

# Masdar City Initiative: One Step in the United Arab Emirates' Journey to the New-Energy Economy

*In the UAE, we have embarked on a program to transform our economy from one based on resource depletion to one based on resource enrichment. By focusing on education and developing our tremendous human capital, we are working to empower our most important resource—our people—with the knowledge, skills, and abilities to lead in the new energy economy. To do so, we are investing in the full value chain of a renewable energy industry. And as a result, the UAE is responsible for 68 percent of the Gulf's renewable energy capacity.*

Dr. Sultan Ahmed Al-Jaber.<sup>1</sup>

## Introduction

Early in the 21st Century, the United Arab Emirates (UAE) government estimated that their oil reserves could run out in 150 years.<sup>2</sup> The UAE began efforts to diversify their economy into clean industries—tourism, technology, and renewable energy. The intention was to signal to the world that the UAE was pivoting away from an oil-based economy toward one that would grow and thrive as an environmentally aware, sustainable, low-carbon economy. By 2016, the UAE had the most diverse economy among the oil-exporting Arab nations.<sup>3</sup>

Masdar City, a UAE marquee project, was intended to be the world's first zero-carbon city. The brainchild of Masdar Company's CEO, Dr. Sultan Al-Jaber, Masdar City was one cornerstone of the UAE's economic diversification. This effort, while bold, was not as straightforward as anticipated and planned. As the Masdar City initiative unfolded, managers encountered obstacles, challenges, and surprises resulting in slower than anticipated progress and a great deal of learning. A decade after the project began, decision-makers had to decide the best next steps to be taken.

## The UAE<sup>4</sup>

The oil-rich UAE was established in December 1971. Located at the southeast end of the Arabian Peninsula on the Persian Gulf, the UAE borders Oman, Saudi Arabia, and shares sea borders with Qatar and Iran. The UAE is strategically positioned on the Straits of Hormuz, through which 20 percent of the world's oil passes each year. Abu Dhabi, the capital, accounts for 87 percent of the UAE's total area. Seventy percent of Abu Dhabi is desert, and most of the population in the UAE is concentrated in three cities, Abu Dhabi, Dubai, and Sharjah.

## Government

The UAE is a constitutional federation comprising seven emirates, including Abu Dhabi, Ajman, Dubai, Fujairah, Ras al-Khaimah, Sharjah, and Umm al-Quwai. See Exhibit 1 for a map of the UAE. An absolute monarch governs each emirate. These seven monarchs form the UAE governing Federal Supreme Council, the highest constitutional authority, responsible for establishing general policies and sanctioning federal legislation. The monarchs select one among them to serve as president of the UAE autocracy. Khalifa bin Zayed bin Sultan Al Nahyan, referred to as Sheikh Khalifa, is currently serving as president.

Exhibit 1. Map of the United Arab Emirates.



Source: <https://www.vecteezy.com/vector-art/103349-free-uae-map-vector>.

### *Economy*

Prior to the 1950s discovery of oil in the UAE, the economy was dependent on fishing and a declining pearl industry. Regional oil exports began in 1962 and oil-revenue-driven economic development soon followed. Sheikh Zayed, ruler of Abu Dhabi and the first president of the UAE, oversaw development of the UAE economy and began its diversification from overreliance on oil revenue toward healthcare, education, and infrastructure. By 2016, the UAE's oil reserves were the seventh largest in the world and natural gas reserves were the 17th largest. By that year, one-third of the UAE's GDP was derived from the oil and gas sector.

The UAE's economy is the most diversified in the Gulf Cooperation Council—a regional political and economic union that includes the Persian Gulf States and Saudi Arabia. The UAE has an open economy with a high *per capita* income and a large annual trade surplus. See Table 1 for an overview of the UAE's contemporary trade statistics.

Table 1. United Arab Emirates Trade Statistics (2015)

<b>Exports</b>	\$323.8 billion (2015)
<b>Goods</b>	Crude oil, natural gas, re-exports, dried fish, dates
<b>Export Partners</b>	Iran (14.5%) Japan (9.8%) India (9.2%) China (4.7%) Oman (4.3%)
<b>Imports</b>	\$273.5 billion
<b>Goods</b>	Machinery and transport equipment, chemicals, food
<b>Import Partners</b>	China (15.5%) India (12.7%) United States (9.6%)
<b>External Debt</b>	\$151.8 billion (12/31/2010 est.)
<b>Per Capita Income</b>	\$39,544 (PPP \$66,102)

Source: CIA World Factbook, 2015; [wikipedia.org/wiki/Economy\\_of\\_the\\_United\\_Arab\\_Emirates](http://wikipedia.org/wiki/Economy_of_the_United_Arab_Emirates).

## *UAE Challenges*

The UAE faces several long-term challenges, including continued dependence on oil despite economic diversification efforts; a very large expatriate workforce; growing inflation pressures; and sensitivity to fluctuating oil prices. The UAE's budget is very sensitive to fluctuations in oil prices. Low oil prices have prompted a reduction in social spending, eliminating, for example, fuel subsidies in 2015. Through investments made by the sovereign investment fund, the UAE has sufficient assets to cover near-term deficits. The UAE's strategic plan is focused on growth through continued economic diversification; on-job creation for nationals through improved education; and increased private sector employment. The UAE's government has undertaken a variety of projects as they strive to implement their strategic plan. The Masdar City initiative is one example of this economic diversification strategy.

## **The (New) Energy Industry**

The energy industry dwarfs all others. Firms in this US\$6 trillion global industry produce and sell energy. The energy industry includes businesses that extract, manufacture, refine or distribute fuel. The industry comprises the petroleum industry sector whose firms extract, refine, transport, and sell carbon-based products; the gas industry sector whose firms extract natural gas or manufacture gas from coal, distribute and sell these products; the electrical power industry sector whose firms generate, distribute, and sell electricity; the coal industry sector; the nuclear power industry sector; and the renewable energy industry sector. Many competitors in this diverse industry—for example, ExxonMobil, Total, Royal Dutch Shell, and British Petroleum, among others—are engaged in multiple sectors.

The vast majority of energy, 87 percent, is derived from fossil fuels—oil, coal, and natural gas. Fossil fuels—concentrated biomass created from the remains of plants and animals that lived millions of years ago—are the cheapest and easiest types of fuel to acquire and use. Since they take millions of years to produce, they are not considered renewable. However, there are still several hundred years of reserves in various locations around the world.

The ability to harness energy makes modern industrialized life possible. Fossil fuels have been used for over a thousand years to produce energy. In the last 200 years, our ability to harness fossil fuel-based energy has driven the growth of cities and the growth of industrial scale to levels much greater than ever before. Seventy percent of the world's supply of energy is used in industrial, commercial, and transportation applications. The remainder is used for residential purposes or to fuel personal automobiles.

Industrialized countries consume the largest share of energy—often consuming more than they produce from home-based sources. South America, Africa, Asia, and the Middle East hold 78 percent of the world's oil and 56 percent of the world's natural gas-proven reserves. These emerging markets consume 46 percent of the world's oil and 26 percent of the world's natural gas—less of the world's oil and gas than they produce.

The production and use of fossil fuels is considered a primary source of vexing environmental degradation issues like climate change, greenhouse gas, acid rain, air pollution, and water pollution.<sup>5</sup> There is disagreement between environmental scientists and some policymakers about the causes of climate change and other environmental degradation issues; that said, there is wide agreement in the scientific community that climate change is man-made and primarily caused by fossil fuels.

