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Masdar City : A Model of Urban Environmental Sustainability

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ABSTRACT :
Masdar City is an archeology project in Abu Dhabi, in the United Arab Emirates. Its core is a planned city, which is being built by Masdar, a subsidiary of Mubadala Development Company, with the majority of seed capital provided by the government of Abu Dhabi. Designed by the British architectural firm Foster and Partners and engineering and environmental consultancy Mott MacDonald, the city will rely entirely on solar energy and other renewable energy sources, with a zero waste ecology. It initially aimed to be a sustainable zero-carbon car-free city. . This article is a case study about "Masdar City," a planned carbon-neutral town in Abu Dhabi. The article describes the key characteristics of Masdar City.
Keywords : Masdar City; United Arab Emirates; Renewable energy

I. Introduction

Masdar City, an eco-city presently being built in the United Arab Emirates. With such unconventional features as an underground network of tunnels for electric cars and an aim of developing a zero-carbon electricity supply Masdar City is one of its kind. It represents an important advance in the field of sustainable urban design. Located in the desert near Abu Dhabi and under construction since
2007, Masdar City is planned as one of the world's first completely sustainable communities, combining renewable energy sources and efficient resource usage with traditional Arabian design and spectacular architectural elements. Masdar is a 6 million square metre sustainable city designed to use low carbon technologies to achieve a car-free, zero waste, carbon neutral community. With an expected completion date of 2016, Masdar will require $22 billion for its construction, furnished by the government and independent investors. Masdar City will host the headquarters of the International Renewable Energy Agency (IRENA). The city is designed to be a hub for cleantech companies. Its first tenant is the Masdar Institute of Science and Technology, which has been operating in the city since it moved into its campus in September
2010. The city as a whole was originally intended to be completed by 2016 but due to the impact of the global financial crisis, the date has now been pushed back to between 2020 and 2025. Due to the limitations found during the initial implementation, the city is now aiming to be low carbon.

II. Location

Masdar City is being constructed 17 kilometers (11 mi) east-south-east of the city of Abu Dhabi, beside Abu Dhabi International Airport. It is easily accessible from all the international airports of all major cities of UAE. It is 154 km from Sharjah Airport , 136 km from Dubai International Airport nearly 1 and half hour drive.

a. The Sustainable City

There was a need to incorporate sustainable planning in cities in response to the rapid climatic changes taking place. More than half the world's population now lives in cities, a percentage that is expected to rise to 70% by 2030. So cities today are responsible for over 70% of global CO2 emissions.

If sustainability is economically feasible communities will be able to implement the technologies and systems. Masdar City is not only committed to building one of the most sustainable cities in the world, and one that is an attractive place live, but also to achieving this in a commercially

viable manner. According to reports in the New York Times, the entire city, developed jointly by the architectural firm Foster & Partners and the Abu Dhabi government, is raised on a 23 foot-high concrete base to maximize its exposure to cooling winds and decrease the need for air conditioning. Gasoline powered vehicles will not be allowed on the narrow streets of the city, about one square mile in area, but a fleet of computer- driven electric cars will navigate a complex of tunnels under the concrete base.

b. Planning and Design

The location of the city is in the middle of a desert region. Thus maintaining temperature was a huge challenge. Appropriate planning needed to be done so as to reduce the energy required in cooling systems. The city's master planners, took inspiration from traditional Arabian city planning. This indigenous design incorporate numerous strategies to address the desert climate. It is characterized by relatively low overall energy consumption. That's

because traditional Arabian cities are compact and densely populated. Hence the city has a population density of 140 people/hectare and average height of buildings is maintained to 4-6 storeys. Environmental pyramid approach was adopted.

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 optimization, with tools such as responsive shading and maximizing 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.

III. Energy Management

The first step was to reduce the energy consumption. Masdar City minimizes energy consumption by deploying the best commercially available international energy-efficient techniques such as insulation, low-energy lighting specifications, the percentage of glazing (i.e., windows), optimizing natural light, and installing smart appliances, smart building management systems.

The next step was to generate the required energy by appropriate techniques. Many different innovative techniques were employed to get the maximum energy. Some of the techniques are:

3.1 Solar Panels

Photovoltaic panels provide much of the electricity generated within Masdar City, so selecting the right technologies for Abu Dhabi's climate was crucial.

