# Masdar City showcases sustainability

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Thanks to oil riches buried deep under its desert sand and in the waters off its shores, citizens in many parts of the United Arab Emirates (UAE) can afford comparatively luxurious lifestyles. Such lifestyles can come at a cost: the country's greenhouse gas emissions per person are some of the highest in the world.

But 17 kilometers from the skyscrapers and SUV traffic of downtown Abu Dhabi sits the futuristic environment-friendly oasis of Masdar City. Here, solar power meets residents' energy needs. Buildings are extremely energy efficient. And people either walk or zip around in small electric pods that run on tracks. Masdar's masterminds hope to make it among the most sustainable cities in the world, by lowering carbon emissions and becoming waste neutral.

The city is part of the multibillion dollar Masdar (Arabic for "source") Initiative founded in 2006 by the Abu Dhabi government to incubate a renewable energy economy in Abu Dhabi. The visionaries behind the initiative want Masdar City to become a research hub and test-bed for clean energy technologies. The hope is that technology solutions developed and tested here could be used in the Gulf region and beyond to achieve sustainability targets.

The original plan was for the city to be a functional home to 40,000 people by 2016. But the global financial crisis has delayed the schedule. So far, the few hundred residents of the city are those living and working at the Masdar Institute of Science and Technology, the graduate-level research university that is the heart of the city.

Meeting Masdar's ambitious goals will take many more years. However, the city already provides novel examples of material use for energy savings. And Masdar Institute, whose curriculum and faculty have been forged in partnership with the Massachusetts Institute of Technology, is attracting talented minds that are generating innovative research on sustainable technologies, including biofuels, desalination, and energy storage.

The design for Masdar City's buildings is the work of British architecture firm Foster + Partners. The buildings use 54% less water than similar-sized conventional buildings through efficient appliances and fixtures; sensors that spot leakages; and smart meters that tell people how much water they're using.

The buildings also reduce energy use by 56%. Active energy management technologies include sensors that measure carbon dioxide, humidity, and temperature levels inside buildings to minimize air conditioning. But much of the energy efficiency comes from passive technologies such as low-energy lighting and appliances, and smart materials.

"A very large part of the city's sustainability approach has to do with the unique, locally sourced materials used," said Masara Al Ameri, director of industry, government, and academic operations at Masdar Institute. The building exteriors, for instance, utilize materials that combat harsh heat. Laboratory buildings have an envelope of inflatable cushions made of ethylene tetrafluoroethylene films, which are extremely insulating and don't radiate heat. The undulating residential building facades have an external concrete screen—the pattern is inspired by traditional Arabic latticework—that provides shade, while an inner layer of 90% recycled aluminum reflects light and, owing to its high thermal conductivity, dissipates heat.

Construction relies on certified sustainably sourced wood as well as low-carbon-emission concrete, made at an on-site plant, in which some cement content is replaced with two industrial by-products: blast furnace slag and fly ash.

A large recovery facility helps recycle and compost the city's solid waste, keeping nearly 50% of it out of landfills. Used concrete goes into making roads, while wood is shredded and mulched. Metals and plastics are taken off site for recycling.

The materials research being done at the Institute focuses on sustainability and renewable energy. In materials science and engineering Professor Raed Hashaikeh's laboratory, for instance, graduate student researchers are busy developing polymer electrolytes for lithium batteries. Lithium polymer batteries can be more compact and rugged than conventional lithium-ion batteries because they use solid polymer electrolytes instead of an organic solvent. The polyethylene oxide electrolytes used today, however, have low ionic conductivity, which means the battery does not charge and discharge quickly. Hashaikeh's team has made a cellulose-triethylene glycol film with ionic conductivity on par with organic solvents. They are now testing the material in lithium-ion coin cells and patenting the invention.