The increasing scarcity of fossil fuels and the impact of climate change pose challenges to the energy industry. In response to these challenges, the nuclear energy and renewable energy industries have emerged, as has the use of clean technology. Nuclear energy provides another 5.5 percent of energy, and hydraulic energy contributes an additional 5.5 percent. All alternative energy sources combined—biomass, ethanol, wind, geothermal, and solar—contribute less than two percent of the world's energy. In 2016, forecasts pointed to less demand for oil, with growth in the natural gas and renewable energy sectors.<sup>6</sup>

## Human Capital

The UAE's population in 2013 was 9.3 million people, of which 1.4 million are Emirati citizens, and the remaining 7.8 million are expatriates, predominantly Indian, Pakistani, Bangladeshi, Filipino, and Thai, among others. The UAE's young and fast-growing population dropped to 9.2 million in 2016 compared to 9.3 million in 2013. Eighty-five percent of the population is urban. Arabic is the official language of the UAE and Islam the official religion. English is widely spoken and is the language of business and education, especially in Abu Dhabi, Dubai, and Sharjah. See Table 2 for a breakdown of the UAE population ethnic composition.

**Table 2. United Arab Emirates Population Ethnic Composition (2016)**

<u>Nationals of</u>	<u>Population</u>	<u>Population Percent</u>
India	2,600,000	27%
UAE	1,400,000	14%
Pakistan	1,200,000	13%
Bangladesh	700,000	07%
Philippines	525,530	05%
Iran	450,000	05%
Egypt	400,000	04%
Nepal	300,000	03%
Sri Lanka	300,000	03%
China	200,000	02%
All Other Countries	1,696,334	17%

Note: More than half of the population in the UAE comes from South Asia.

Source: <http://abudhabi2.com> Information for Residents and Travelers. Retrieved July 2, 2016.

Heavily reliant on foreign labor to sustain economic growth and a high standard of living in the country, in 1971 the UAE government introduced a temporary guest-worker program called the Kafala Sponsorship System that allows nationals, expatriates, and companies to hire migrant workers. The Kafala System has posed a number of challenges for UAE policymakers, especially in the eyes of international observers. Chief among these: ensuring economic opportunities for UAE nationals; and the need to close policy and implementation gaps to address widespread concerns that migrants fall victim to labor and human rights abuses in the country.

## Doing Business in the UAE

The UAE is considered business friendly, although they do place limitations on some foreign investment. The UAE's Commercial Companies Law (CCL) requires that companies established in the UAE have one or more UAE national partners who hold at least 51 percent of the company's capital. Companies in the oil industry, the production of electricity and gas, and the treatment and distribution of water are exempt from the 51 percent requirement. Companies established in free-trade zones may be exempt from the 51 percent requirement, if the zone has special provisions regulating the company. Foreign banks are exempt from having to appoint a local partner. See Table 3 for an overview of the UAE investment climate.

**Table 3. UAE Investment Climate**

- The UAE has one of the most liberal trade regimes in the Gulf Region and attracts strong capital flow from the region;
- The UAE is focused on diversification in trade, logistics, tourism, real estate, and manufacturing; and provides opportunities in various industries;
- The UAE has a well-established infrastructure, a strong banking system, and a stable political system;
- There are restrictions on company ownership by non-GCC nationals, the UAE provides free-trade zones that can allow 100 percent ownership and a nil taxation scheme;
- The UAE provides a tax-favorable environment for most industries;
- Expatriates account for 80 percent of the workforce;
- There are no exchange control restrictions, and it is possible to have unrestricted repatriation of income and capital;
- The UAE's culture is based on Islamic traditions. The 150 expatriate nationalities are able to practice their own cultures;
- The UAE provides a safe and secure family environment with one of the lowest crime rates in the world.

Source: <http://www.uaeinteract.com/business/settingup.asp>. Retrieved July 15, 2016.

The renewable energy industry includes alternative energy companies and sustainable energy companies—those involved in hydroelectric power, wind power, solar power, and alternative fuels. The renewable energy industry is also referred to as the new energy industry or the clean energy industry. Clean technology is any technology used to produce energy that limits a negative impact on the environment or increases the efficiency of energy-consuming machinery or processes, thus limiting the use of fossil fuels. The UAE renewable energy value chain is shown in Table 4 below.

**Table 4. UAE Renewable Energy Value Chain**

Technology Research	Technology Development	Manufacturing and Service Scale-Up	Technology Diffusion
<ul style="list-style-type: none"> <li>◦ Human Capital</li> <li>◦ Knowledge Access</li> <li>◦ Investment Capital</li> </ul>	<ul style="list-style-type: none"> <li>◦ Human Capital</li> <li>◦ Knowledge Access</li> <li>◦ Experimentation</li> <li>◦ Opportunity</li> <li>◦ Investment Capital</li> </ul>	<ul style="list-style-type: none"> <li>◦ Project Finance</li> <li>◦ Technical Expertise</li> <li>◦ Cost of Capital</li> <li>◦ Economies of Scale</li> </ul>	<ul style="list-style-type: none"> <li>◦ Project Finance</li> <li>◦ Brand Management</li> <li>◦ Technical Expertise</li> <li>◦ Global Trade</li> <li>◦ Agreements</li> </ul>

Source: Adapted from Bloomberg (2016). "Global Trends in Renewable Energy Investment 2016." Frankfurt School: FS-UNEP Collaborating Center for Climate and Sustainable Energy Finance.

The *Sustainable Energy for All* initiative launched by the United Nations in 2011 presents opportunities and challenges for the global energy industry. "This initiative will engage governments, the private sector, and civil society partners globally to achieve three major goals by 2030: (1) ensure universal access to modern energy services; (2) reduce global energy intensity by 40 percent; and (3) increase renewable energy use globally by 20 percent."<sup>7</sup> The UAE was one of the champions of this initiative.

### The Mubadala Development Company<sup>8</sup>

*MDC's mission is "To be a catalyst that is facilitating Abu Dhabi's ambition to diversify and transform its economy, developing a new generation of leaders and building a prosperous future for the people of the Emirates."*<sup>9</sup>

The Abu Dhabi government started the Mubadala Development Company (MDC) in 2002 to support and facilitate diversification of Abu Dhabi's economy. *Mubadala* is the Arabic word for exchange. In 2016, the company had a US\$67.1 billion diversified portfolio designed to generate long-term sustainable profits by focusing on investment and development in multiple sectors. MDC focused on long-term value propositions that support the UAE's economic diversification, infrastructure development, and socioeconomic goals. MDC invests in initiatives that drive the establishment of new industry sectors and vital infrastructure in Abu Dhabi.

Their vision is, "We invest with world-class partners, creating global champions across multiple industries for Abu Dhabi through active asset management; we provide sustainable financial returns to our shareholders and socio-economic benefits for the Emirates." Sectors included in their diversified portfolio are Aerospace; Capital Investments; Defense Services; Healthcare; Information & Communications Technology; Metals & Mining; Oil & Gas; Real Estate & Infrastructure; Renewables; Semiconductors; and Utilities. Their partners include globally recognized firms, including AMD, Airbus, Boeing, GE, HP, Rolls Royce, Shell, Siemens, and Total, among others.

MDC supports its mission and vision through four core values:

- **Inspiration:** We are motivated by a deep sense of purpose—encouraging ourselves and each other to create an impact for the greater good.
- **Integrity:** We do what we say, acting in accordance with the highest professional and ethical standards.
- **Accountability:** We take responsibility for our actions and strive to be humble, transparent, and efficient in everything we do.
- **Partnership:** We work hand-in-hand together in the spirit of inclusion, supporting each other while growing One Mubadala.<sup>10</sup>

## The Masdar Company

MDC created the Masdar Company (Masdar), a wholly owned subsidiary, in 2006, to advance the development, commercialization, and use of renewable energy and clean technologies—a link between the current fossil-fuel economy and the energy economy of the future. The Abu Dhabi Economic Vision 2030, a program that drives economic diversification and strengthens the UAE’s knowledge-based economic sectors, guides Masdar’s activities.

