way, we were able to weigh alternatives and pick the most efficient network possible saving on both costs and carbon."

Optimising placement of facilities

One of Masdar's greatest tasks is to optimise the placement of a wide variety of facilities such as water and sewage treatment plants, recycling centres, a solar farm, geothermal wells, and plantations of different tree species useful for producing biofuels. "Never before have so many environmental facilities come together in one place," confirms McElvaney.

This approach combines traditional planning principles with a variety of cutting-edge technologies: a critical one being ArcGIS. "The Masdar team is still deciding how to fit everything on site, and GIS is being heavily used at the moment to help make those decisions. Is there enough physical space? How much are the buildings shading each other? How much space do we need between a facility and residents? GIS helps Masdar select sites, evaluate alternatives and visualise construction sequences for the whole city," explains McElvaney.

Ensuring the vision of the master plan

For any large development, especially that of a city, the master plan acts as the guiding blueprint upon which all other decisions are made. With more than one hundred different contractors on board who are responsible for their own activities, Masdar must ensure that each decision is aligned with the sustainable city vision and that all construction is accurately placed as per the master plan.

This is a complex activity. "There is no doubt that GIS has played an instrumental role in assuring that the precepts of the master plan are met," says McElvaney. "Through GIS, we have been able to model things like water and power usage over a period of 10 years, plotting the monthly resource demand across the city like a geographic histogram. The variables appear as different heights, allowing us 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."

The same GIS tools are being used to check road widths and proposed building dimensions. "Only recently, we spotted a set of lines on one structure that was about 30 centimetres off from the previous line work," McElvaney reveals. "If that structure was a bridge, a mistake like that could be very time- and cost-intensive to fix at the construction stage. GIS is extremely helpful in preventing that kind of thing from happening."

Tracking environmental infractions

Within such a pioneering environmental project, there are bound to be changes made during construction which could affect carbon neutrality. What's important is that these changes are properly recorded so that action can be taken to quickly and accurately correct any issues.

Masdar City has a team that keeps track of all fuel and materials used on the build. This team is also responsible for logging any environmental infractions. "The team takes photos with a GPS-enabled camera documenting the location of the infraction which we plot in the GIS," explains McElvaney. "That way, it's easy to see what happened and where, so the team can do something about it."

Balancing carbon, cash flow and schedule

While creating a sustainable carbon-neutral city is the main aim of this project, it must be effectively balanced with cost – specifically, cash flow. Managing the cost of building Masdar City on a daily, weekly and monthly basis is extremely important to keep build momentum going.

To get a handle on these three important drivers, the Masdar GIS team built a unique, 6D GIS model – designed to depict the construction costs, carbon emissions and schedule of the planned build in 3D. "Masdar can change any set of variables to see its impact on overall construction costs or carbon at any given time. Visualising different combinations helped them to sub-divide original phases into smaller neighbourhood sub-phases which helped to manage costs while monitoring impacts on carbon emissions," McElvaney confirms.

Interestingly, seeing the data modelled in one way sparked new ideas for modelling other data. "When GIS is used across disciplines and departments it facilitates both collaboration and innovation," explains McElvaney.

Providing clear, fast progress reports

Using the same ESRI modelling technology, the Masdar GIS team creates Google Earth Pro mash-ups every month to depict project progress. "When it's 3D GIS, it's very easy to convey complex information which everybody can digest quickly," says McElvaney. "We're proud to say that this is one of the highlights of the monthly executive briefing."

Performing accurate modelling for a safer city

Because GIS is able to integrate and model so many variables with such accuracy, it has drawn attention to a number of unforeseen safety issues.

One issue was the emergency fire response. When the Masdar GIS team modelled turning circles for fire engines within the compact city, they soon realised there wasn't enough space. "Masdar is being designed as a compact, pedestrian city. Vehicles will be left at the perimeter, and people will either walk or use a uniquely designed transportation system to get around," McElvaney explains. "GIS modelling revealed that the streets were too narrow for fire engines to turn around." This resulted in meetings with planners, local authorities and emergency response teams to discuss the problem. Ultimately, the only solution was to re-size some of the streets. "Through GIS, we could make the city much safer from the very start," McElvaney concludes.

Designing a cutting-edge city experience

Building a brand new city presents a unique opportunity to redesign some traditional city features.