For selection of right type of panels tests were carried out. International PV Competition was organized which began in September 2008. The results from the test field help guide Masdar City in selecting the best PV modules for both roof and ground placement.

3.2 The Beam Down Project

It is a joint pilot project of the Masdar Institute, Japan's Cosmo Oil Company and the Tokyo Institute of Technology It takes the conventional Concentrating Solar Power (CSP) design and literally turns it on its head. Most CSP plants use mirrors 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.

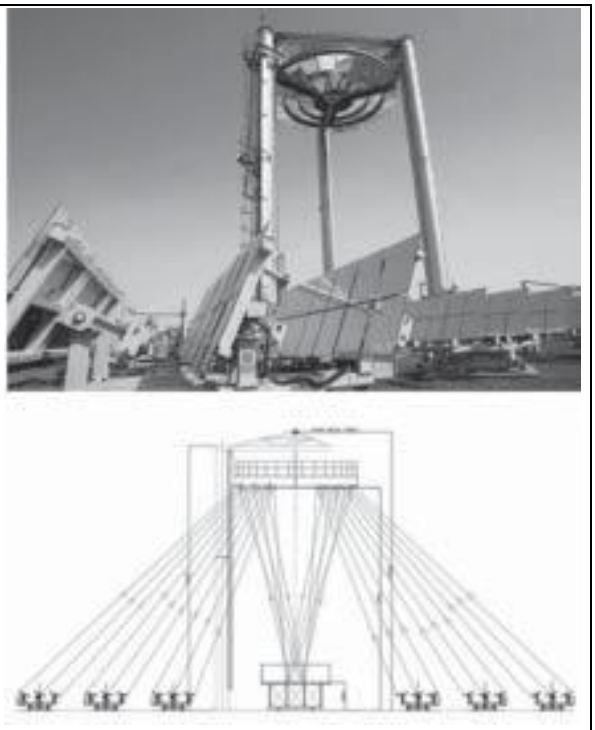


Figure 3 : Beam down plant

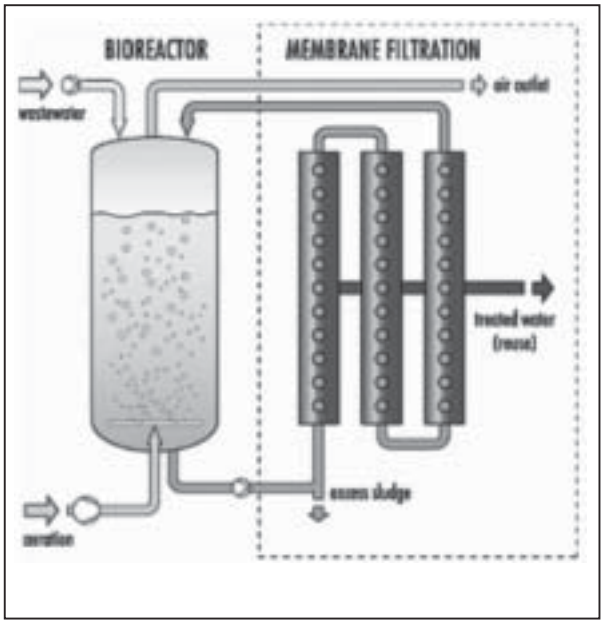
Managed by Masdar Institute, the Beam Down Plant has the potential to convert sunlight into electricity in a more efficient, lower-cost way than other technologies. By placing the receiver at the base of the tower (ground level), the thesis is that it will eliminate the energy loss resulting from pumping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

3.3 Power Plant

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 campus and Masdar's temporary on-site offices, as well as some of the ongoing Masdar City construction activities.

IV. Water Management

Masdar City has been designed to minimise water waste and maximise the efficiency of treatment and production techniques. In the long term the goal is to reduce, in stages, the domestic water consumption to the target potable water consumption of 105 litres per person per day, far below business as usual. Water-use reduction technologies include high- efficiency appliances, low-flow showers, highly efficient laundry systems, a water tariff that promotes water efficiency, incentives, real-time monitoring, smart water metres that inform consumers of their consumption, reducing leakage ultimately to 1%, treated wastewater recycling, and high-efficiency irrigation and low- water use landscaping, particularly through use of indigenous desert flora. The current wastewater system combines grey water and black water for processing and treatment at the city's membrane bioreactor (MBR) plant.