Masdar is a commercially driven renewable energy company. Their mission is to invest, incubate, and establish and otherwise nurture a new energy industry in Abu Dhabi and around the world. Masdar plays an important role in extending Abu Dhabi’s energy leadership beyond hydrocarbons by adopting an integrated and holistic business model. This business model merges higher education with R&D, investment, and sustainable urban development. See Table 5 for a description of Masdar’s value creation activities.

**Table 5. Masdar Value Creation Activities**

<b>Masdar Institute</b>	An independent, graduate-level research university dedicated to advancing renewable energy and sustainable technologies.
<b>Masdar City</b>	One of the world’s most sustainable low-carbon cities. A complete eco-system that integrates knowledge, R&D, a technology cluster, and a free-trade zone. As a hub of innovation and sustainability, it is home to international and local businesses, educational institutions, and residences.
<b>Masdar Clean Energy</b>	A renewable energy developer and investor—building some of the world’s most sophisticated, commercially driven, clean energy projects. Number of projects in the UAE (111), Spain (120), the UK (1,032), Jordan (117), Oman (50), Mauritania (15), Seychelles (6), and the South Pacific.
<b>Masdar Capital</b>	An investor in the world’s most promising clean-tech companies—maturing the technologies that will power a more sustainable future.
<b>Masdar Special Projects</b>	A provider of specialized small and medium-sized renewable energy applications, and operates in areas that address pressing and unique energy and technology challenges.

Source: Masdar Fast Facts. [www.masdar.ae](http://www.masdar.ae). Retrieved December 14, 2016.

Spearheaded and launched by Dr. Al-Jaber in 2006, Masdar City was an innovative Masdar initiative funded by a US\$22 billion R&D investment sponsored by MDC’s Renewables Sector business. Dr. Al-Jaber guided Masdar’s strategic direction as the company played an increasingly prominent role in the global effort of advancing renewable energy and clean technology.<sup>11</sup> See Table 6 for Dr. Al-Jaber’s biography.

**Table 6. Dr. Sultan Al-Jaber Biography**

Dr. Sultan Al-Jaber is a champion for sustainability and renewable resources. His education and experience have positioned him as the Middle East’s leading expert on these issues. Dr. Al-Jaber is a scarce talent resource whose skills and know-how are in very high demand in Abu Dhabi, the UAE, the region, and internationally.

Dr. Al-Jaber holds the following degrees:

- BSc in Chemical Engineering (University of Southern California)
- MBA (California State University, Los Angeles)
- PhD in Business and Economics (Coventry University)

Dr. Al-Jaber’s recent accomplishments and appointments:

- 2006 Founded Masdar City
- 2009 Attracted IRENA to UAE/Masdar City
- 2009 Appointed to the UN’s Advisory Group on Energy & Climate Change
- 2010 Appointed UAE’s Special Envoy for Energy and Climate Change
- 2012 Received UN’s Champions of the Earth award for Entrepreneurial Vision
- 2012 Appointed Commander of the Most Excellent Order of the British Empire
- 2013 Joined the UAE Cabinet
- 2015 Appointed CEO of Mubadala’s Energy Business
- 2016 Appointed Director-General of Abu Dhabi National Oil Company

Source: [https://en.wikipedia.org/wiki/Sultan\\_Ahmed\\_Al\\_Jaber](https://en.wikipedia.org/wiki/Sultan_Ahmed_Al_Jaber). Retrieved 8/1/16.

Dr. Al-Jaber envisioned Masdar City to be a commercially viable model for sustainable urban development, regionally and globally—a sustainable urban development and economic free-trade zone relying on solar energy and other renewable resources. The Arabic word *masdar* means the source. Masdar City was designed to be a *greenprint* for cities of the future, a source of knowledge and demonstrated know-how.

*Masdar City: Greenprint for the Future of Urbanization*<sup>12</sup>

*Masdar City is a low-carbon, low-waste urban development that will be one of the most sustainable cities in the world. It not only embodies Abu Dhabi’s commitment to a sustainable future, but also pioneers best practices in sustainable urban planning, design, and construction.*

Dr. Al-Jaber, 2013.<sup>13</sup>

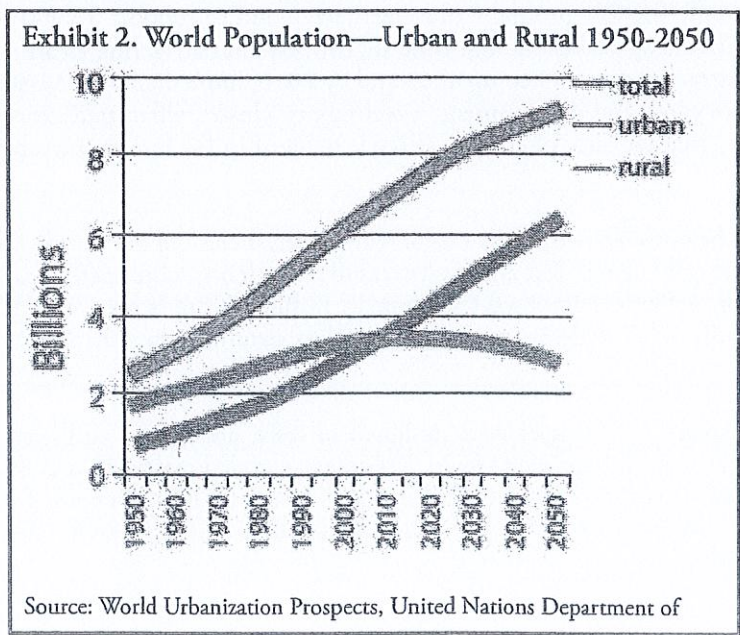
Masdar City is a planned sustainable city, the first in the world; it was conceived to revolutionize thinking about cities and the built environment. In an *e-Architect* interview, Norman Foster, head of the Foster + Partners design firm that developed the Masdar City initiative, commented:

*The environmental ambitions of the Masdar Initiative—zero carbon and waste-free—are a world first. They have provided us with a challenging design brief that promises to question conventional urban wisdom at a fundamental level. Masdar promises to set new benchmarks for the sustainable city of the future.*

*The principle of the Masdar development is a dense walled city to be constructed in an energy-efficient two-stage phasing that relies on the creation of a large photovoltaic power plant, which later becomes the site for the city’s second phase, allowing for urban growth yet avoiding low-density sprawl. Strategically located for Abu Dhabi’s principal transport infrastructure, Masdar will be linked to surrounding communities, as well as the centre of Abu Dhabi and the international airport, by a network of existing road and new rail and public transport routes.*

*Rooted in a zero-carbon ambition, the city itself is car-free. With a maximum distance of 200m to the nearest transport link and amenities, the compact network of streets encourages walking and is complemented by a personalised rapid transport system. The shaded walkways and narrow streets will create a pedestrian-friendly environment in the context of Abu Dhabi’s extreme climate. It also articulates the tightly planned, compact nature of traditional walled cities. With expansion carefully planned, the surrounding land will contain wind, photovoltaic farms, research fields, and plantations, so that the city will be entirely self-sustaining.*<sup>14</sup>

Unprecedented urbanization growth is a trend that is having a major impact on global economic development, especially in emerging markets. Urban planners are seeking sustainable alternatives to urban sprawl caused by rapid urbanization. Masdar City offers a potential solution. Changes in urban and rural populations from 1950-2050 are shown in Exhibit 2, and urbanization trends and cities of the future are shown in Table 7.