Together with Nidal Hilal, a professor of water and environmental engineering, Hashaikeh has also filed a patent for a technology that could make seawater desalination cheaper and more efficient. Much of the Gulf region's water comes from energy-intensive thermal desalination, which involves evaporating seawater to remove salt. Membranes that physically separate salt are an attractive alternative, but chemical or

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Solar panels sit atop the modern-looking laboratory buildings and the local sand-colored, Arabic architecture-inspired residential buildings that sit side by side in the Masdar Institute of Science and Technology. Image courtesy of Masdar City.

bacterial buildup clogs their pores over time. Membrane desalination plants typically employ chemical or mechanical techniques to clean fouled membranes. "These techniques are inefficient because you have to stop the desalination process," Hashaikeh says.

Hashaikeh and Hilal have made membranes using nanofibers that they spin from hydrophobic polymers. The nanofibers are coated with a self-cleaning film that prevents fouling. Tests of the antifouling membrane are being piloted at Masdar Institute.

Materials science and engineering Professor Amal Al Ghaferi, meanwhile, is collaborating with MIT researchers to integrate organic polymers and nanomaterials such as carbon nanotubes into conventional silicon-based solar cells. Such hybrid organic/inorganic solar cells could be cheaper and more flexible than their silicon counterparts, Al Ghaferi said.

There are many other energy-related research projects that hold commercialization potential and could have a broad impact, said Bruce Ferguson, professor of engineering systems management.

The question is whether the knowledge and technologies developed at Masdar Institute can make their way out to the world.

This is happening to some extent through Masdar's active outreach and technology transfer efforts, said Executive Director of Institute Initiatives Steve Griffiths. For one, energy-efficient technologies developed at the Institute and being piloted in the city are transferable to Abu Dhabi, he said. For instance, the sustainable materials used in the city can readily be translated to construction in Abu Dhabi and the region.

The Institute introduces local government and private industry stakeholders to ongoing research through short courses, conferences, and workshops. There are research collaborations with global universities; multinational corporations such as Siemens, Boeing, and Honeywell; as well as local entities such as the Emirates Aluminum Company and the Abu Dhabi Executive Affairs Authority. Plus, added Griffiths, our intent is that cutting-edge technologies being developed at Masdar Institute will eventually be licensed to local companies and, in the longer term, spur startups.

So far though, according to Hashaikeh, while applying for technology patents has been easy, the next step to commercialization has not.

"The ecosystem for entrepreneurship in Abu Dhabi is pretty challenging," Ferguson said. Many students are business-minded and interested in startups, he said. But "there is no substantial venture capital network, no network of mentors and advisors, and no network of existing entrepreneurs." Ferguson hopes this will change with a new center for innovation and entrepreneurship that he is helping to establish at Masdar Institute.

The barriers to entrepreneurship in the UAE are political and cultural, he said. Good jobs in the public sector are open to local graduates, often reducing their motivation to take risks. Besides, startup failure carries a social stigma, and the country's legal and regulatory frameworks have historically made forming a company challenging.

On the positive side, the regulatory framework changes faster than it does in the West. The country's small size, tolerance for change—almost 90% of the country's residents were born abroad—and the government's desire to place the UAE on the global technology and renewable energy map all make it easier to get things done quickly. Plus there is no shortage of financial capital.

This could give the country a tremendous advantage for materials and energy research, Ferguson said. While the venture capital industry in the United States focuses mainly these days on information technologies, which require significantly less capital and maturation time than materials technologies, things could be different in the UAE. If the UAE is successful, it could eventually be as easy to innovate here as it is in the West. This includes taking innovation from laboratories and making products.

Masdar City is, of course, still in its early stages. The academic body at Masdar Institute is tiny compared to major universities around the globe: there are now 336 students (16 are enrolled in materials science and engineering) and 71 faculty members. And, despite the eco-city in its midst, the UAE won't wean itself off oil anytime soon. Nonetheless, said Griffiths, "Masdar City sets an example of sustainable living. Leadership by example is a critical element in creating awareness." □



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