Waste water 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 offi ces, as well as Masdar Institute buildings. The MBR process involves a suspended, growth-activated sludge system that uses microporous membranes for solid/liquid separation in lieu of secondary clarifiers. The treated sewage effluent produced at the MBR will be used for landscaping. The biosolids resulting from the wastewater treatment can be reused for compositing and in any future waste-to-energy plant.

V. Waste Management

Masdar City's waste management strategy seeks to minimise waste to landfill and maximise the resource potential of materials (i.e., recycling and reuse). As a first step, systems will be used and awareness will be raised to reduce the amount of waste generated in the city, i.e., by encouraging reusable bags and containers. The next step is to sort and collect the waste produced by those living and working in the city. Masdar Institute buildings have separate waste chutes to allow for the separation waste. At later stages, vacuum waste systems may be implemented to automatically remove all waste from point of use, ensuring the city is clean and tidy and reducing the need for traditional dustcarts. Once collected, the waste is sorted into compostable, non-recyclable and recyclable waste.

All appropriate bio-waste will be composted and the product used to enrich the landscaping. Recyclable waste will be processed in the city or as close by as possible.

VI. Material Recycling Centre

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.

VII. Transportation

In answering one of the overriding priorities of Masdar City's master plan to be a pedestrian focused community a rich network of public and personal transportation options will ensure it is easy to move across the city in comfort and ease. As a result, walking and self-propelled transport will be the most convenient forms of transportation to many destinations within the city, as well as the most pleasant. This is the result of planners' focus on creating extensive shaded sidewalks and pathways throughout the city. In addition, a public transport system of electric buses and other clean-energy vehicles will provide transport within the city, while Abu Dhabi's light rail and Metro lines will pass through the center of Masdar City, providing transport within the city and serving as a link to the wider metropolitan area. This extensive public transportation network means that no destination within the city will be more than 250-300m some form of public transport. Most private vehicles will be kept at the city's edge in a number of parking lots that will be linked by electric bus routes to other public transportation traversing the city.

Figure 6 : PRT system

In its search for an appropriate and sustainable transportation solution, Masdar City is piloting a Personal Rapid Transit (PRT) system of electric-powered, automated, single-cabin vehicles that offer the privacy, comfort and non-stop travel of a taxi service, and the reliability and sustainability of a public transport system. The initial pilot route runs on a 1,700m track linking Masdar Institute to its parking lot. However, this emerging technology will serve only Masdar Institute at this time, as it is not yet ready for implementation on a wider scale. As other new transport technologies emerge, they will be evaluated for use within the city.

VIII. Supply Chain

Throughout the construction and operational life of Masdar City, there is an ongoing drive to use the latest sustainable products, materials and

services. Through a detailed product evaluation process that includes environmental, economic (including cost and quality) and social considerations, Masdar City is reducing the overall impact of the materials chosen for the buildings and infrastructure in the city.

There are many important considerations in this evaluation, including: cradle-to-grave lifecycle analysis, evaluation of recycled content, manufacturing processes, the level of energy and water used in manufacturing, assembly plant location, logistics, distribution, durability and recyclability. Through this screening and product specification process, Masdar City is having a positive local and regional effect by encouraging the overall supply chain to become more sustainable.

Examples of the supply chain outcomes in the six existing buildings of Masdar City include :

- 100% sustainably sourced timber
- 90% recycled-content aluminium used for the inner façade
- Green concrete that used ground granulated blasted slag to replace cement, resulting in a reduction of the concrete carbon footprint by 30-40% of CO_2
- Water-based paints that have no volatile organic compound, which harm human health
- Reinforcing bars made of 100% recycled steel

IX. Conclusion

A place where businesses can thrive and innovation can flourish, Masdar City is a modern Arabian city that, like its forerunners, is in tune with its surroundings. As such, it is a model for sustainable urban development regionally and globally, seeking to be a commercially viable development that delivers the highest quality living and working environment with the lowest possible ecological footprint. Thus making it one of its kind. This is the future of sustainable development

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