**Table 7. Urbanization Trends and Cities of the Future**

- McKinsey & Company claims that growth of cities is driving the most significant economic transformation in history. They claim that urbanization is reshaping the world.
- For the past thirty years, the global urban population has grown at the equivalent rate of adding seven Chicagos a year, every year. Chicago's population is 2.7 million people. This trend is expected to continue or accelerate for at least three more decades.
- By 2030, at least 60 percent of the world's population—5 billion people—will live in cities. By 2050, projections are that 2.5 billion people will be added to global urban centers.
- Growth in urban centers is uneven—90 percent of this growth is forecasted to be in Asia and Africa's industrializing countries.
- Just over 50 percent of the urbanized world population generates more than 80 percent of the global GDP.
- Nairobi, for example, has 9 percent of Kenya's population but produces 20 percent of the country's GDP.
- Megacities will increase from 14 in 1995 to over 30 in 2020.
- Fifty-nine percent, most of the urban center growth, is in small and medium-size cities. These are growing at the fastest rates.
- Climate change has become a major part of the urbanization discussion—cities are responsible for 60-80 percent of global energy consumption, and many are located in low-lying, climate-related, disaster-prone areas.
- The Masdar City "greenprint" is intended to provide solutions for global urbanization needs and resource gaps.

Source: <http://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/the-four-global-forces-breaking-all-the-trends>. Retrieved July 26, 2016.

## Masdar City's Evolution<sup>15</sup>

Masdar City, a low-carbon, low-waste, urban development powered entirely by renewable energy, emerged in the UAE's arid desert, propelled by Dr. Al-Jaber's vision of clean-energy technology and sustainable development.<sup>16</sup> The aspiration was that Masdar City could act as an incubator for a future generation of Emirati greentech entrepreneurs, and serve as a global hub for greentech innovation.

Masdar City was planned to be a six square kilometer (~2.3 square mile) eco-city. Appendix 1A shows an architectural model of Masdar City. Foster + Partners, a UK-based firm, designed Masdar City with the intention of a two-phase project completion within a decade. Appendix 1B shows a plan of Masdar City. Construction began on Masdar City in 2008, and the first six buildings that formed the beginning of the city core were completed and occupied in 2010.

Masdar City's development goal was to attract 1,500 MNCs and start-up companies—primarily those that specialized in environmentally friendly products and greentech—and to support 50,000 residents and 40,000 commuters. Masdar City had a special economic zone that focused on attracting clean technology and other firms. By 2014, they had attracted over 200 companies, and by 2016, more than 360. Masdar City is a complete ecosystem that integrates research and development, a technology cluster, a free-trade zone, and an investment zone. As a free-trade zone, Masdar City offers 100 percent ownership for foreign investors with zero tax and liberal licensing provisions.

City was designed to be powered entirely by onsite renewables, including the world's largest hydrogen plant and an array of photovoltaic solar panels. The entire city was to be built on a nine-meter raised platform to enable an electric vehicle ride-share scheme, combined with a smart public transport network and high walkability to revolutionize intra-city transport. The design included driverless electronic cars that move passengers between buildings.

Built-in shades and smart technologies were designed to resist desert heat and keep cooling costs low.<sup>17</sup> The photovoltaic network atop buildings, made from 90 percent recycled materials, was designed to ensure low external energy and resource demands. Photos of the futuristic Masdar City are included in Appendix 1C–E.<sup>18</sup> Thousands of solar panels formed a solar hub on the outskirts of the city to provide for energy needs. Photos of the solar hub are in Appendix 1F.



Chris Wan was hired as design manager for Masdar City, and was instrumental in bringing Masdar City to life. Wan holds a BA in architecture from the University of Bath in the United Kingdom. He is a member of the Royal Institute of British Architects and the Hong Kong Institute of Architects. He has worked in a variety of professional roles, including Walt Disney Imagineering in Hong Kong. He began working with the Masdar City initiative in May 2008.<sup>19</sup> By 2016, the evolving city had 15 buildings—the completed city core—with several more under construction.

## Masdar City Tenants

Masdar City's first tenant was the Masdar Institute of Science and Technology established in 2007, which has been operating in the city since September 2010 when it moved to the Masdar campus. The Masdar Institute of Science and Technology is the Middle East's first graduate research institute dedicated to renewable energy and sustainability technologies. The Masdar Institute has graduated or is training many of the UAE's future entrepreneurs, researchers, and thought leaders. It was established in partnership with the Massachusetts Institute of Technology. By 2016, the Masdar Institute developed and offered nine accredited master's degree programs. All programs are based on the U.S. graduate education model. MIT collaborates on the development of degree programs and curriculum. MIT faculty serve on the PhD committees of Institute students, and these students spend one semester at MIT prior to graduation. The faculty comment that the PhD graduates are basically world-class.

When the Institute opened, they had over 90 students from 22 countries, and planned on reaching and stabilizing with 800 students. Qualified students from around the world, once admitted to any of the Institute's programs, are provided full tuition scholarships, a monthly stipend, travel reimbursement, a laptop, books, and accommodation.

Five years after locating in Masdar City, the Masdar Institute employed 91 faculty members from 30 countries and had 456 students from over 50 countries. Twenty percent of the faculty and 52 percent of the students are UAE nationals. About half of the students are women. The first master's students graduated in 2011 and the first PhD students graduated in 2015.

### *Masdar Institute—A Learning Laboratory*

Masdar Institute is a learning laboratory for its students since it demonstrates best practices in building, layout, and design. Built to consume 75 percent less cooling demand than a conventional building of its size, as well as 70 percent less potable water, 95 percent less domestic hot water energy, and 70 percent less electricity, the Masdar Institute campus has clean technology at its core. The campus offers students a unique experiential opportunity to live and study in an environment with cutting-edge sustainable technology.

The layout and design of the campus provide shaded routes to encourage pedestrian activity and simultaneously promote airflow at street level. Inside all of the Institute's buildings, thick columns line long corridors and high thermal-mass materials—materials that absorb and store heat—have been applied to all structural surfaces. Consideration was given to sustainable factors such as recyclability, low embodied-energy properties,<sup>20</sup> and low emission materials and finishes, within the building's specifications. The building's façades have been developed to passively reduce heat transfer while also being highly sealed to keep air-conditioned cooling inside (see Appendix 1B and 1C). Materials with a low thermal mass act as a fast responsive system, cooling down quickly at night to avoid transferring heat to the surrounding space.<sup>21</sup> In choosing the sustainable materials used in the Masdar Institute buildings, special preference was given to local products.

### *The International Renewable Energy Agency and Other Core Buildings*

A second six-story large steel building in the core is the International Renewable Energy Agency (IRENA) global inaugural headquarters. Masdar attracted IRENA in 2009 with the promise of a state-of-the-art sustainable building. The 32,000 square meter (~345,00 square feet) IRENA building uses one-third of the energy of similar office buildings in Abu Dhabi because it has, among other sustainable features, air-tight insulation, high-efficiency elevators, natural lighting, and solar water heaters. Rooftop solar photovoltaic panels generate more than 340,000 Kilowatt-hours per year. The innovative design created an efficient, flexible, and environmentally sustainable

building that will house anchor tenants, ranging from MNCs to small and medium-size enterprises. IRENA's 90 employees occupy the six-story building, and fewer work on the campus.

- *Incubator Building*: The Incubator Building lies at the center of Masdar City and is strategically located adjacent to the Masdar Institute. It is a hub for innovation and designed to provide entrepreneurs and businesses unique, convenient, and flexible office solutions. The building's proximity to the Masdar Institute makes it ideal for greentech entrepreneurs and innovators looking for partnerships with the Institute.
- *Siemens Building*: The remaining completed portions in the core include a large building, Siemens Middle East headquarters; a 45-meter Teflon-coated wind tower that channels cool breezes through a shaded street (see Appendix 1C) This street has a grocery store, bank, post office, canteen, and two coffee shops. The Siemens and IRENA buildings are state-of-the-art in terms of optimizing energy usage. In addition to Siemens and at least 300 other firms, like GE's Ecomagination, Mitsubishi, and Lockheed Martin, have an official presence in the core, but local sources say these are mostly "hot desks" or flexible, shared workspaces.