Within Masdar City, traffic is one design feature left off the list. Like a traditional Arab city, the entire city is designed to be traversed on foot, yet unlike any other city in the world, its pedestrian level is six metres above ground which allows for a Personal Rapid Transit (PRT) network to be built on the ground level. One of the technologies being evaluated is an innovative six-person driverless vehicle that runs on batteries charged with clean solar power. Linkages to Light Rail Transit (LRT) and the Metro will connect Masdar to its immediate neighbours as well as to the airport.

ESRI ArcGIS has been invaluable in checking the city's unique transportation infrastructure. "We used GIS to visualise all routes for the PRT network, and to test predicted walk times between PRT stations. We also used it to help transportation planners decide on the optimal location for perimeter parking garages along with effective road and rail transport routes into the city," confirms McElvaney.

… to ongoing maintenance of the world's first carbon-neutral city

For a city that relies so heavily upon geography at its conception, it's inevitable that GIS will continue to have a key role in its life. Once the city is up and running, GIS will be used on a daily basis, to help manage its assets – and its carbon-neutral status.

Managing the city's assets with precision

Masdar City's detailed design is being performed using industry-leading Building Information Modelling (BIM) software which will provide a 3D CAD-based representative model of all structural components of the city. Export routines will feed the GIS with the spatial data necessary to locate every single asset with pinpoint precision. This includes the location and interrelation of all gas pipes, electrical cables, clean and wastewater networks, and the transportation infrastructure.

When the city is fully operational, this will enable simpler, more effective asset management. "This means Masdar City will be able to do proper incremental maintenance. Studies in the UK have shown that if you can constantly make small enhancements to your assets, you can effectively double the life of those assets," enthuses McElvaney. "The GIS will be integrated with a Computerised Maintenance Management System (CMMS) which will automatically generate work orders that are sent directly to technical engineers who will then carry out the work, and instantly update the system. The whole process will be paperless as befits a sustainable city!"

Managing carbon balance, every day

GIS will also help city management analyse the resource use and carbon balance within every room of every building. "Masdar will use the GIS to visualise energy and water usage for the city as a whole and communicate the status to residents in novel ways that are currently under development. Each resident will be able to see a more detailed breakdown of information – such as how much water is used when they take a shower," states McElvaney. "By raising awareness, building in incentives, and communicating the real-time status of the city's sustainability, GIS will play a major role in helping everyone in Masdar City work together to cut down on resource use."

Tracking and communicating key performance indicators is an important element of the project

ESRI ArcGIS makes it possible

Sustainability is about wise resource use and recycling. It's about clean energy and readily available transportation. It's about cities built around people instead of cars. And it's made much easier with technologies like ESRI ArcGIS, which enables the Masdar team to bring all of these elements to work cohesively together.

"It would have been infinitely more difficult to manage this project without GIS," confirms McElvaney. "If you walk around our offices, you're likely to see plenty of groups of people standing around a monitor, using the GIS to point out issues and discuss alternative solutions. Maps help people make major decisions every day that benefit this project. Even with all that we have done, we have only just scratched the surface as far as our use of GIS goes. There is much more to come!"

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About the Masdar Initiative

Masdar is Abu Dhabi's multi-faceted initiative advancing the development, commercialisation and deployment of renewable and alternative energy technologies and solutions. Masdar is driven by the Abu Dhabi Future Energy Company (ADFEC), a wholly-owned company of the government of Abu Dhabi through the Mubadala Development Company.

For more information about the Masdar Initiative, please visit www.masdaruae.com

About CH2M HILL

CH2M HILL is a global leader in full-service engineering, consulting, construction and operations, and is the programme manager for Masdar City. Its role is to help develop new technologies in renewable, alternative and sustainable energies, including wind, solar, thermal, solid waste and photovoltaic.

CH2M HILL is an Enterprise Business Partner and Authorised Systems Integrator with ESRI.

For more information, visit www.ch2m.com

About ESRI

Founded in 1969, ESRI is the world leader in GIS modelling and mapping software and technology, with more than 300,000 clients worldwide.

Through our technology, we aim to help people and organisations unite and analyse their information, for improved decision making, safer communities, and to help create a more sustainable world.

ESRI technology is used today to solve critical business problems for customers in industries such as government, utilities, retail, banking, insurance, oil and gas, transportation, and health.

For more information, visit www.esri.com

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Our thanks to Foster and Partners for supplying imagery for this case study.