"Everything about Masdar City, from its widespread use of renewable energy sources, to recycled building materials, to grey water for irrigation, has been done with an eye toward sustainability, energy efficiency, and carbon-footprint minimization. Taking advantage of the intense year-round sunlight, photovoltaic panels generate electricity, while solar power also provides energy for cooling." A 10MW solar photovoltaic (PV) plant, the largest such plant in the Middle East, powers the Masdar Institute and other core buildings. A huge, hollow tower in the center of town acts as a cooling wind catcher that noticeably reduces temperatures in the city (see Appendix 1C). Treated wastewater is 100 percent recycled for use in landscaping.<sup>22</sup>

## Masdar City Recognition

In its early stages, Masdar City attracted world attention from politicians, investors, and media. In 2011, for example, Secretary of State Hillary Clinton gave a speech touting the benefits of the Masdar City initiative and how it could be a model for future developments. "The old strategies for growth and prosperity will no longer work," Secretary Clinton said, "For too many people in too many places, the status quo today is unsustainable. Masdar City, though only in the early stages of construction, has already made a name for itself as an environmental leader. It is putting into practice what it means to be sustainable and laying the groundwork for economic, environmental, and social progress."<sup>23</sup> She observed, "The UAE is positioning itself to be a center for innovation and entrepreneurship for years to come."<sup>24</sup>

In 2013, Export-Import Bank officials signed a memorandum of understanding with Masdar to explore opportunities to structure and deploy up to \$2 billion of finance supporting U.S. green energy-related exports—technologies, products, and services—to Masdar's renewable energy projects.<sup>25</sup> Priorities under the MoU included carbon capture, use and storage, utility-scale solar desalination, sustainable-city development, and waste-to-energy projects.

Masdar City has won a variety of awards for innovation and design, sustainable development, and boldness in business. The nominations for these awards have been from diverse sources, including architects, media, real estate developers, and NGOs. See Table 8 for a list of Masdar City awards and recognitions.

**Table 8. Masdar City Awards and Recognitions<sup>26</sup>**

- Conde Nast Traveler Innovation & Design Award (Sustainability)
- Best Sustainable Development, Cityscape Abu Dhabi
- *Financial Times* ArcelorMittal Boldness in Business Award
- AJ100 Sustainability Initiative of the Year 2008
- Global Renewable Energy Award—Sustainable City of the Year
- Cityscape Real Estate Awards—Best Environmental Real Estate Project

Source: <http://www.e-architect.co.uk/dubai/masdar-abu-dhabi>. Retrieved August 26, 2016.

## Mishaps, Obstacles, and Surprises on the Journey<sup>27</sup>

Not everything in this ambitious initiative has gone according to plan. By 2016, only a fraction of the city had been built—less than five percent of the original six square kilometer greenprint plan. As Dr. Al-Jaber observed, “We’re learning while doing... Look, nobody’s done this before, but we want to do it right.”<sup>28</sup> Fewer than 2,000 people are employed in Masdar City in 2016. More than 400 Masdar Institute students live onsite. A water desalination plant, for example, was scrapped because the projected energy needed to clean the exceptionally salty local water was excessive. The rooftop solar photovoltaic panels were moved to an offsite location where they were easier to maintain.

Even at a fraction of its planned footprint, Masdar City is not close to zeroing out greenhouse gas emissions. It will not reach that goal even if the development gets fully built. Chris Wan observed, “We are not going to try to shoehorn renewable energy into the city just to justify a definition created within a boundary... As of today, it’s not a net zero future... it’s about 50 percent.”<sup>29</sup>

Masdar developers abandoned the original 2016 completion goal of building the world’s first zero-carbon city in the UAE desert. The path to realizing this ambitious vision was fraught with economic and technological obstacles. The completion date has been pushed back to 2030.

“The project is still under development...” according to Dr. Federico Cugurullo, a scholar who has studied the development of Masdar City, “...It has always been a slow development, because of its costs, mechanics, and the number of actors involved. They *are* likely to finish it, but it will take at least 15 years, and the final shape will be very different to the original master plan... Masdar City is sustainable inasmuch as it manages to sustain the economic and political system that it draws on.”<sup>30</sup>

According to Anthony Mallows, Director of Planning and Delivery: “Masdar City is being built in phases, but of course real cities are never finished. This approach provides us the flexibility to embrace new technologies, apply lessons learned, and make improvements moving forward. Masdar City will be transformed over the next decade. Around 35 percent of the planned built-up area will be completed over the next five years, and nearly 30 percent has already been committed to, including private homes, schools, hotels, and more office space.”<sup>31</sup>

The goal to have major international companies locate in Masdar City to develop new green technologies was not realized, except for Siemens. Steve Geiger, Masdar’s co-founder and director from 2006-2009, commented: “We beat our heads against the wall to try to bring in corporate partners to set up research and development—the big guys... But why build them in Abu Dhabi? There’s limited indigenous talent, and local markets are too small to justify localising a lot of R&D.”<sup>32</sup>

In addition to the failure to attract MNCs, Masdar City faced similar difficulties in attracting start-ups. Foreign companies and start-ups were required to be majority-owned by UAE locals—who receive large state salaries. Recently, the UAE began to provide regulatory incentives to set up new businesses. Masdar City opened an onsite agency to streamline the complex administration associated with starting up a company.<sup>33</sup> But these technological and bureaucratic challenges were the least of Masdar’s problems.

The 2008-2009 Global Financial Crisis disrupted Masdar City development progress. The crisis drove down the price of oil and gas and had a major negative impact on the development of Masdar City. Oil fell from a high of \$147 a barrel in February 2008 to \$33 in February 2009. Gas fell from \$14/MMBtu to \$4 in the same period.<sup>34</sup> According to Dr. Cugurullo: “The eco-city is a project where ‘eco’ does not stand for ‘ecological’ but for ‘economic’... the project is severely undermined by an internal tension between economic interests and environmental concerns: a tension which ultimately shatters the sustainability potential of the new city.”<sup>35</sup>

Less than two hours’ drive from Masdar City was Dubai’s state-owned investment company, Dubai World. Dubai World had US\$59 billion in unserviceable debt due to the dramatic oil and gas revenue decline. As a result of the Global Financial Crisis, the Emirati housing market crashed, and “The city’s rental-income projections collapsed overnight and, with them, any hope of finishing the Masdar site by 2015. Out went the dream of 50,000 residents and a zero-carbon settlement... We promised the world it was going to be the first zero-carbon

[city], but it's just not economically feasible. Now it's low carbon... We said it was going to be zero-waste. We said it would be car-free. We said it would be built on a nine-metre-high platform—we had to backpedal on all those ideas.<sup>36</sup>

“In the beginning, we thought that we could just find out the latest and greatest technology, and create a high-performance building,” said Chris Wan. “... But because the financial crisis forced it to scale back its budget and its ambitions,” Wan said, they had to come up with routes to sustainability that could be “more easily and more usefully replicated in other cities.”<sup>37</sup> From this perspective, it would be easy to see the project as a failure. Despite these challenges, Masdar City initiative leaders persisted in driving toward their grand vision.

Masdar's former COO, Dale Rollins, commented: “The Masdar master plan is changing as the world economy changes... It's unfair to say that what was decided in 2006 will hold forevermore. The objectives have not changed, but we have reworked the master plan. The technology and the market have moved on. We say we can do it better, and we can do it in less expensive ways.”<sup>38</sup>

## The Future

Reflecting on the Masdar City initiative, Dr. Al-Jaber commented, “At the outset, the biggest challenge we faced was convincing the world we were serious about renewable energy. People would ask, ‘Why is a major oil-producing country talking about climate change and renewable energy?’ But we see the move into renewable energy and sustainable technologies as a natural extension of our conventional-energy leadership.”<sup>39</sup>

Dr. Al-Jaber believes that it's time to stop thinking solely through the prism of the city. “It's the one piece of our story that has remained at the forefront of people's minds... But Masdar is, and has always been, more than just a city.” Masdar City may be a work in progress; however, some parts of the mission have already borne fruit. According to Steve Geiger: “These projects are all world-first or world's-largest—and one way or another, we can take credit for that. Collectively, Abu Dhabi is probably the largest investor in renewable energy in the world.” Gerard Evenden, the lead architect from Fosters, contends that the project should not be criticized. The technological learning, about photovoltaic placement, for example, will save future builders time and inefficiencies, especially for projects of this scale. The Arabic term *estidama* means sustainability. Sustainability is now part of the mindset of regional architects and builders.

“Whatever we think of Masdar now, the mere fact that a public agency is actually putting its money where its mouth is, and investing in an environmentally sustainable city, is something that must be a good thing. There's so much talk about these things, but Masdar has, with all its strengths and weaknesses, created one,” observed Richard Burdett, Professor of Urban Studies at the London School of Economics. Masdar has introduced Emiratis to the concepts of climate change and renewable energy, and other regional governments are following the UAE lead.

In the decade since the Masdar City initiative was conceptualized, other eco-cities have emerged around the world. In China, the Sino-Singapore Tianjin-Ecocity and Dongtan City initiatives have both pioneered zero-carbon footprints, albeit with limited success. South Korea has developed Songdo with zero-carbon objectives. Denmark's Sansoe is pursuing similar objectives. Similar city-projects, and many less-ambitious projects, are developing and learning from each other. In many instances, technology that was cutting edge a decade ago has been leapfrogged by more efficient or more effective technology.

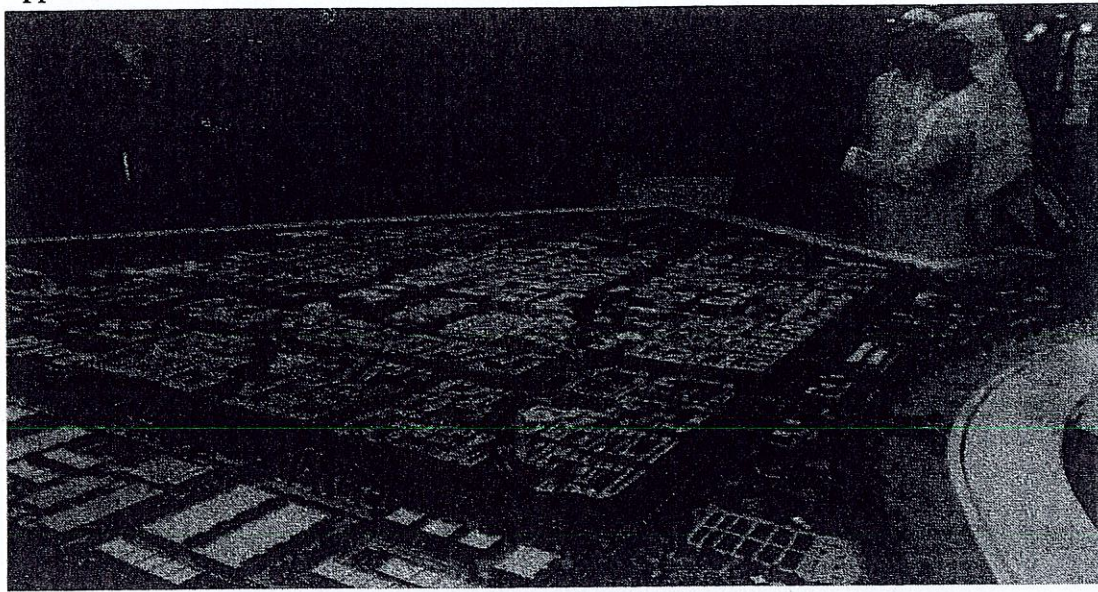
When thinking about a greenfield eco-city, many urban thinkers wrestle with a pressing question: how do we make ancient, densely populated cities like London, Mumbai, New York, or Cairo more sustainable? What can be learned from the Masdar City initiative that would inform transformation of these established cities? Should we focus our efforts on making brand new cities like Masdar City, or retrofitting and making existing cities more sustainable?

Those responsible for the implementation of Masdar City have encountered obstacles beyond their control—financial crisis; leapfrogging technology; and changes in government priorities. How can challenges such as these be attenuated? Part of the project plan was to attract foreign new-energy entrepreneurs. This has not materialized as envisioned. What could be done to make Masdar City a more attractive new energy cluster?

## Endnotes

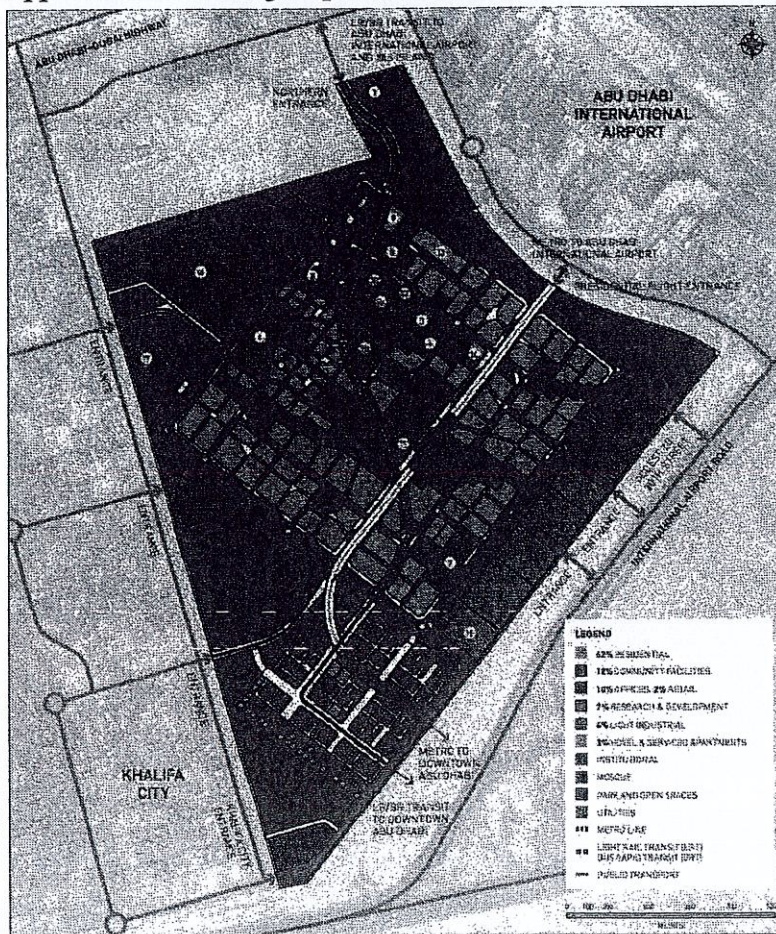
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- <sup>2</sup> Goldenberg, S. (2016). "Masdar's Zero-Carbon Dream Could Become World's First Green Ghost Town." *The Guardian*, February 16. <https://www.theguardian.com/environment/2016/feb/16/masdars-zero-carbon-dream-could-become-worlds-first-green-ghost-town> Retrieved 8/2/2016.
- <sup>3</sup> <https://www.imf.org/external/np/pp/eng/2016/042916.pdf>. Retrieved 9/12/2016.
- <sup>4</sup> Information for this section has been synthesized from the following sources: <https://www.cia.gov/library/publications/the-world-factbook/geos/ae.html>; <http://www.worldometers.info/world-population/united-arab-emirates-population>. Retrieved 8/2/2016; and [https://en.wikipedia.org/wiki/United\\_Arab\\_Emirates](https://en.wikipedia.org/wiki/United_Arab_Emirates).
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- <sup>10</sup> Ibid.
- <sup>11</sup> <http://www.huffingtonpost.com/author/dr-sultan-ahmed-al-jaber>. Retrieved August 1, 2016.
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- <sup>16</sup> <http://viterbi.usc.edu/news/news/2013/city-of-dreams.htm>. Retrieved August 29, 2016.
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- <sup>20</sup> See the following article for information on embodied energy: [https://www.canadianarchitect.com/asf/perspectives\\_sustainability/measures\\_of\\_sustainability/measures\\_of\\_sustainability\\_embodied.htm](https://www.canadianarchitect.com/asf/perspectives_sustainability/measures_of_sustainability/measures_of_sustainability_embodied.htm).
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- <sup>33</sup> Ibid.
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- <sup>35</sup> <http://grist.org/climate-energy/the-worlds-first-zero-carbon-city-is-a-big-failure/>. Retrieved August 29, 2016.
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- <sup>37</sup> Ibid.
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### Appendix 1A. Architect's Model of Masdar City Plan



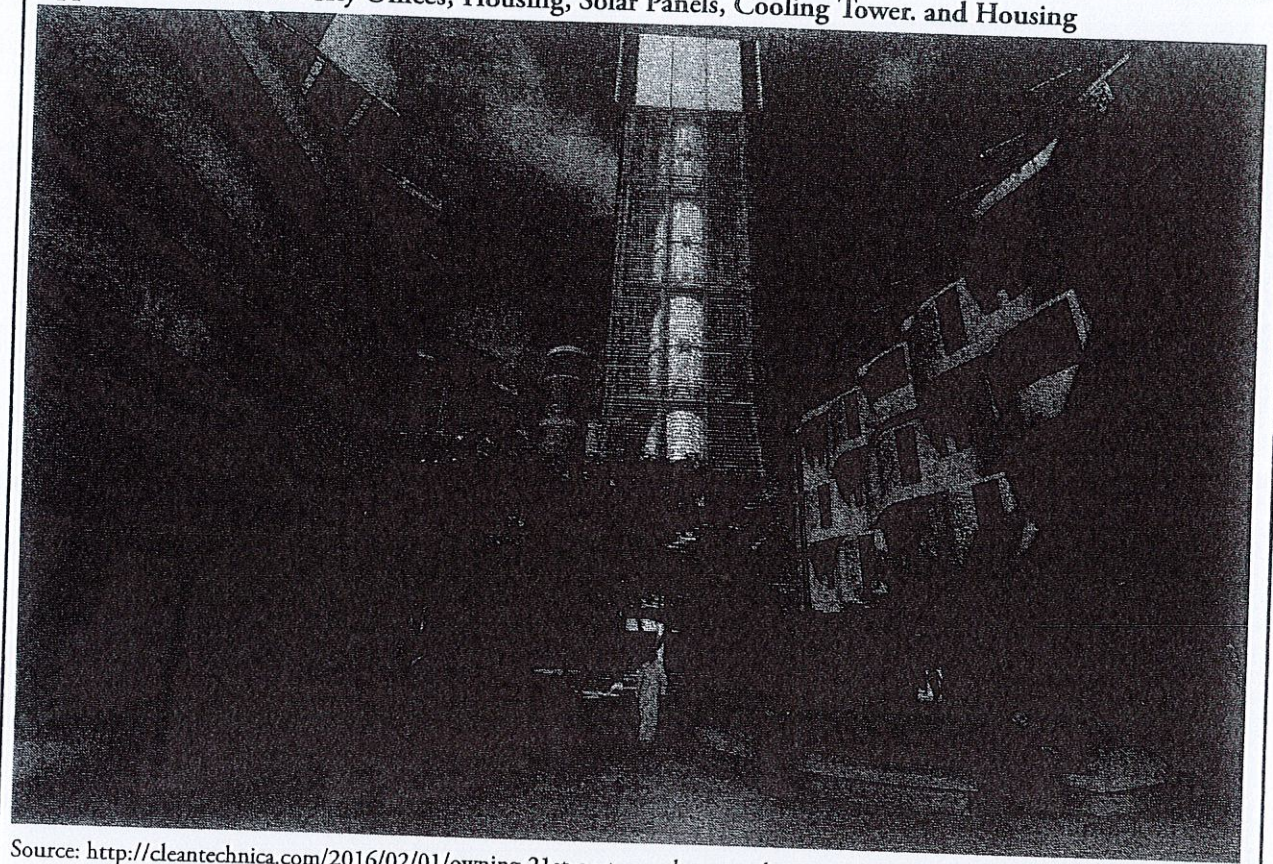
Source: <http://cleantechnica.com/2016/02/01/owning-21st-century-solar-water-brain-power/>. Retrieved July 7, 2016.

### Appendix 1B. Planning Map of Masdar City



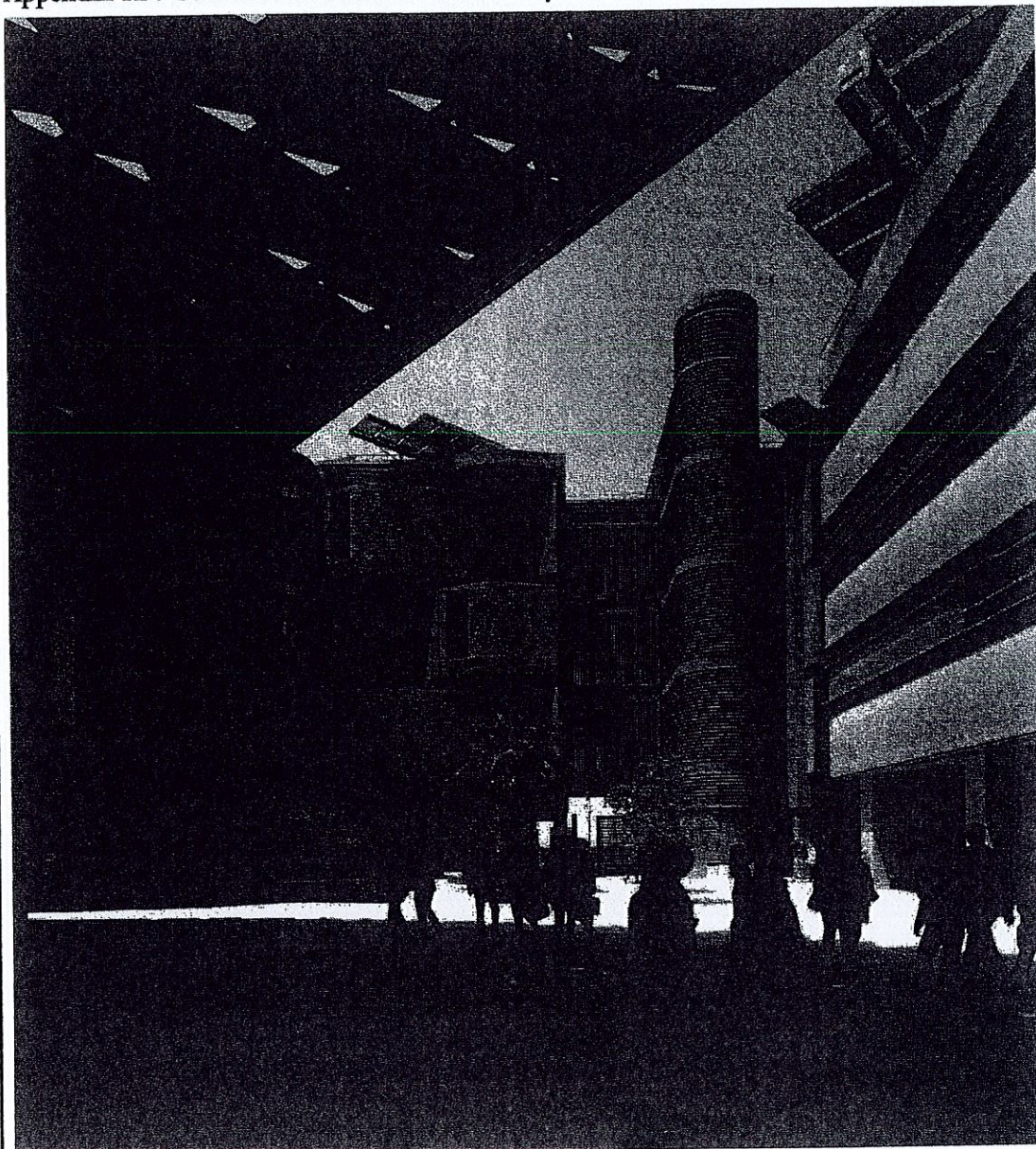
Source: <http://grist.org/climate-energy/the-worlds-first-zero-carbon-city-is-a-big-failure/>. Retrieved August 29, 2016.

Appendix 1C. Masdar City Offices, Housing, Solar Panels, Cooling Tower, and Housing



Source: <http://cleantechnica.com/2016/02/01/owning-21st-century-solar-water-brain-power/>. Retrieved July 7, 2016.

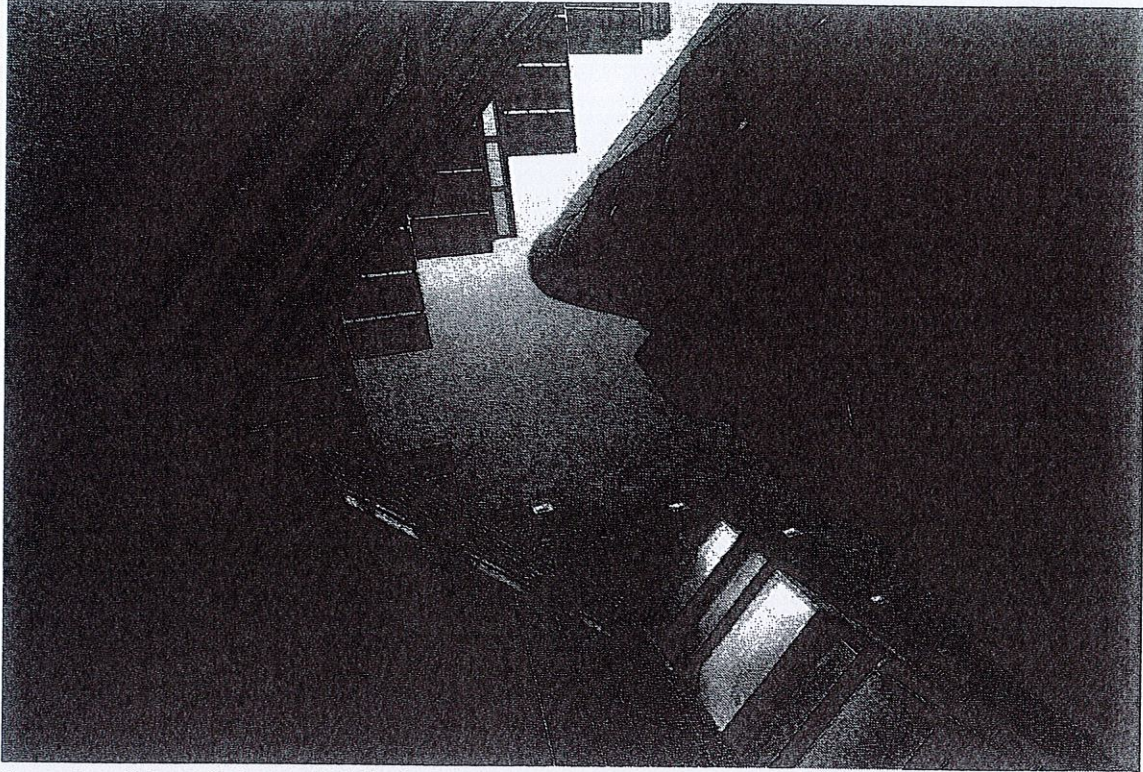
Appendix 1D. Commons Area Inside Masdar City



Source: <http://cleantechnica.com/2016/02/01/owning-21st-century-solar-water-brain-power/>. retrieved July 7, 2016.

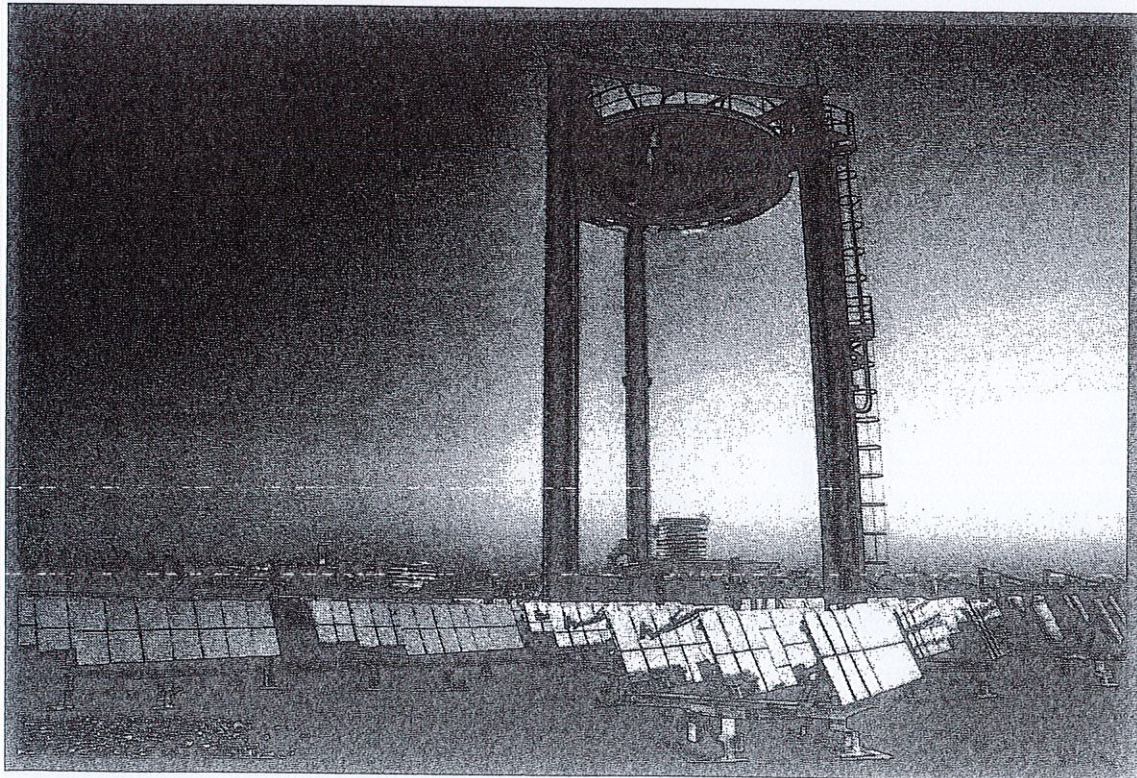


Appendix 1E. Solar Technology and Use of Shade in Masdar City



Source: <http://cleantechnica.com/2016/02/01/owning-21st-century-solar-water-brain-power/>. Retrieved July 7, 2016.

Appendix 1F. Solar Hub on the Outskirts of Masdar City



Source: <http://cleantechnica.com/2016/02/01/owning-21st-century-solar-water-brain-power/>. Retrieved July 7, 2016.

